**OPTIMIZING ENERGY EFFICIENCY AND POWER QUALITY THROUGH A WEB-BASED AUDIT PLATFORM**

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of the Requirements for the

Degree of Bachelor of Science in Electrical Engineering

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In Partial Fulfillment of the requirements for the Degree of Bachelor of Science in Electrical Engineering, this thesis entitled **“OPTIMIZING ENERGY EFFICIENCY AND POWER QUALITY THROUGH A WEB-BASED AUDIT PLATFORM”**, prepared and submitted by **John Kenneth Villarin**, **Gerald Chris Balaba**, **Marco Philippe Martinez**, **Raymond Tobias Managay, and Renzy Laurenz Logroño** has been examined, accepted, and approved for PROPOSAL HEARING.

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# CHAPTER 1

THE PROBLEM AND ITS SCOPE

INTRODUCTION

### Rationale of the Study

The evaluation of the electrical system of the old building of the University of Cebu-Lapu-Lapu and Mandaue described the need for greater awareness of electrical standards and regulatory frameworks. Engineers and researchers collaborated to assess the existing system, focusing on compliance requirements under modern safety, efficiency, and sustainability guidelines. Inherent challenges affected the operational efficiency of aging electrical systems; nevertheless, their efficiency and lifetime could be enhanced with diligent management and upgrading, setting the stage for further system improvements (Few, 2009; Mackinlay, 2000).

Data visualization thus played an active role in developing an understanding of real-time monitoring data: it translated complex information into simple, actionable insights. Presenting information through graphs, charts, and dashboards increased stakeholders' ability to spot patterns, trends, and anomalies. Tools such as configurable dashboards to lessen cognitive load enabled different users, like facility managers and maintenance staff, to quickly make informed decisions that greatly increased system reliability and performance (Knaflic, 2015).

Web-space technologies like cloud computing transformed the processes of monitoring and controlling electrical systems. With cloud-based platforms that allowed remote access, real-time monitoring of electrical systems was possible from any device with an internet connection. These technologies also created a centralized data processing and storage facility, leading to easier system management and ensuring reliable opportunities for preventive maintenance. Such systems were designed to adjust to the latest tools or features and kept pace with technological developments, such as smart grids and automation (Marinos & Briscoe, 2009; Buttimer & Downey, 2010).

### Theoretical Background

The theoretical foundation of this study derived from several key frameworks concerning the design, evaluation, and modernization of electrical infrastructure at the University of Cebu – Lapu-Lapu and Mandaue Old Building (UCLM). This research primarily anchored on General Systems Theory (Bertalanffy, 1968), Safety Engineering and Risk Management, Human Factors and User-centered Design principles, Sustainability and Technological Integration, Human Machine Interface (HMI) Theory, Diffusion of Innovations Theory (Rogers, 1962), and Reliability Centered Maintenance (RCM) Theory (Nowlan & Heap, 1978). It provided a comprehensive treatment of electrical system design, user interaction, safety considerations, and system reliability and brought modern technological solutions centered around energy efficiency and sustainability.

#### General Systems Theory; Bertalanffy, 1968

Ludwig von Bertalanffy's (1968) General Systems Theory proposed a holistic view of the interaction of components in any given system. According to this theory, systems could not be comprehended through studying the separate components; instead, they should have been regarded as a network where every element continually interacted with the remaining elements. It was important to think of each component separately in electrical systems, e.g., power sources, distribution panels, and protection devices—all of them and how they worked together to protect the integrity and safety of the system. General Systems Theory applied to UCLM's electrical infrastructure to establish a lens through which the interdependencies among components constituting an aging system could be identified and assessed.

By applying this theory, the dynamic nature of the system was identified, and modifications in any area of the system could lead to cascading effects across the entire network. For example, upgrading a power distribution panel might have demanded that the wiring or grounding systems accommodate changes to ensure the electrical flow remained safe. This methodology aimed to find the system's most important vulnerabilities and improve them without introducing additional risks. In addition, General Systems Theory emphasized the importance of continuous monitoring and system adaptation that enabled the electrical infrastructure to evolve continually in response to changes in demands, technological advancements, and regulatory requirements.

A systems-based approach to the electrical network at UCLM also enabled a better understanding of how to extrapolate a modification's impacts on the performance of the complete system. This comprehensive perspective ensured that technological or safety-related enhancements remained consistent with the recognized and fundamental goal of generating a safe, reliable, and efficient electrical environment.

#### Safety Engineering and Risk Management (Heinrich, 1931; Reason, 1990; Leveson, 2004)

How an electrical system was designed to minimize hazards and maximize safety for all building occupants required the integration of the Safety Engineering and Risk Management frameworks. It looked at how to identify and remove hazards from the system. This entailed the application of engineering principles that helped design safety features like circuit protection devices, grounding systems, and fail-safes to minimize the risk of electrical faults, fire outbreaks, and system failures. Anticipation and prevention of accidents were key in safety engineering, proactively addressing points of failure in the electrical infrastructure.

Risk Management took this framework further by providing a structured analysis to work with the risks. The entire process revolved around finding out where there could be some threat, assessing its likelihood, and evaluating the severity of the potential outcome, before attempting to solve it. In the case of the UCLM electrical system, the risk management practices allowed for the prioritization of interventions based on the severity of the risks, addressing critical safety risks such as electrical fires or system malfunctions first. Furthermore, risk management frameworks were utilized to decide on new safety technologies, including fault detection systems, circuit breakers, and emergency shutdown mechanisms, ensuring that these technologies were effective and met regulatory requirements.

A comprehensive safety engineering and risk management approach developed to create a safe, reliable electrical system. By minimizing potential hazards and streamlining real-time risk assessment, these frameworks assisted in keeping everyone safe, including students, faculty, maintenance staff, and the greater campus community.

#### Human Factors and User-Centered Design Principles (Norman, 1988; Chapanis, 1951; Shneiderman, 1987; Nielsen, 1994)

Human Factors and User-Centered Design Principles ensured that the electrical system functioned effectively and was accessible, intuitive, and user-friendly. They were based on an understanding that human users interacted with technology, and the systems were designed based on these interactions. Human factors theory dealt with human capabilities and limitations and stated that systems should be tuned to work within a range of human abilities (cognitive or physical). The study proposed that by applying human factors theory, an interface and infrastructure of the electrical system at UCLM would be designed to minimize user error and improve system usability and safety.

The application of Human Factors and User-Centered Design Principles in constructing an electrical system ensured that the system was functional and user-friendly. For UCLM's electrical system, this meant developing distribution panels, monitoring interfaces, and control mechanisms that were easy to use and understand, regardless of the user's technical knowledge. The objective was to make the system tasks manageable for maintenance staff and building occupants, ensuring that tasks could be performed safely and efficiently.

Human factors and user-centered design also improved interactions with the electrical system. For example, circuits were clearly labeled, with easy access to emergency shutdown mechanisms and intuitive monitoring systems, which made the system safer and more effective. These theories reduced risk by ensuring the electrical system was accessible and usable, thereby reducing the risk of human error, which frequently contributed to electrical accidents and system failures.

#### Sustainability and Technological Integration (Elkington, 1994; Lovins, 1976; Daly, 1996; Hawken, 1999)

The design of modern electrical systems was increasingly guided by sustainability principles, aiming to minimize environmental impact, optimize resource use, and reduce energy consumption. This shift towards energy-efficient electrical infrastructure, including LED lighting, energy-efficient appliances, and smart energy management systems, was a step towards reducing the building's carbon footprint and operational costs, fostering a sense of environmental responsibility.

The move towards modernization relied on technological integration at UCLM. The demand for energy-efficient and smart technologies grew, and incorporating innovations such as IoT-enabled devices, automated fault detection, and predictive maintenance systems became an essential part of the regular product lineup. Not only did these technologies help lead to sustainability, but they also helped to increase the operational efficiency of the electrical system. UCLM's electrical infrastructure became more resilient, green, and cheaper by incorporating renewable energy sources like solar panels and optimizing power consumption through intelligent systems.

It was crucial to include sustainability in technology to bring the electrical system up to date with environmental advancements and prepare for the future of UCLM. The institution embraced smart technologies to remain on the cutting edge of energy management practices and to benefit the global sustainability effort where appropriate. Finally, these technologies allowed the system to scale as energy demands rose or new technologies became available.

#### Human-machine interface (HMI) Theory (Card, Moran, & Newell, 1983; Wickens, 1984; Norman, 1988; Rasmussen, 1986)

The automation of electrical infrastructure monitoring depended on the human-machine interface (HMI) theory, which focused on the mechanics that governed human and machine interactions. HMI design ensured ease of data interpretation, decision-making, and system interaction in a complex system effectively and intuitively. HMI design became important in electrical systems because maintenance personnel, facility managers, and other users required easy monitoring, controlling, and responding to system alerts and faults.

Clarity was one of the basic principles of HMI design. Interfaces remained unambiguous, reducing users' cognitive load and allowing them to make more informed decisions based on what was happening in the system's status. In particular, it monitored critical signals like voltage levels, current dissipation, and fault detection in electrical systems. It reinforced safety by being visible, eliminating the likelihood of user error, and increasing user safety through continuous display and updating of the system status.

Feedback and consistency in HMI design were also important. Users received feedback to remind them of what actions' results they could see in real time. However, consistency allowed users to develop a mental model of the system, predict system behavior, and navigate the system to complete various tasks. These principles were applied in UCLM's electrical system modernization to reduce the likelihood of errors and improve system efficiency by making the monitoring interfaces easy to use.

The HMI principles were applied so that an automated monitoring system improved the electrical system's functionality, user safety, efficiency, and confidence. Consequently, the UCLM Community achieved an easier, more understandable, and more solid system.

#### Diffusion of Innovations Theory (Rogers, 1962)

The Diffusion of Innovations Theory (Fleming & Marcus, 2006; Rogers, 1962) proved useful for understanding how new technology and innovations diffused through social systems. This theory examined how people and organizations pushed innovations and what factors governed their adoption. It identified five stages of adoption: Persuasion, knowledge, decision, software implementation, and knowledge confirmation. For UCLM, this theory helped in understanding how faculty, staff, and maintenance personnel adopted new technologies (such as automated monitoring systems, energy-efficient devices, and smart grid systems).

The theory of innovation emphasized a perceived relative advantage; the new technology was likely to be adopted if its benefits were clear, efficient, safer, or saved money. Its compatibility with existing practices, ease of use, and the ability to trial the new system before full implementation all played significant roles in adoption rates. UCLM increased its chances of implementing electrical system upgrades as stakeholders embraced these changes when UCLM understood these factors. Diffusion depended on the social system and communication channels (Rogers, 1962). To successfully adopt UCLM, institutional collaboration and communication were promoted, training was provided through assistance, and regular feedback was given to all institution constituents. UCLM assured that switching to a new modernized electricity network was easy and fast and welcomed the opportunity to address issues and state the new system's benefits.

#### Reliability-Centered Maintenance (RCM) Theory (Nowlan & Heap, 1978)

Reliability Centered Maintenance (RCM) by F. Stanley Nowlan and Howard F. Heap, 1978 aimed to ensure that systems performed as desired without failure. In RCM, it was stressed that preventive maintenance strategies should be adopted to maintain the reliability of system components throughout the entire system's life. As it underwent modernization, the electrical system needed to be maintained, and its longevity assured; for UCLM, this was crucial, applying RCM theory. RCM was the process by which critical components were identified, and maintenance strategies were created to maintain the reliability of those components while minimizing downtime.

The RCM approach involved several key steps: identifying the function of system components, analyzing the consequences of failure, ranking the failure modes, and developing methods to minimize or eliminate the risks resulting from the failures. RCM applied at UCLM allowed the institution to prioritize upgrading the electrical system so that the upgraded system was much more reliable and experienced less disruption. The principles of RCM were incorporated into the new automated monitoring systems via preventive and predictive maintenance strategies to identify potential problems before they caused system failures, thus reducing costs and enhancing reliability.

An Assessment on the Electrical System Design and Facilities of a Private University in Mandaue City, Cebu Philippines

**Code Compliance**

PEC 20117 OSHS Standards

**Theories**

System Theory

Human-Machine Integration (HMI) Theory

Reliability-Centered Maintenance (RCM) Theory

Data Collection

Overall Assessment of Energy Baseline Performance 2022

Analysis and Evaluation

Recommendation and Solutions

Comprehensive Energy Audit Towards Technology Management

*Figure 1: Schema of the Theoretical Framework*

### Review of Related Literature

Together with electrical engineers, the researchers evaluated the electrical system design of the University of Cebu – Lapu-Lapu and Mandaue (UCLM) old building by studying relevant literature for understanding the standards in the design, compliance of regulatory frameworks, and the methods in improving system performance. The study emphasized the importance of an overall assessment of the UCLM building's electrical system, which could generate important electrical plans, load calculations, and operational information. This knowledge at the foundation served as the basis for decisions in upgrading the system and its surety because it fit modern standards of safety, efficiency, and sustainability. However, as electrical systems creaked and aged, maintaining their reliability and operational efficiency became increasingly challenging. However, with management and designed upgrades, they lasted longer and were more effective.

#### Data Visualization

Data visualization was pivotal in interpreting large volumes of data comprehensibly and meaningfully. It enabled users to take complex real-time monitoring data and translate them into visually clear graphs, charts, and interactive dashboards. Few (2009) told us that one of data visualization's goals was to provide understanding by allowing users to visually explore patterns, trends, and anomalies in the data. It helped make the data more understandable and implied a feeling of control and confidence in the decision-making process. Effective visualization tools were required to facilitate stakeholders' timely decision-making in power systems, with constantly changing real-time data about load, voltage, and equipment status.

Data visualization brought valuable, immediate, actionable insights into real-time monitoring systems. For example, a well-designed visualization could show voltage fluctuations, load imbalances, or fault conditions to warn maintenance personnel of potential problems before they worsened. Smart visualizations assisted in reducing cognitive load so people could devote their attention to the most important parts of the information (Knaflic, 2015). Data visualization was about displaying information and giving the user the means to respond to the system's status quickly and effectively.

Furthermore, interactive components, including zooming, filtering, and customizable dashboards, were integrated to empower users to select their new data view. In the case of a complex building electrical system, this level of customization was very useful as users may have had different views based on their roles. For example, facility managers may have been interested in consuming energy data, while components of maintenance staff could have been watching for system faults and anomalies in system performance. Therefore, data visualization offered a forgiving yet user-friendly interface that flexibly supported users in making faster and more informed decisions.

It further enabled data visualization to be applied to real-time monitoring systems to make them more efficient. Cleverly, by feeding data in real-time, energy operators could look for inefficiencies in energy use, power distribution, and the potential for failure, allowing them to do proactive maintenance and optimization. Mackinlay (2000) suggested that visualization could show rubbish patterns and inefficiencies in the system, thus enabling smarter management of electrical resources. By doing that, the system operated at peak efficiency, and thus, downtimes were minimized, energy wasted was minimized, and the lifespan of electrical components was extended.

#### Web-Based Technologies

Earlier this century, when electrical systems began to be monitored and managed from remote locations, the rapid advancement of web technologies revolutionized and significantly enhanced electrical systems' capacity for electronic monitoring and control. Remote access and control of electrical systems, made possible by cloud computing, web interfaces, and responsive design, brought flexibility and accessibility to building managers, maintenance teams, and other stakeholders. Real-time monitoring from any device with internet connectivity became a key factor in modernizing electrical system management. More importantly, these advancements increased system efficiency and reassured users of their proper functionality.

Data storage and processing centralization were enabled through web-based technologies such as cloud computing. Marinos and Briscoe (2009) explained that cloud computing provided a scalable and flexible infrastructure to accommodate large amounts of real-time data generated by complex electrical systems in environments such as university campuses or large buildings. This scalability was essential, as it eliminated the need for on-site monitoring and allowed users to remotely access and manage electrical systems from various devices and locations. A centralized approach to data management minimized inconsistencies and facilitated quicker decisions and more proactive maintenance, thereby improving overall system efficiency.

The simplicity of maintaining and updating web-based technologies was another major advantage. Updates, bug fixes, and new feature releases could be delivered centrally, enabling users to access the latest functionality without manual intervention. Web-based platforms could be continually developed to integrate new tools and technologies as they evolved, ensuring that the monitoring system remained up-to-date with advancements such as smart grids, energy management systems, and automation technologies (Buttimer & Downey, 2010). Additionally, these platforms supported collaboration among multiple users, such as engineers and facility managers, by fostering efficient coordination during maintenance, troubleshooting, or emergencies. Integrating communication tools such as chat and notification systems further enhanced efficiency, creating an environment for proactive fault correction and improved overall performance.

#### User Experience (UX) in Monitoring Systems

User experience (UX) design was critical to the success of real-time monitoring systems. A well-designed system interface helped ease users' workload in navigating, understanding, and responding to data. The stakes were high in the case of electrical system monitoring, and so was the complexity of the data: UX was extremely important. UX design aimed to develop functional and intuitive systems that helped users complete tasks easily and effortlessly (Nielsen, 1993). In real-time monitoring systems, operators had to make quick decisions based on the data shown, which was particularly important.

Clarity was a crucial part of electrical system monitoring and the design of UX. It needed visual elements such as dashboards, icons, and color schemes to convey the most salient data in a simple format. It was important in design to reduce the cognitive load of users and to have "affordances" in the interface (i.e., the function of the interface was verifiable to the user). This could have meant using color codes for the status of different circuits (say green for normal, red for faults) or interactive components like clickable panels that allowed users to read more about the performance of some equipment. These design principles allowed users to understand system health and act appropriately (Norman, 1988).

Clarity was not all they were looking for; efficiency was too. As the number of steps a user had to walk through to get to specific information decreased, so did the overall experience. In monitoring systems, users should have accessed critical data and been able to perform the required actions with little or no clicks or interactions. Features like customizable dashboards and alerts let people work on specific areas of interest and respond to actual time issues without delay. These efficiencies directly helped the system monitor and maintain electrical systems (Garrett, 2010).

The second critical element of UX was ensuring that design was accessible to many users. Moreover, when monitoring systems were installed in institutional buildings, it was necessary to make sure they were usable for everyone, from people with disabilities to those with various degrees of technical expertise. Ensuring that interfaces were designed to work in an accessible way (e.g., ensuring text was readable, using high contrast colors, and being accessible via the keyboard) greatly increased user satisfaction. Inclusive design principles ensured that all users could use the system, independent of their physical or cognitive abilities. This made the system more usable and reduced the probability of user error, enhancing system reliability (Salvo, 2014).

#### Energy Management

Energy management was important to optimize large buildings' electrical systems, which consumed a lot of energy. However, whereas the EMS's potential decrease in energy usage fell squarely within the mandate of a well-designed EMS, so did the actual supervision and control of energy usage; thus, its potential reduction in energy usage directly corresponded with savings and sustainability in terms of costs and environmental conditions. EMS technologies from Liu et al. (2014) empowered real-time data integration into decision tools to change consumption patterns in diversified systems. It was quite relevant in the monitoring platforms where constant data flow had been observed; through them, inefficiencies were pinpointed, and improvements were suggested.

Real-time monitoring systems, which formed an integral part of energy management, provided instant benefits to facility managers. These systems were key to the efficiency and control of the building's energy usage. Consumption patterns could be traced in real-time, and deviant usage patterns were detected and addressed immediately based on inefficiencies or problems, such as equipment failure or overuse of energy. Real-time data analytics helped strengthen energy consumption forecasting and scheduling by integrating demand response methodologies into energy management systems (Sioshansi, 2011). Continuous monitoring of the energy supply introduced changes that reduced general consumption, comfort, and efficiency in the buildings' operations, meaning that the system's existence in daily activities manifested to the observer.

An energy management system, especially if it possessed real-time monitoring, was of great importance to decrease operational costs. Through constant monitoring of electrical systems, several areas related to savings could be determined. Some of them included HVAC optimization and energy-efficient lighting. This theme underscored cost reduction and made the reader financially responsible and efficient; for instance, a smart lighting system that adjusted according to occupancy or ambient light levels contributed to enormous savings in energy waste. Yang et al. (2013) emphasized that such systems reduced operational costs while increasing the sustainability factor of the system by reducing carbon footprints.

Predictive analytics energy management systems promoted long-term sustainability in energy management. Building managers could make informed and proactive energy procurement, consumption, and conservation decisions through such energy management systems. With such systems, management provided profound insights into projected energy requirements. Real-time systems could make predictions based on the analysis of historical data, the user's behavior, and environmental factors by optimizing load distribution and, at the same time, minimizing the chances of energy deficit. The forecasting capabilities inherent in these systems further assured long-term sustainability and operational efficiency of the electrical infrastructure on established regulations concerning energy consumption and emissions.

#### Real-time Monitoring in Electrical Systems

Real-time monitoring played an important role in controlling and supervising electrical systems, especially in institutions such as the UCLM building. Circuit breakers, transformers, and load meters were some electrical equipment that collected and analyzed data to monitor the health and performance of real-time systems. Such a system enabled early detection of inefficiencies or anomalies and thus provided operators with information as current as the electrical system's condition.

One of the merits of real-time monitoring was the ability to detect faults immediately. Real-time systems measured the performance of different electrical devices like circuit breakers, load meters, and transformers and could detect voltage spikes, excessive temperature, or even overloads. When such issues were identified, the system could send out alarms to maintenance staff to minimize impact and subsequent system outages. For instance, fluctuations in current through a circuit breaker above certain threshold values triggered appropriate alarms, informing technicians to carry out preemptive action.

In addition, real-time monitoring made it easy to maintain the electrical safety and the safety of the building occupants. Such designated monitoring helped to identify various potential dangers, which included faulty wires, short circuits, or overheating parts, which could lead to unfortunate circumstances in the building. With this ability, operators could implement corrective measures immediately, thus preventing accidents and meeting safety standards. Additionally, real-time information made it possible to monitor the performance of all components that posed a risk to safety, such as grounding systems and protective devices, and ensured their effectiveness.

An additional benefit of such extended capabilities was the increased energy efficiency in real-time systems. Such systems enabled the most effective management of buildings while detecting excessive power usage standards and practices in different parts of the buildings. For example, if an electrical appliance was faulty or too old, it could consume more energy than needed, which could be easily spotted and resolved. This resulted in a much more economical building and helped meet environmental objectives by maximizing energy efficiency and reducing waste. In addition, the data obtained from the real-time monitoring system could also assist in making recommendations for improving or replacing equipment that used too much energy.

While identifying failures and defects was one of the objectives of such monitoring practices, IRT monitoring also helped maintain an electrical system. Because maintenance, given continuous data from the sensors and monitoring tools, could identify patterns and historical data for some components, maintenance activities could be planned and carried out in a preventive manner and in reaction to the performance and wear of system components, not merely on a scheduled basis or arbitrary periods. With this transition, real-time monitoring assisted in countering increasing failure rates in electrical equipment and encouraged lower maintenance expenditures.

Last but not least, real-time monitoring systems effectively gathered information crucial in optimizing the system in question. By receiving real-time information from different electrical parts, the operators could assess the electrical system's effectiveness and decide what needed enhancing or when to increase other systems. For instance, once it had been established that some circuits were under some stress, such stress could be relieved to ensure an even load was provided to the system. In the future, real-time data gathered and assessed was expected to assist in developing the system, improving its performance, and ensuring compliance with all legal standards.

#### Maintenance Optimization

Effective maintenance optimization was vital in operating the life of electrical systems, especially in large-scale institutional buildings. Mobley (2002) established that predictions for information systems were predictive maintenance strategies that employed data from real-time monitoring systems to predict the time of system failures on some components. This encouraged action so that the problems could be avoided easily. This was advantageous in reducing failures inside any other sensitive systems, thus maintaining less downtime and reducing repair costs. Predictive maintenance was advantageous through real-time monitoring of degraded equipment that increased reliability and operational efficiency by ensuring that systems ran efficiently while extending the life of their components and minimizing expensive emergency repairs.

This included doing so for the repair processes. Through real-time monitoring, building managers and maintenance staff had access to the current information on the status of electrical systems and managed problems as they arose so they could prioritize repairs based on their seriousness. Real-time monitoring systems improved coordination among maintenance teams, improving response times and overall operational effectiveness. Handling issues before they worsened ensured better reliability and durability of the electrical infrastructure (Brown & Hyndman, 2006).

Maintenance optimization had to do with managing electrical equipment's lifespan. Commonly, real-time monitoring systems allowed monitoring of vital components' age, condition, and performance, so one knew when they needed replacement or servicing. Recommendations from Dhillon and Singh (1981) showed that predictive analytics operated to keep electrical systems functioning longer and to make alarms for imminent failures. It caused reductions in the frequency of breakdowns of the electrical systems, thus reducing unplanned maintenance that could attract negative financial implications while disturbing the overall operation.

In short, real-time monitoring of maintenance optimization was associated with safety and compliance. Organizations that continuously tracked their systems' performance functions ensured that the equipment and devices functioned within mandated standards. When a deviance occurred, it was acted on accordingly. This boosted the safety of the electrical systems within the building and obliged the establishment to abide by standards such as the Philippine Electrical Code and building safety regulations. Maintenance directed towards ensuring safety and reliability in institutional settings accompanied real-time monitoring systems founded on data.

### Research Paradigm: Integrating a Web-Based Audit Systems for Modernized Electrical Infrastructure at UCLM

This study explicates approaches instituted through web-based audit system for enhancing the electrical infrastructure's safety, efficiency, and reliability at the University of Cebu - Lapu-Lapu and Mandaue Campus (UCLM). It is based on a three-phased scheme: pre-implementation, implementation, and post-implementation post-implementation, to facilitate a systematic assessment of modernization impacts. During each of these three phases, the physical states of each electrical system should be documented before the actual deployment of the system in terms of even anticipated improvements and benefits to give a strong basis for infrastructure modernization plans.

#### Pre-Implementation Phase

The pre-implementation phase systematically gathered and analyzed data from UCLM's archive logbooks, historical energy consumption records, and maintenance documentation, laying a solid foundation for the study. Structured survey questionnaires were prepared for stakeholders such as maintenance personnel, faculty members, and building occupants to capture qualitative insights about system performance and users' experiences.

The main objective of this phase was to establish weak points in the electrical system. The primary parameters under investigation included failure type frequencies, average fault response time, total outage time, and trends in energy usage. This coupled indicator provided a thorough appraisal of the condition of the facility infrastructure, mainly highlighting inefficiencies, safety hazards, or areas necessitating urgent intervention.

The pre-implementation stage established a performance baseline that served as a criterion against which the real-time monitoring system's outcomes could be judged. Data-driven decisions ensured that the research focused on areas where the system could deliver maximum impact in any further phases.

#### Implementation Phase

This phase concerned the effective implementation and operation of a web-based real-time monitoring system. It was a critical point because, after this phase, a move away from static analysis and reliance on perpetual dynamic monitoring was in the offing. The real-time system provided several advanced monitoring mechanisms to trace fault occurrences, energy consumption, and overall operational performance.

It was primarily noteworthy for its fault detection: the meaningful instant-to-fault identification. Such logging enabled maintenance teams to respond more quickly and effectively by constantly monitoring system activity for fixes and the exact clock ticks of some faults. Other metrics examined in-depth included the time from fault to detection, detection to fault resolution, and comparisons between two or more proposed techniques.

Transparency was highlighted in the implementation stage. With real-time dashboards, stakeholders could easily monitor a system's health and make decisions proactively. Such web-based dashboards enabled authorized personnel to monitor the system's functioning from remote areas. This open communication promoted teamwork, minimized downtime, and also contributed to leveraging reliability in the system.

In addition, the system provided exhaustive information about various aspects of usage and performance trends. This supported predictive maintenance by pointing to possible problems years before an insignificant failure. Developing a good implementation phase severely heightened the level of information on how well-planned and executed maintenance would be handled effectively and safely.

#### Post-Implementation Phase

Once the proposed solution was implemented, this phase evaluated whether the life event monitoring system had been achieved. Using the before-during-and-after framework, a comparative analysis of KPIs was then assessed. Some KPIs included reduced mean downtime, maintenance faults, and energy consumption time readings.

A vital aspect of this phase was the style of this methodology, which recognized trends and patterns. The evaluation of data collected during implementation determined whether the modernization program had addressed aging infrastructure concerns; for example, reducing system failures and achieving quicker response times signaled higher reliability. Furthermore, energy conservation represented a decrease in inefficiency and sustainability.

The analysis included feedback from stakeholders. Surveys and interviews were conducted with both maintenance personnel and building users to assess the usability and efficacy of the system. This qualitative data combined with quantitative analysis to richly depict the real-world effect of the monitoring system.

An assessment of findings from this phase yielded recommendations that could again be applied to the next improvement phase. Should the findings indicate that the system had significantly contributed to safety, efficiency, and reliability, the study would provide guidelines for scaling it up to another building or campus. If gaps were found, the research recommended fine-tuning system performance.

**Output**

**Process**

**Input**

* Assessment of UCLM’s electrical system using Systems Theory and Safety Engineering.
* Design and development of an automated device based on HMI principles.
* Implementation of smart technologies for real-time data collection and diagnostic.
* Evaluating of safety, efficiency, and compliance with PEC 2017 and Energy Management Handbook (7th Edition).
* Modernized electrical system with real-time monitoring.
* Improved problem detection and preventive maintenance.
* Enhanced safety, reliability, and efficiency of UCLM’s electrical infrastructure.
* A benchmark for maintaining similar aging structures.
* Technological advancements (smart grid and automation) in electrical systems.
* Agung electrical infrastructure of UCLM.
* Theories: Systems Theory, Safety Engineering, HMI Design, Diffusion of Innovation Theory, Reliability-Centered Maintenance Theory.

**Feedback**

*Figure 2: Research Paradigm*

# THE PROBLEM

### Statement of the Problem

The University of Cebu - Lapu-Lapu and Mandaue Campus (UCLM) faces significant challenges due to its aging electrical infrastructure. The outdated wiring and components pose serious safety risks, and the current manual inspection methods are inefficient and time-consuming. These factors contribute to a high likelihood of electrical failures, which can disrupt operations, endanger the safety of students and staff, and result in costly repairs.

Objectives:

1. Modeled the UCLM Old Building's existing electrical system:

* Created a detailed lighting and power layout.
* Developed a schedule of loads for the electrical system.

1. Modeled a 3D layout of the electrical system using DIALux evo:

* Visualized the spatial arrangement of electrical components for better understanding and analysis.

1. Assessed compliance with PEC 1 and energy management standards:

* Evaluated the existing electrical system against the Philippine Electrical Code 1 (2017 Edition) and energy management best practices.

1. Developed a programming application for existing energy audit tools:

* Created a software tool that incorporates the standards of PEC 1 and the Energy Management Handbook (7th Edition) to streamline the energy audit process.

1. Tested the Developed Energy Audit Tool

* Determined the effectiveness of the newly developed energy audit tool in accurately assessing the electrical infrastructure's performance was determined.

1. Evaluated Using the Technology Acceptance Model (TAM)

* Assessed user acceptance of the developed energy audit tool was assessed to determine its impact on practical implementation and effectiveness.

### Significance of the Study

The conduct of this study was beneficial to:

**UCLM and Campus Safety:** This research minimized the potential mishaps related to old-age infrastructure after adopting automated monitoring systems in the old UCLM building. The proposed system detected the faults in real-time, which significantly reduced the risk of severe electrical accidents that could have endangered students, faculty, and staff. The levels of safety were raised to improve the safety of students in line with the institution's ethos of prioritizing the students' well-being.

**Maintenance Operations and Efficiency:** Automation helped overcome the time-consuming manual inspections and repair activities in UCLM and thus improved the total time spent on the system. Predictive diagnostics and the use of online monitoring also reduced the frequency of regular maintenance, so that the time spent on maintenance was much less than otherwise, along with its related costs. Employees in facility management were relieved of constantly dealing with repairs, allowing them to work more efficiently and deliver superior service.

**Educational Advancements:** UCLM students, especially those in engineering and technology, benefited from learning about the operations of a modern electrical model system installed on their campus. This system provided unique practical exposure to contemporary principal electrical works involving computerized or automated systems and IoT. The future holders of degrees were more prepared for work with the latest technologies and, therefore, were more desirable to employers and better equipped to tackle the industry's challenges.

**Broader Industry Implications:** This study provided a prototype for modernizing educational buildings for safety, sustainability, and electrical compliance. The results were crucial for educational institutions and other organizations planning infrastructure upgrades due to aging buildings. They created a basis for other retrofitting initiatives and contributed essential knowledge to electrical systems engineering.

# RESEARCH METHODOLOGY

This study assessed the integration of a real-time web-based monitoring system into the aging electrical infrastructure of the University of Cebu-Lapu-Lapu and Mandaue Campus. As challenges with the campus's electrical systems became apparent with age, maintenance downtimes increased, power consumption became less efficient, and safety risks heightened; thus, continuous improvement required a system and data-driven assessment of current infrastructure developments, the application of innovative solutions, and the evaluation of their impacts.

Adopting the phased methodology granted a wide analysis. The pre-implementation phase collected baseline data from manual logbooks, energy consumption reports, and surveys. This phase developed a detailed picture of the electrical system's performance, including reliability-based measures such as system failures, response times, and energy inefficiencies.

The newly implemented web-based audit system was introduced into the implementation phase to monitor the electrical system's current performance in real-time. This system generated data on fault detection, maintenance response, and energy consumption trends. The continuous monitoring feature allowed for the improvement of system reliability, operational efficiency, and compliance safety.

In the last phase, the system's outcome was evaluated by comparing the data obtained before and during implementation. Key performance indicators included reductions in maintenance downtime and proposed improvements in fault resolution time, energy efficiency, and safety standards.

This study analyzed each of its phases, finding out whether a web-based audit system was an added technology that would help modernize UCLM's electrical infrastructure to keep pace with present safety, reliability, and efficiency standards.

### Research Method

This research used a mixed-methodology approach to collect systematic mixed data taken before and after an automated monitoring system was installed on the aging electrical infrastructure of the University of Cebu - Lapu-Lapu and Mandaue Campus (UCLM). It intended to help examine how this system affected the electrical infrastructure's safety, efficiency, and reliability. This methodology brought together data sources for a robust evaluation of the system's effectiveness at resolving existing problems of an old electrical network.

#### Pre-Implementation Phase

Data collection started with a complete analysis of existing infrastructure documents such as blueprints, wiring layouts, load schedules, and so forth of a building's electrical system. These documents laid a baseline set of knowledge about the design and capacity of the system and what it was meant to achieve. Initial benchmarks for system reliability, unavailability, and energy efficiency were established by analyzing historical logbook entries, incident reports, and past energy consumption records. While these records looked into common faults, time to fix the problem, and operational inefficiencies, they also showed where the system had traditionally failed to meet performance expectations.

Surveys were also taken with maintenance personnel to capture qualitative insights into the operational challenges, safety issues, and maintenance practices. These surveys aimed to capture, in a subjective manner, what the working personnel had experienced with the system and what it tended to do differently. For example, a common failure mode, downtime cause, or even a general state of the system. For this phase, The Energy Management Handbook (7th Edition) was a critical reference that spelled out the energy management practice guidelines and best practices for energy efficiency evaluation and improvement from a system level.

#### Implementation Phase

During the implementation phase, real-time data from the newly integrated automated monitoring system was continuously gathered. The data included information such as fault detection times, system alerts, diagnostic logs, voltage levels, and load distribution, including fault incidences. For system-level performance under automated monitoring conditions, analyses were made of these inputs to determine how well the system could detect problems quickly and correctly and to understand the system's overall performance under automated monitoring compared to manual tracking. Using the computerized system to diagnose faults, monitor energy use, and provide real-time alerts for maintenance personnel suggested a first assessment of how well the system could meet its intended result, for instance, improving operational efficiency and reducing downtime.

This stage complied with principles described in the Energy Management Handbook to determine the electrical system's energy usage through data viewed collected in this phase. An important part of the evaluation was the system's effectiveness in identifying energy inefficiencies and ensuring that the electrical infrastructure operated within optimal performance parameters. With real-time monitoring, operational deviations could be tracked in parallel with remedial efforts as they occurred, enabling real-time responses to performance issues.

#### Post-Implementation Phase

After the system's full implementation, the post-implementation stage involved a comparative study of the pre and post-implementation data. Key performance indicators (KPIs) associated with improving fault detection and response times, increasing system uptime, and improving energy efficiency were the focus. The baseline of this comparison was the pre-implementation data, such as historical energy consumption records and system performance logs. The feasibility of examining the effects of the integration of real-time monitoring on these metrics with post-implementation data from the monitoring system was demonstrated.

A comparative performance analysis was also conducted to ensure the system complied with relevant standards, such as the Philippine Electrical Code (PEC 2017). In this work, we evaluated the ability of the system to meet these standards in terms of safety protocols, maintenance requirements, and operational efficiency. This assured that other than meeting technological goals, the modernization of the electrical infrastructure or infrastructure in general met the regulatory and safety standards.

The post-implementation evaluation also included user feedback. Maintenance personnel and building users were surveyed and interviewed to evaluate the system's usability, user experience, and operational impact. These stakeholders provided invaluable feedback on the system's effectiveness in enhancing safety, efficiency, and the like, and facilitated the maintenance processes. In addition, it described any issues with the system's interface, functionality, or operation that required improvement.

### Research Design

This research utilized a mixed-methods design, combining quantitative analysis with qualitative insights to evaluate the impact of an automated monitoring device on UCLM’s aging electrical infrastructure. The study started with a pre-implementation assessment to determine the baseline data on system reliability, energy consumption, and reliability with the Philippine Electrical Code (PEC 2017) and Energy Management Handbook (7th Edition) standards. Real-time data on fault detection, energy use, and response times were collected during the implementation phase of the automated monitoring system based on best practices of energy management. After implementation, improved system reliability, efficiency, and safety were compared. Qualitative feedback from maintenance staff and building users assessing the system's usability and operational impacts also supported this analysis. Third, the modernization was evaluated through a compliance review with PEC standards and energy management guidelines to determine how successfully it had improved the overall plant's safety, efficiency, and sustainability. Such an approach enabled a holistic appreciation of the quantitative and qualitative impacts of the infrastructure modernization effort.

### Research Environment

The research environment for this study was the University of Cebu - Lapu-Lapu and Mandaue Campus (UCLM), specifically focusing on the Old Building located at A. C. Cortes Avenue, Mandaue City, Cebu. A long-standing structure within the campus, this building was a high-traffic area used daily by students, faculty, and staff for academic and administrative functions. Over the years, its electrical infrastructure had aged and was beginning to show signs of deterioration that threatened both safety and efficiency. The reason that this environment was such a good one for assessing the impacts of an automated monitoring system was that it had many diverse types of use, old electrical components, and maintenance challenges, and therefore, it was a realistic place to test and validate system improvements in terms of saving on energy while increasing safety and reliability of the facility.

*Figure 3: Map of the Environment*

### Research Respondents

This study's research respondents were a heterogeneous group of persons engaged in or otherwise concerned with the electrical systems in the Old Building at the University of Cebu - Lapu-Lapu and Mandaue Campus (UCLM). They were also provided with essential inputs and data concerning the current infrastructure and the proposed automated monitoring framework.

**Maintenance Personnel:** This group consisted of technicians and engineers responsible for the upkeep and safety of electrical systems. Their experience with maintenance issues, historical data on electrical failures, and feedback on the usability of the automated monitoring system were the most valuable in assessing the system's effectiveness.

**Faculty and Staff:** Respondents were faculty members and administrative staff who used the Old Building and provided commentary concerning how the electrical system had impacted their daily operations. Their insights were explained through the user experience involved in the electrical failures and operational disruptions and the respondents' satisfaction with the environment.

**Students:** The student respondents were a representative sample of people who went to the Old Building to take classes, as well as attend meetings and other activities. To gauge how these perceptions were adjusted, various expectations of safety and reliability regarding the electrical system and the importance of improving it through an automated monitoring system were sent out for feedback.

**Safety and Compliance Officers:** Respondents included individuals responsible for ensuring that electrical work was done according to safety standards and electrical codes. Their expertise was helpful in evaluating in detail the effectiveness of the automated system in relation to safety and compliance with regulations.

### Research Instrument

The study utilized a combination of quantitative and qualitative research instruments to evaluate the effects of the automated monitoring system on UCLM's electrical infrastructure. Quantitative data regarding maintenance personnel, faculty, staff, and student perceptions of electrical system performance, efficiency, and safety was collected from structured surveys and questionnaires distributed at three points: before and after implementation. Additionally, semi-structured interviews were conducted to elicit qualitative understanding from maintenance personnel and compliance officers about challenges in maintenance, system usability, and adherence to safety standards. Furthermore, automated monitoring data logs provided precise, real-time quantitative data such as fault detection times, load distribution, voltage irregularities, and response times, which were incorporated into the research. These instruments produced a complete picture of the system's impact, using objective technical performance metrics paired with subjective human judgments to assess both efficiency, safety improvements, and reliability.

### Research Procedure

In the research, phases were meticulously organized so that all the steps involved in assessing the effectiveness of the automated monitoring system for improving the electrical infrastructure at UCLM were comprehensively evaluated. Data was rigorously collected, performance was assessed, and insights were created to guide future improvements and system refinements for each phase. The first phase, Pre-Implementation Assessment, included a detailed evaluation of the current infrastructure, with a set of baseline data collected according to existing logbook records, energy consumption reports, and incident reports. This documentation contained valuable information on how the system had performed historically, including past failures, downtime, and inefficiency in energy. Surveys were also distributed to maintenance personnel, faculty and staff, and building users to assess perceptions of the current system's safety, reliability, and energy efficiency. This served as the starting point for understanding how those who used these services viewed the current system, and from there, it formed a baseline for the upcoming phases.

After the pre-implementation assessments, the Implementation Phase integrated the automated monitoring system into UCLM's electrical infrastructure. Subsequently, the system was deployed onto the existing framework and diagnostics were performed to check that the system worked as expected. At this stage, logs of data captured in real-time were recorded to monitor system performance under automatic monitoring conditions. Among these were the occurrences of monitoring, response times, and stem alerts. The data collection supported further understanding of the system's performance under normal mode and the results of the system's efficiency in detecting and responding to defects. Feedback was also collected via follow-up surveys and stakeholder interviews (maintenance personnel, classroom faculty & staff) to learn about stakeholders' experiences and opinions regarding the system's operational capabilities, user-friendliness, and impact.

At this point, the post-implementation phase followed, which analyzed the benefits or enhancements introduced by embedding the automated monitoring system. In this phase, a final round of surveys and in-depth interviews with stakeholders were distributed, and the observed system performance changes were fed back to this group for feedback. One goal was to identify how the fault detection measures, reduction of downtime, and perhaps energy efficiency had improved, as well as what changes could have been brought in the perceived safety of the electrical system. Performance metrics were pre-implemented and post-implemented; the collected data was compared, and performance was evaluated to determine whether the integration of the monitoring system had led to measurable improvements in operational efficiency and system reliability. The analyzed key performance indicators (KPIs) included reductions in maintenance downtime, energy utilization improvements, and fault detection efficiency.

Further, the research considered Compliance and Safety Assessment to provide an overall study. In this aspect of the study, the system's alignment with safety and compliance with the Philippine Electrical Code was reviewed. It also examined how the university's automated monitoring system contributed to meeting the obligation to satisfy regulatory and safety requirements. The research evaluated the system's compliance with these standards, revealing the degree of efficiency and safety to which the modernization of the electrical infrastructure had contributed to the electrical systems of the campus.

Ultimately, a Sustainability and User Acceptance Assessment was performed to investigate the system and its user acceptance in the long run. From a technical and human-centered perspective, the effectiveness of the automated monitoring system was assessed. This phase evaluated the sustainability of the technology and the potential for scaling (or replication) across other areas of the campus based on continuous stakeholder engagement and user feedback. The users' acceptance and the propensity to adopt the new system helped to understand the possible difficulties or even challenges in offering future system implementations with maximum benefit in the long term. A user-centric approach was taken here, which made the system technically sound and useful while meeting the needs and expectations of the users.

This structured and iterative approach evaluated the automated monitoring system's impact on UCLM's electrical infrastructure. Generating this valuable data helped facilitate future improvements in technology and system management at the university's electrical systems, making them safer, more reliable, and more sustainable. To this end, the current approach guaranteed a complete inspection of the existing system and opened doors for future improvements, creating a positive outlook for the future of the system and the overall electrical infrastructure of the university.

### Data Gathering

A mixed-methods approach was applied to evaluate the effectiveness of the automated monitoring system at UCLM. Structured surveys and automated monitoring logs collected quantitative data that included metrics such as fault detection time, energy usage, and reliability indicators. The monitoring logs provided precise real-time metrics crucial to operational efficiency, and these surveys offered numerical insights into stakeholder perceptions of system performance. Parallel to this, qualitative data was derived through interviews with maintenance personnel and related compliance officers, as well as through open-ended survey responses. The qualitative component captured the users’ experiences, system usability, and perceived safety improvements to create a complete picture of the impact the automated monitoring system had on the system. The research integrated both the quantitative and qualitative data to deliver a detailed examination of the measurable and subjective improvements in the user experience.

### Treatment of Data

* **Descriptive Statistics**

A descriptive summary of observed data on respondents' characteristics used frequencies, percentages, and means. The descriptive statistic provided an overview and information about the data.

1. **Average Weighted Mean**

The weighted mean served as a tool for summarizing data where experts in electrical safety had different levels of knowledge of electrical safety among electrical engineering students. Including weights made sense as it offered a more accurate and more representative measure of central tendency.

Where:

= weighted mean

= sum of scores

= total number of respondent

* **Inferential Statistics**

These methods provided researchers the capacity to make evidence-based decisions and conclusions, estimate population parameters, and determine if observed differences or correlations were statistically significant.

1. **ANOVA (Analysis of Variance)**

Analysis of Variance (ANOVA) was used to evaluate the relative efficacy of the automated web-based real-time monitoring system utilizing key performance indicators before, after, and during implementation. ANOVA helped us determine whether the observed improvements in metrics such as fault detection times, system uptime, and energy efficiency were statistically significant. Comparing the mean values in different implementation phases allowed us to attribute the measure of impact on UCLM's electrical infrastructure to modernization and estimate the extent to which the automated system facilitated safety, efficiency, or reliability.

* **Thematic Analysis**

Thematic analysis was applied to qualitative data from interviews and open-ended survey responses with maintenance personnel, faculty, and students. It identified recurring themes and insights around user experiences, perceived system improvements, and safety enhancements related to the installation of the automated monitoring system. Patterns that emerged from the feedback analysis allowed for a deeper understanding of stakeholders' perceptions of the usability, reliability, and impact on daily operations of the system upon which these quantitative findings relied, thereby providing a holistic picture of how effective this system was.

1. **Reflective Thematic Analysis**

Reflexive Thematic Analysis was utilized to interpret qualitative data, particularly from interviews and open-ended survey responses. We were confident that by taking this approach, we identified patterns in participant feedback that brought us a little closer to understanding participant perception, experience, and challenges of the automated monitoring system. Reflexive Thematic Analysis was developed and coded through them to identify core themes that reflected respondents’ viewpoints and attitudes. A complement to that quantitative data, these insights were used to provide a detailed picture of how the system impacted and was used by those in actual contact with the system.

### Definition of Terms

**Automated Monitoring System:** A system that constantly observes and records data on an electrical system's performance in terms of fault detection, energy usage, and operational efficiency to generate real-time insights into maintenance and safety.

**Compliance:** Prescribed standards like the Philippine Electrical Code (PEC 2017) and sound energy management practices ensure electrical systems' safety and proper performance.

**Data Gathering:** Involves the systematic collection of quantitative or qualitative information from surveys, interviews, logbook reviews, and monitoring logs to evaluate the electrical system's performance and reliability.

**Electrical Infrastructure:** A network of electrical components in the Old Building at UCLM that supplies and manages electricity.

**Fault Detection:** Decide on malfunctions or irregularities in the electrical system for safety purposes to reduce downtime.

**Human-Machine Interface (HMI):** A user interface for human operator control and monitoring of an electrical infrastructure via automated monitoring systems.

**Mixed-Methods Design:** A research approach using numerical (quantitative) and descriptive (qualitative) data to analyze the automated monitoring system's impacts thoroughly.

**Operational Efficiency:** The ability of the electrical system to work efficiently with reduced use of the resources yet producing maximum energy.

**Philippine Electrical Code (PEC 2017):** The national standard of the Philippines for electrical installations, prescribing safety (and engineering) requirements and practices for safe and efficient electrical systems.

**Predictive Diagnostics:** Electrical system potential failure prediction methods can be used to predict future failed systems before they occur, improving safety and maintenance strategy planning.

**Pre-Implementation Analysis:** Before the automated monitoring system was installed, a baseline evaluation was conducted to collect data on the existing state of the electrical infrastructure, which would be used to benchmark the inspection.

**Reliability:** Electricity can be described as consistent if its system of functions has performed without failure over time.

**Safety Risks:** Potential accident-causing hazards, especially in aging infrastructure for electric systems, to damage or result in injuries that occur when operating electricity.

**Surveys:** Questionnaires are structured for respondents to answer about the electrical systems' performance, safety, and efficiency.

**System Performance Metrics:** The efficiency, reliability, and operational effectiveness of the electrical system are measured by quantitative means, such as fault detection times and energy consumption levels.

**Energy Management:** Monitoring, controlling, and optimizing the energy consumption within the electrical system to assure, decrease, and make possible the electrical system's overall efficiency, cost-effectiveness, and environmental friendliness.

**Maintenance Optimization:** Techniques for utilizing real-time monitoring data to extend the lifespan of electrical system components and reduce downtime by prioritizing preventive maintenance activities and producing a plan.

**Real-Time Monitoring:** A continuous process that does data collection and analysis of electrical system components to discover faults (or rather faults are found), improve performance, and provide safety through immediate feedback.

**Sustainability:** Combines practices and technologies that can be integrated into an electrical system to reduce environmental impact, increase energy efficiency, and facilitate long-term operational effectiveness.

**User Experience (UX):** Understanding the users' interaction with the automated monitoring system by emphasizing its ease of use, accessibility, and effectiveness in meeting users' needs.

# CHAPTER 2

# PRESENTATION, ANALYSIS, AND INTERPRETATION OF DATA

## Presentation, Analysis, and Interpretation of Data

The findings, analysis, and interpretation of the data gathered to assess whether the electrical system of the Old Building of the University of Cebu Lapu Lapu and Mandaue (UCLM) campus complied with electrical standards were presented in this chapter. The scope of this study involved performing a focused energy audit of the building's major aspects of electrical infrastructure to evaluate its current state compared to safety and performance standards.

A thorough evaluation was carried out on several critical aspects of the electrical system using the audit tool to systematically collect and analyze data. The categories included fundamental components such as lighting systems, power outlets, conductor sizes, circuit breakers, and enclosures. The assessment framework adhered to the Philippine Electrical Code requirements. All assessments utilized industry norms, energy efficiency strategies, and best practices outlined in the Energy Management Handbook (7th Edition) to guide evaluations.

An energy audit tool was employed to create the electrical infrastructural detail profile of the building. The availability of this profile made it possible to identify potential non-compliance areas, quantify energy losses, and pinpoint potential safety hazards. The process allowed for the identification of system deficiencies and actionable insights aimed at improving the system's reliability, efficiency, and overall safety.

The results from the assessment, which were the focus of this chapter, were discussed in depth. The study investigated the differences between the current system's performance and the established standards, gaps, and areas requiring intervention. It specifically examined incorrect installations, inefficient energy utilization, and outdated design components in relation to the building's operational integrity.

Furthermore, the findings were interpreted to emphasize their significance to overall system performance, safety, and sustainability. The interpretation included recommendations for corrective measures intended to address the issues identified. The proposed solutions aimed at achieving compliance with PEC standards, optimizing energy consumption, and enhancing the electrical infrastructure of the entire building.

The chapter concluded with a data-driven foundation for making informed decisions about electrical system upgrades. The study also contributed to the ongoing modernization of UCLM, starting with the audit tool used to ensure that the electrical infrastructure had met the demands of safety, reliability, and energy efficiency in accordance with the changing technological environment.

### Risk Assessment Criteria

#### Table 1: Probability of Occurrences

|  |  |  |
| --- | --- | --- |
| **QUALITATIVE DEFINITION** | **MEANING** | **RANGE** |
| Frequent | Occurs many times and will continue unless action is taken to change the events. | 5 |
| Likely | Occurs sometimes (50-99% of the time) and follows normal patterns or procedures. The event is repeatable, and issues are minimal, though process performance failures may be evident. | 4 |
| Occasional | Unlikely but possible, occurring 25-50% of the time. Events are sporadic and may be discovered during specialized reviews. There is a higher potential for latent system errors. | 3 |
| Seldom | Very unlikely (1-25% of the time) and may not have occurred yet. The likelihood of identifying issues is low during general reviews. | 2 |
| Improbable | A remote likelihood being almost inconceivable that event will occur. | 1 |

Table 1: Showed that the provided scale assessed the likelihood of an occurrence from "Frequent" to "Improbable." Each category had numerical values specified, with larger numbers indicating greater probability. An event was characterized as "Frequent" when it had taken place repeatedly and was likely to continue, while it was "Improbable" when the event was highly unlikely. The nearer the score was to 0, the lesser the likelihood that the event would be able to happen. This was handy for risk description and decision-making by providing a quantitative aspect to qualitative probability.

#### Table 2: Severity of Occurrences

|  |  |  |
| --- | --- | --- |
| **ENERGY SYSTEM CONDITION** | **MEANING** | **VALUE** |
| Catastrophic | Destruction of electrical system equipment, multiple fatalities, significant environmental impact, complete system failure, and uncontrollable public relations crises. Serious safety violations leading to death. | A |
| Critical | Significant safety reduction, serious injury or death, major equipment damage, moderate environmental impact, and non-compliance leading to system degradation. Recurrent safety issues causing severe injury. | B |
| Moderate | Minor injuries, electrical facility damage, small environmental impact, and equipment downtime up to 5 days. Possible disruption of operations and additional PR efforts required. | C |
| Minor | Minimal or no electrical equipment damage, no public relations or regulatory impact, and no environmental consequences. No operational disruption. | D |
| Negligible | No environmental, public relations, equipment, or operational impact. | E |

Table 2: The table presented summarized energy system conditions based on severity, ranging from catastrophic to negligible. Catastrophic scenarios involved loss of lives, major environmental degradation, or disruption to the entire system. Critical incidents could have resulted in serious injuries, damage to property, or major outages. Moderate incidents had moderate consequences like minor injuries, equipment damage, or service interruptions of limited duration. Minor incidents also caused insignificant impacts, while negligible incidents had no major impacts at all on the system's operation and safety. This classification was useful for risk management prioritization, resource allocation, and the creation of emergency response plans.

#### Table 3: Risk Severity

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **RISK PROBABILITY** | **Catastrophic** | **Critical** | **Moderate** | **Minor** | **Negligible** |
| **A** | **B** | **C** | **D** | **E** |
| 5 - Frequent | 5A | 5B | 5C | 5D | 5E |
| 4 - Likely | 4A | 4B | 4C | 4D | 4E |
| 3 - Occasional | 3A | 3B | 3C | 3D | 3E |
| 2 - Seldom | 2A | 2B | 2C | 2D | 2E |
| 1 - Improbable | 1A | 1B | 1C | 1D | 1E |

Table 3: In the provided table, the risk matrix combined risk probability and severity to assess the total level of risk. The horizontal axis showed severity, ranging from catastrophic (A) to negligible (E). The vertical axis exhibited the risk from frequency (5) to improbable (1). Thus, the two-letter code like 5A, 4B, or 1E corresponded to the level of intersection achieved by probability and severity levels. This code provided an easily perceivable expression of the total level of risk, where high severity and high probability implied higher risk. This matrix assisted in the prioritization of risk mitigations and efficient allocation of resources.

#### Table 4: Assessment Risk Index

|  |  |  |
| --- | --- | --- |
| **ASSESSMENT RISK INDEX** | **CRITERIA** | **VALUE** |
| 5A, 5B, 5C, 4A, 4B, 3A | Unacceptable under existing circumstances, requires immediate action | 4 |
| 5D, 5E, 4C, 3B, 3C, 2A, 2B | Manageable under risk control and mitigation | 3 |
| 4D, 4E, 3D, 2C, 1A, 1B | Acceptable under review of operation. Requires continued tracking and recorded action plans | 2 |
| 3E, 2D, 2E, 1C, 1D, 1E | Acceptable with continued data and trending for continuous improvement | 1 |

Table 4: This table explained the risks and their classifications depending on their occurrence and severity. High-risk scenarios requiring immediate action were classified as unacceptable. Manageable risks could be controlled and mitigated. Acceptable risks could be tolerated under conditions of ongoing review and action plans. Risks deemed acceptable with continued monitoring required data analysis and trend tracking for continuous improvement. This classification aided in prioritizing risk management efforts and directing resource allocation.

### Data Analysis

#### Table 5: Assessment of Old Building Ground Floor

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **ITEM NO.** | **CATEGORY** | **CONDITIONS** | **REFERENCE STANDARDS** | **COMPLIED?** | | **RISK INDEX** | | | |
| **YES** | **NO** | **PO** | **SO** | **ARI** | **VALUE** |
| 1 | Registrar | Size of Wires | PEC Article 3 | **ü** |  | 2 | E | 2E | 1 |
| Protection | PEC Article 2.40 | **ü** |  | 2 | E | 2E | 1 |
| Electrical Outlet | PEC Article 3.0.1.14-15 | **ü** |  | 2 | E | 2E | 1 |
| Lighting | PEC Article 3 |  | **ü** | 3 | D | 3D | 2 |
| 2 | Guidance | Size of Wires | PEC Article 3 | **ü** |  | 2 | E | 2E | 1 |
| Protection | PEC Article 2.40 | **ü** |  | 2 | E | 2E | 1 |
| Electrical Outlet | PEC Article 3.0.1.14-15 | **ü** |  | 2 | E | 2E | 1 |
| Lighting | PEC Article 3 |  | **ü** | 4 | C | 4C | 3 |
| 3 | EDP | Size of Wires | PEC Article 3 | **ü** |  | 2 | E | 2E | 1 |
| Protection | PEC Article 2.40 | **ü** |  | 2 | E | 2E | 1 |
| Electrical Outlet | PEC Article 3.0.1.14-15 | **ü** |  | 2 | E | 2E | 1 |
| Lighting | PEC Article 3 | **ü** |  | 2 | E | 2E | 1 |
| 4 | Accounting | Size of Wires | PEC Article 3 | **ü** |  | 2 | E | 2E | 1 |
| Protection | PEC Article 2.40 | **ü** |  | 2 | E | 2E | 1 |
| Electrical Outlet | PEC Article 3.0.1.14-15 | **ü** |  | 2 | E | 2E | 1 |
| Lighting | PEC Article 3 | **ü** |  | 2 | E | 2E | 1 |

`

Table 5: The table stated that the electrical components of the Old Building's ground floor were analyzed in a focused manner with regard to the PEC articles outlined. Items evaluated included wire sizes, protection devices, electrical outlets, and lighting fixtures, which were subject to the mentioned areas (Registrar, Guidance, EDP, and Accounting). The "COMPLIED?" column provided a negative or positive score regarding the compliance of each item with the PIC standards. A "YES" signified compliance, while a "NO" implied non-compliance. The "RISK INDEX" column scored the risk of each non-compliant component from lowest to highest.

The report identified potential areas of concern, particularly the lighting system, which was found to be non-compliant with the PEC articles related to the Registrar and Guidance Office. It was crucial to understand that such non-compliant items were not to be taken lightly; they presented serious risks of electrical hazards and should, therefore, have been given top priority for resolution.

To address those issues, a thorough inspection and assessment needed to be carried out to locate specific reasons for non-compliance. Following that, corrective actions such as replacing defective items, rewiring, or upgrading electrical works had to be undertaken without delay to secure compliance with the PEC and, thus, mitigate possible risks.

#### Table 6: Assessment of Old Building Mezzanine Floor

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **ITEM NO.** | **CATEGORY** | **CONDITIONS** | **REFERENCE STANDARDS** | **COMPLIED?** | | **RISK INDEX** | | | |
| **YES** | **NO** | **PO** | **SO** | **ARI** | **VALUE** |
| 1 | GSR 1 | Size of Wires | PEC Article 3 | **ü** |  | 2 | E | 2E | 1 |
| Protection | PEC Article 2.40 | **ü** |  | 2 | E | 2E | 1 |
| Electrical Outlet | PEC Article 3.0.1.14-15 | **ü** |  | 2 | E | 2E | 1 |
| Lighting | PEC Article 3 | **ü** |  | 2 | E | 2E | 1 |
| 2 | GSR 2 | Size of Wires | PEC Article 3 | **ü** |  | 2 | E | 2E | 1 |
| Protection | PEC Article 2.40 | **ü** |  | 2 | E | 2E | 1 |
| Electrical Outlet | PEC Article 3.0.1.14-15 | **ü** |  | 2 | E | 2E | 1 |
| Lighting | PEC Article 3 | **ü** |  | 2 | E | 2E | 1 |
| 3 | Research Hub | Size of Wires | PEC Article 3 | **ü** |  | 2 | E | 2E | 1 |
| Protection | PEC Article 2.40 | **ü** |  | 2 | E | 2E | 1 |
| Electrical Outlet | PEC Article 3.0.1.14-15 | **ü** |  | 2 | E | 2E | 1 |
| Lighting | PEC Article 3 |  | **ü** | 3 | D | 3D | 2 |
| 4 | Research & CARES Office | Size of Wires | PEC Article 3 | **ü** |  | 2 | E | 2E | 1 |
| Protection | PEC Article 2.40 | **ü** |  | 2 | E | 2E | 1 |
| Electrical Outlet | PEC Article 3.0.1.14-15 | **ü** |  | 2 | E | 2E | 1 |
| Lighting | PEC Article 3 |  | **ü** | 3 | D | 3D | 2 |
| 5 | M4 | Size of Wires | PEC Article 3 | **ü** |  | 2 | E | 2E | 1 |
| Protection | PEC Article 2.40 | **ü** |  | 2 | E | 2E | 1 |
| Electrical Outlet | PEC Article 3.0.1.14-15 | **ü** |  | 2 | E | 2E | 1 |
| Lighting | PEC Article 3 |  | **ü** | 3 | D | 3D | 2 |
| 6 | M3 | Size of Wires | PEC Article 3 | **ü** |  | 2 | E | 2E | 1 |
| Protection | PEC Article 2.40 | **ü** |  | 2 | E | 2E | 1 |
| Electrical Outlet | PEC Article 3.0.1.14-15 | **ü** |  | 2 | E | 2E | 1 |
| Lighting | PEC Article 3 | **ü** |  | 2 | E | 2E | 1 |
| 7 | M2 | Size of Wires | PEC Article 3 | **ü** |  | 2 | E | 2E | 1 |
| Protection | PEC Article 2.40 | **ü** |  | 2 | E | 2E | 1 |
| Electrical Outlet | PEC Article 3.0.1.14-15 | **ü** |  | 2 | E | 2E | 1 |
| Lighting | PEC Article 3 | **ü** |  | 2 | E | 2E | 1 |
| 8 | M1 | Size of Wires | PEC Article 3 | **ü** |  | 2 | E | 2E | 1 |
| Protection | PEC Article 2.40 | **ü** |  | 2 | E | 2E | 1 |
| Electrical Outlet | PEC Article 3.0.1.14-15 | **ü** |  | 2 | E | 2E | 1 |
| Lighting | PEC Article 3 |  | **ü** | 3 | D | 3D | 2 |
| 9 | Safety Office | Size of Wires | PEC Article 3 | **ü** |  | 2 | E | 2E | 1 |
| Protection | PEC Article 2.40 | **ü** |  | 2 | E | 2E | 1 |
| Electrical Outlet | PEC Article 3.0.1.14-15 | **ü** |  | 2 | E | 2E | 1 |
| Lighting | PEC Article 3 | **ü** |  | 2 | E | 2E | 1 |
| 10 | Cisco Lab. 2 | Size of Wires | PEC Article 3 | **ü** |  | 2 | E | 2E | 1 |
| Protection | PEC Article 2.40 | **ü** |  | 2 | E | 2E | 1 |
| Electrical Outlet | PEC Article 3.0.1.14-15 | **ü** |  | 2 | E | 2E | 1 |
| Lighting | PEC Article 3 | **ü** |  | 2 | E | 2E | 1 |
| 11 | Cisco Lab. 3 | Size of Wires | PEC Article 3 | **ü** |  | 2 | E | 2E | 1 |
| Protection | PEC Article 2.40 | **ü** |  | 2 | E | 2E | 1 |
| Electrical Outlet | PEC Article 3.0.1.14-15 | **ü** |  | 2 | E | 2E | 1 |
| Lighting | PEC Article 3 | **ü** |  | 2 | E | 2E | 1 |
| 12 | Building Maintenance | Size of Wires | PEC Article 3 | **ü** |  | 2 | E | 2E | 1 |
| Protection | PEC Article 2.40 | **ü** |  | 2 | E | 2E | 1 |
| Electrical Outlet | PEC Article 3.0.1.14-15 | **ü** |  | 2 | E | 2E | 1 |
| Lighting | PEC Article 3 |  | **ü** | 3 | D | 3D | 2 |
| 13 | Mezzanine Hallway | Size of Wires | PEC Article 3 | **ü** |  | 2 | E | 2E | 1 |
| Protection | PEC Article 2.40 | **ü** |  | 2 | E | 2E | 1 |
| Electrical Outlet | PEC Article 3.0.1.14-15 | **ü** |  | 2 | E | 2E | 1 |
| Lighting | PEC Article 3 | **ü** |  | 2 | E | 2E | 1 |

Table 6: The table evaluated the electrical components of the Mezzanine floor in UCLM Old Building against the provision of articles PEC. Major elements assessed included wire sizes, protection devices, electric outlets, and lighting systems in various areas: Research Hub, Building Maintenance, CARES office, Cisco labs, and GSR 1, GSR 2. The "COMPLIED?" column reflected if the firm followed PEC standards, indicating "YES" for compliance and "NO" for non-compliance. It provided a numerical value indicating the severity of the non-compliance, including factors like Probability of occurrence (PO), Severity of Outcome (SO), and Associated Risk Index (ARI) ranging from low risk to high risk.

Wire sizes, protection devices, and electrical outlets all met the PEC standards and scored a '1' or low risk. Nevertheless, some parts of the lighting systems in the Research Hub, Mezzanine Hallway, and some offices were non-compliant, which was rated a '3D' risk unless rectified.

#### Table 7: Assessment of Old Building 2nd Floor

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **ITEM NO.** | **CATEGORY** | **CONDITIONS** | **REFERENCE STANDARDS** | **COMPLIED?** | | **RISK INDEX** | | | |
| **YES** | **NO** | **PO** | **SO** | **ARI** | **VALUE** |
| 1 | 207 | Size of Wires | PEC Article 3 | **ü** |  | 2 | E | 2E | 1 |
| Protection | PEC Article 2.40 | **ü** |  | 2 | E | 2E | 1 |
| Electrical Outlet | PEC Article 3.0.1.14-15 | **ü** |  | 2 | E | 2E | 1 |
| Lighting | PEC Article 3 |  | **ü** | 3 | D | 3D | 2 |
| 2 | 208 | Size of Wires | PEC Article 3 | **ü** |  | 2 | E | 2E | 1 |
| Protection | PEC Article 2.40 | **ü** |  | 2 | E | 2E | 1 |
| Electrical Outlet | PEC Article 3.0.1.14-15 | **ü** |  | 2 | E | 2E | 1 |
| Lighting | PEC Article 3 |  | **ü** | 3 | D | 3D | 2 |
| 3 | Repair Room | Size of Wires | PEC Article 3 | **ü** |  | 2 | E | 2E | 1 |
| Protection | PEC Article 2.40 | **ü** |  | 2 | E | 2E | 1 |
| Electrical Outlet | PEC Article 3.0.1.14-15 | **ü** |  | 2 | E | 2E | 1 |
| Lighting | PEC Article 3 |  | **ü** | 3 | D | 3D | 2 |
| 4 | Cisco Lab. 1 | Size of Wires | PEC Article 3 | **ü** |  | 2 | E | 2E | 1 |
| Protection | PEC Article 2.40 | **ü** |  | 2 | E | 2E | 1 |
| Electrical Outlet | PEC Article 3.0.1.14-15 | **ü** |  | 2 | E | 2E | 1 |
| Lighting | PEC Article 3 | **ü** |  | 2 | E | 2E | 1 |
| 5 | 211 | Size of Wires | PEC Article 3 | **ü** |  | 2 | E | 2E | 1 |
| Protection | PEC Article 2.40 | **ü** |  | 2 | E | 2E | 1 |
| Electrical Outlet | PEC Article 3.0.1.14-15 | **ü** |  | 2 | E | 2E | 1 |
| Lighting | PEC Article 3 |  | **ü** | 3 | D | 3D | 2 |
| 6 | 212 | Size of Wires | PEC Article 3 | **ü** |  | 2 | E | 2E | 1 |
| Protection | PEC Article 2.40 | **ü** |  | 2 | E | 2E | 1 |
| Electrical Outlet | PEC Article 3.0.1.14-15 | **ü** |  | 2 | E | 2E | 1 |
| Lighting | PEC Article 3 |  | **ü** | 3 | D | 3D | 2 |
| 7 | HRD Office | Size of Wires | PEC Article 3 | **ü** |  | 2 | E | 2E | 1 |
| Protection | PEC Article 2.40 | **ü** |  | 2 | E | 2E | 1 |
| Electrical Outlet | PEC Article 3.0.1.14-15 | **ü** |  | 2 | E | 2E | 1 |
| Lighting | PEC Article 3 |  | **ü** | 3 | D | 3D | 2 |
| 8 | Female CR | Size of Wires | PEC Article 3 | **ü** |  | 2 | E | 2E | 1 |
| Protection | PEC Article 2.40 | **ü** |  | 2 | E | 2E | 1 |
| Electrical Outlet | PEC Article 3.0.1.14-15 | **ü** |  | 2 | E | 2E | 1 |
| Lighting | PEC Article 3 |  | **ü** | 3 | D | 3D | 2 |
| 9 | 2nd Floor Hallway | Size of Wires | PEC Article 3 | **ü** |  | 2 | E | 2E | 1 |
| Protection | PEC Article 2.40 | **ü** |  | 2 | E | 2E | 1 |
| Electrical Outlet | PEC Article 3.0.1.14-15 | **ü** |  | 2 | E | 2E | 1 |
| Lighting | PEC Article 3 | **ü** |  | 2 | E | 2E | 1 |

Table 7: The table considered PEC requirements and the electrical equipment on the second floor of the Old Building. It described the basics for every item, from wire sizes to protection devices, electrical outlets, and lighting systems for installation in different building places. The "COMPLIED?" column indicated whether the devices were compliant with PEC, with a value of "YES" for compliance or "NO" for non-compliance. Factors were measured concerning the Probability of Occurrence (PO), the Severity of Outcome (SO), and Associated Risk Index (ARI), respectively, with its values as levels of 'RISK INDEX' to the severity of levels of non-compliance.

This demonstrated that most parts, including wire sizes, protection devices, and electrical outlets, had a 2 "E" or PEC rating. However, the lighting systems of some areas, such as the Repair Room and Cisco Lab 1, were also not compliant but rated with a moderate risk (rating "3D").

Conducting a comprehensive inspection was vital to identify the underlying issues that led to non-compliance, which could have been due to various reasons. Implementing corrective measures such as upgrading the lighting systems, revising installation practices, and conducting regular checks helped ensure full compliance with the PEC standard and reduced potential risks.

#### Table 8: Assessment of Old Building 3rd Floor

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **ITEM NO.** | **CATEGORY** | **CONDITIONS** | **REFERENCE STANDARDS** | **COMPLIED?** | | **RISK INDEX** | | | |
| **YES** | **NO** | **PO** | **SO** | **ARI** | **VALUE** |
| 1 | 305 | Size of Wires | PEC Article 3 | **ü** |  | 2 | E | 2E | 1 |
| Protection | PEC Article 2.40 | **ü** |  | 2 | E | 2E | 1 |
| Electrical Outlet | PEC Article 3.0.1.14-15 | **ü** |  | 2 | E | 2E | 1 |
| Lighting | PEC Article 3 |  | **ü** | 3 | D | 3D | 2 |
| 2 | 306 | Size of Wires | PEC Article 3 | **ü** |  | 2 | E | 2E | 1 |
| Protection | PEC Article 2.40 | **ü** |  | 2 | E | 2E | 1 |
| Electrical Outlet | PEC Article 3.0.1.14-15 | **ü** |  | 2 | E | 2E | 1 |
| Lighting | PEC Article 3 |  | **ü** | 3 | D | 3D | 2 |
| 3 | 307 | Size of Wires | PEC Article 3 | **ü** |  | 2 | E | 2E | 1 |
| Protection | PEC Article 2.40 | **ü** |  | 2 | E | 2E | 1 |
| Electrical Outlet | PEC Article 3.0.1.14-15 | **ü** |  | 2 | E | 2E | 1 |
| Lighting | PEC Article 3 |  | **ü** | 3 | D | 3D | 2 |
| 4 | 308 | Size of Wires | PEC Article 3 | **ü** |  | 2 | E | 2E | 1 |
| Protection | PEC Article 2.40 | **ü** |  | 2 | E | 2E | 1 |
| Electrical Outlet | PEC Article 3.0.1.14-15 | **ü** |  | 2 | E | 2E | 1 |
| Lighting | PEC Article 3 |  | **ü** | 3 | D | 3D | 2 |
| 5 | 309 | Size of Wires | PEC Article 3 | **ü** |  | 2 | E | 2E | 1 |
| Protection | PEC Article 2.40 | **ü** |  | 2 | E | 2E | 1 |
| Electrical Outlet | PEC Article 3.0.1.14-15 | **ü** |  | 2 | E | 2E | 1 |
| Lighting | PEC Article 3 |  | **ü** | 3 | D | 3D | 2 |
| 6 | Cisco Lab. 4 | Size of Wires | PEC Article 3 | **ü** |  | 2 | E | 2E | 1 |
| Protection | PEC Article 2.40 | **ü** |  | 2 | E | 2E | 1 |
| Electrical Outlet | PEC Article 3.0.1.14-15 | **ü** |  | 2 | E | 2E | 1 |
| Lighting | PEC Article 3 | **ü** |  | 2 | E | 2E | 1 |
| 7 | 312 | Size of Wires | PEC Article 3 | **ü** |  | 2 | E | 2E | 1 |
| Protection | PEC Article 2.40 | **ü** |  | 2 | E | 2E | 1 |
| Electrical Outlet | PEC Article 3.0.1.14-15 | **ü** |  | 2 | E | 2E | 1 |
| Lighting | PEC Article 3 |  | **ü** | 3 | D | 3D | 2 |
| 8 | Nursing Faculty | Size of Wires | PEC Article 3 | **ü** |  | 2 | E | 2E | 1 |
| Protection | PEC Article 2.40 | **ü** |  | 2 | E | 2E | 1 |
| Electrical Outlet | PEC Article 3.0.1.14-15 | **ü** |  | 2 | E | 2E | 1 |
| Lighting | PEC Article 3 |  | **ü** | 3 | D | 3D | 2 |
| 9 | Nursing Skills Lab. 2 | Size of Wires | PEC Article 3 | **ü** |  | 2 | E | 2E | 1 |
| Protection | PEC Article 2.40 | **ü** |  | 2 | E | 2E | 1 |
| Electrical Outlet | PEC Article 3.0.1.14-15 | **ü** |  | 2 | E | 2E | 1 |
| Lighting | PEC Article 3 |  | **ü** | 3 | D | 3D | 2 |
| 10 | Nursing Skills Lab. Extension Room | Size of Wires | PEC Article 3 | **ü** |  | 2 | E | 2E | 1 |
| Protection | PEC Article 2.40 | **ü** |  | 2 | E | 2E | 1 |
| Electrical Outlet | PEC Article 3.0.1.14-15 | **ü** |  | 2 | E | 2E | 1 |
| Lighting | PEC Article 3 |  | **ü** | 3 | D | 3D | 2 |
| 11 | Female CR | Size of Wires | PEC Article 3 | **ü** |  | 2 | E | 2E | 1 |
| Protection | PEC Article 2.40 | **ü** |  | 2 | E | 2E | 1 |
| Electrical Outlet | PEC Article 3.0.1.14-15 | **ü** |  | 2 | E | 2E | 1 |
| Lighting | PEC Article 3 | **ü** |  | 2 | E | 2E | 1 |
| 12 | 3rd Floor Hallway | Size of Wires | PEC Article 3 | **ü** |  | 2 | E | 2E | 1 |
| Protection | PEC Article 2.40 | **ü** |  | 2 | E | 2E | 1 |
| Electrical Outlet | PEC Article 3.0.1.14-15 | **ü** |  | 2 | E | 2E | 1 |
| Lighting | PEC Article 3 |  | **ü** | 3 | D | 3D | 2 |

Table 8: The table evaluated the electrical components on the third floor of the Old Building against PEC standards. The sizes of wires, protection devices, electrical outlets, and lighting systems were assessed. The 'COMPLIED?' column indicated whether the components met PEC standards. The 'RISK INDEX' was a numerical measure of the severity of non-compliance. It was crucial for everyone to understand the importance of compliance, as it directly impacted the safety of everyone in the building.

Results indicated that most components' values, including the wire size, present protection devices, and electrical outlets, had a low-risk rating of 2E. For instance, lighting systems in Rooms 305, 306, 307, 308, 309, and Cisco Lab 4 all rated non-compliance with moderate risk ratings such as 3D.

A complete inspection was needed to understand precisely what caused the troubles with non-compliance. Immediate action had to be taken by upgrading lighting systems, ensuring good quality of installation, and executing regular inspections. This guaranteed that PEC standards were followed constantly, ensuring that all people who entered the building were safe and well.

#### Table 9: Assessment of Old Building 4th Floor

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **ITEM NO.** | **CATEGORY** | **CONDITIONS** | **REFERENCE STANDARDS** | **COMPLIED?** | | **RISK INDEX** | | | |
| **YES** | **NO** | **PO** | **SO** | **ARI** | **VALUE** |
| 1 | CADS Office | Size of Wires | PEC Article 3 | **ü** |  | 2 | E | 2E | 1 |
| Protection | PEC Article 2.40 | **ü** |  | 2 | E | 2E | 1 |
| Electrical Outlet | PEC Article 3.0.1.14-15 | **ü** |  | 2 | E | 2E | 1 |
| Lighting | PEC Article 3 | **ü** |  | 2 | E | 2E | 1 |
| 2 | Anatomy Lab. | Size of Wires | PEC Article 3 | **ü** |  | 2 | E | 2E | 1 |
| Protection | PEC Article 2.40 | **ü** |  | 2 | E | 2E | 1 |
| Electrical Outlet | PEC Article 3.0.1.14-15 | **ü** |  | 2 | E | 2E | 1 |
| Lighting | PEC Article 3 |  | **ü** | 3 | D | 3D | 2 |
| 3 | Amphitheater | Size of Wires | PEC Article 3 | **ü** |  | 2 | E | 2E | 1 |
| Protection | PEC Article 2.40 | **ü** |  | 2 | E | 2E | 1 |
| Electrical Outlet | PEC Article 3.0.1.14-15 | **ü** |  | 2 | E | 2E | 1 |
| Lighting | PEC Article 3 | **ü** |  | 2 | E | 2E | 1 |
| 4 | Nursing Skills Lab. 1 | Size of Wires | PEC Article 3 | **ü** |  | 2 | E | 2E | 1 |
| Protection | PEC Article 2.40 | **ü** |  | 2 | E | 2E | 1 |
| Electrical Outlet | PEC Article 3.0.1.14-15 | **ü** |  | 2 | E | 2E | 1 |
| Lighting | PEC Article 3 | **ü** |  | 2 | E | 2E | 1 |
| 5 | HRM Mini Resto | Size of Wires | PEC Article 3 | **ü** |  | 2 | E | 2E | 1 |
| Protection | PEC Article 2.40 | **ü** |  | 2 | E | 2E | 1 |
| Electrical Outlet | PEC Article 3.0.1.14-15 | **ü** |  | 2 | E | 2E | 1 |
| Lighting | PEC Article 3 |  | **ü** | 3 | D | 3D | 2 |
| 6 | Cold Kitchen | Size of Wires | PEC Article 3 | **ü** |  | 2 | E | 2E | 1 |
| Protection | PEC Article 2.40 | **ü** |  | 2 | E | 2E | 1 |
| Electrical Outlet | PEC Article 3.0.1.14-15 | **ü** |  | 2 | E | 2E | 1 |
| Lighting | PEC Article 3 |  | **ü** | 3 | D | 3D | 2 |
| 7 | Kitchen Lab. 1 | Size of Wires | PEC Article 3 | **ü** |  | 2 | E | 2E | 1 |
| Protection | PEC Article 2.40 | **ü** |  | 2 | E | 2E | 1 |
| Electrical Outlet | PEC Article 3.0.1.14-15 | **ü** |  | 2 | E | 2E | 1 |
| Lighting | PEC Article 3 |  | **ü** | 3 | D | 3D | 2 |
| 8 | OPD ER | Size of Wires | PEC Article 3 | **ü** |  | 2 | E | 2E | 1 |
| Protection | PEC Article 2.40 | **ü** |  | 2 | E | 2E | 1 |
| Electrical Outlet | PEC Article 3.0.1.14-15 | **ü** |  | 2 | E | 2E | 1 |
| Lighting | PEC Article 3 |  | **ü** | 3 | D | 3D | 2 |
| 9 | Female CR | Size of Wires | PEC Article 3 | **ü** |  | 2 | E | 2E | 1 |
| Protection | PEC Article 2.40 | **ü** |  | 2 | E | 2E | 1 |
| Electrical Outlet | PEC Article 3.0.1.14-15 | **ü** |  | 2 | E | 2E | 1 |
| Lighting | PEC Article 3 |  | **ü** | 3 | D | 3D | 2 |
| 10 | 4th Floor Hallway | Size of Wires | PEC Article 3 | **ü** |  | 2 | E | 2E | 1 |
| Protection | PEC Article 2.40 | **ü** |  | 2 | E | 2E | 1 |
| Electrical Outlet | PEC Article 3.0.1.14-15 | **ü** |  | 2 | E | 2E | 1 |
| Lighting | PEC Article 3 |  | **ü** | 3 | D | 3D | 2 |

Table 9: The table evaluated the fourth floor of the Old Building on electrical systems for PEC conformity. Wire sizes, protection devices, electrical outlets, and lighting were assessed. The second column indicated whether each element satisfied the required standards either with "YES" (compliant) or with "NO" (non-compliant). The "RISK INDEX" indicated the impact of non-compliance, accounting for Probability of Occurrence (PO), Severity of Outcome (SO), and Associated Risk Index (ARI). Most results followed PEC standards for parts, including wire sizes, protection devices, and electrical outlets, having low-risk (2E) results. To prevent shortcomings, corrective measures such as improving the lighting systems, increasing the level of installations, and adopting regular inspection schedules were maintained for a complete pact and minimized risks: electrical outlets and lighting systems.

The results primarily complied with PEC standards for various parts, such as wire sizes, protection devices, and electrical outlets, showing low-risk ratings, such as 2E. However, lighting systems in different areas, like the HRM Mini Resto, Cold Kitchen, Kitchen Lab. 1, OPD ER, Female CR, and Anatomy Lab, did not comply with a moderate risk rating ("3D").

A proper inspection should have been conducted on them to diagnose the causes of non-compliance. Corrective actions like improving the lighting systems, enhancing the quality of installations, and offering regular inspection schedules ought to have been taken to ensure full compliance and minimize risk.

#### Table 10: Assessment of Old Building 5th Floor

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **ITEM NO.** | **CATEGORY** | **CONDITIONS** | **REFERENCE STANDARDS** | **COMPLIED?** | | **RISK INDEX** | | | |
| **YES** | **NO** | **PO** | **SO** | **ARI** | **VALUE** |
| 1 | Old Engineering Faculty Room | Size of Wires | PEC Article 3 | **ü** |  | 2 | E | 2E | 1 |
| Protection | PEC Article 2.40 |  | **ü** | 4 | B | 4B | 4 |
| Electrical Outlet | PEC Article 3.0.1.14-15 | **ü** |  | 2 | E | 2E | 1 |
| Lighting | PEC Article 3 |  | **ü** | 3 | D | 3D | 2 |
| 2 | 507 Physics Lab. | Size of Wires | PEC Article 3 | **ü** |  | 2 | E | 2E | 1 |
| Protection | PEC Article 2.40 |  | **ü** | 4 | B | 4B | 4 |
| Electrical Outlet | PEC Article 3.0.1.14-15 | **ü** |  | 2 | E | 2E | 1 |
| Lighting | PEC Article 3 | **ü** |  | 2 | E | 2E | 1 |
| 3 | 507 Physics Stockroom | Size of Wires | PEC Article 3 | **ü** |  | 2 | E | 2E | 1 |
| Protection | PEC Article 2.40 |  | **ü** | 4 | B | 4B | 4 |
| Electrical Outlet | PEC Article 3.0.1.14-15 | **ü** |  | 2 | E | 2E | 1 |
| Lighting | PEC Article 3 |  | **ü** | 3 | D | 3D | 2 |
| 4 | 509 Chemistry Lab. | Size of Wires | PEC Article 3 | **ü** |  | 2 | E | 2E | 1 |
| Protection | PEC Article 2.40 | **ü** |  | 2 | E | 2E | 1 |
| Electrical Outlet | PEC Article 3.0.1.14-15 | **ü** |  | 2 | E | 2E | 1 |
| Lighting | PEC Article 3 |  | **ü** | 3 | D | 3D | 2 |
| 5 | 509 Stockroom | Size of Wires | PEC Article 3 | **ü** |  | 2 | E | 2E | 1 |
| Protection | PEC Article 2.40 | **ü** |  | 2 | E | 2E | 1 |
| Electrical Outlet | PEC Article 3.0.1.14-15 | **ü** |  | 2 | E | 2E | 1 |
| Lighting | PEC Article 3 | **ü** |  | 2 | E | 2E | 1 |
| 6 | 511 Chemistry Lab. | Size of Wires | PEC Article 3 | **ü** |  | 2 | E | 2E | 1 |
| Protection | PEC Article 2.40 |  | **ü** | 4 | B | 4B | 4 |
| Electrical Outlet | PEC Article 3.0.1.14-15 | **ü** |  | 2 | E | 2E | 1 |
| Lighting | PEC Article 3 |  | **ü** | 3 | D | 3D | 2 |
| 7 | Storage Room | Size of Wires | PEC Article 3 | **ü** |  | 2 | E | 2E | 1 |
| Protection | PEC Article 2.40 | **ü** |  | 2 | E | 2E | 1 |
| Electrical Outlet | PEC Article 3.0.1.14-15 | **ü** |  | 2 | E | 2E | 1 |
| Lighting | PEC Article 3 | **ü** |  | 2 | E | 2E | 1 |
| 8 | Old EE Lab. | Size of Wires | PEC Article 3 | **ü** |  | 2 | E | 2E | 1 |
| Protection | PEC Article 2.40 | **ü** |  | 2 | E | 2E | 1 |
| Electrical Outlet | PEC Article 3.0.1.14-15 | **ü** |  | 2 | E | 2E | 1 |
| Lighting | PEC Article 3 | **ü** |  | 2 | E | 2E | 1 |
| 9 | Old Toolroom | Size of Wires | PEC Article 3 | **ü** |  | 2 | E | 2E | 1 |
| Protection | PEC Article 2.40 | **ü** |  | 2 | E | 2E | 1 |
| Electrical Outlet | PEC Article 3.0.1.14-15 | **ü** |  | 2 | E | 2E | 1 |
| Lighting | PEC Article 3 | **ü** |  | 2 | E | 2E | 1 |
| 10 | Old ECE Lab. | Size of Wires | PEC Article 3 | **ü** |  | 2 | E | 2E | 1 |
| Protection | PEC Article 2.40 | **ü** |  | 2 | E | 2E | 1 |
| Electrical Outlet | PEC Article 3.0.1.14-15 | **ü** |  | 2 | E | 2E | 1 |
| Lighting | PEC Article 3 | **ü** |  | 2 | E | 2E | 1 |
| 11 | Old COE Lab. | Size of Wires | PEC Article 3 | **ü** |  | 2 | E | 2E | 1 |
| Protection | PEC Article 2.40 | **ü** |  | 2 | E | 2E | 1 |
| Electrical Outlet | PEC Article 3.0.1.14-15 | **ü** |  | 2 | E | 2E | 1 |
| Lighting | PEC Article 3 | **ü** |  | 2 | E | 2E | 1 |
| 12 | Biology Lab. | Size of Wires | PEC Article 3 | **ü** |  | 2 | E | 2E | 1 |
| Protection | PEC Article 2.40 | **ü** |  | 2 | E | 2E | 1 |
| Electrical Outlet | PEC Article 3.0.1.14-15 | **ü** |  | 2 | E | 2E | 1 |
| Lighting | PEC Article 3 |  | **ü** | 3 | D | 3D | 2 |
| 13 | Female CR | Size of Wires | PEC Article 3 | **ü** |  | 2 | E | 2E | 1 |
| Protection | PEC Article 2.40 | **ü** |  | 2 | E | 2E | 1 |
| Electrical Outlet | PEC Article 3.0.1.14-15 | **ü** |  | 2 | E | 2E | 1 |
| Lighting | PEC Article 3 | **ü** |  | 2 | E | 2E | 1 |
| 14 | 5th Floor Hallway | Size of Wires | PEC Article 3 | **ü** |  | 2 | E | 2E | 1 |
| Protection | PEC Article 2.40 | **ü** |  | 2 | E | 2E | 1 |
| Electrical Outlet | PEC Article 3.0.1.14-15 | **ü** |  | 2 | E | 2E | 1 |
| Lighting | PEC Article 3 | **ü** |  | 2 | E | 2E | 1 |

Table 10: The table assessed the electrical equipment on the 5th floor of the Old Building against the standards set by PEC. These included checking the wire sizes, protection devices, electrical outlets, and lighting systems. The "COMPLIED?" column reflected whether each of these met the set standards, whereby "YES" indicated compliance and "NO" indicated non-compliance. The "RISK INDEX," on the other hand, measured how alarming the non-compliance was in terms of Probability of Occurrence (PO), Severity of Outcome (SO), and Associated Risk Index (ARI), and had low to high scoring.

This report emphasized that most components, including wire sizes, protection devices, and electrical outlets, complied with PEC standards and were therefore assessed as low risk (2E). However, lighting systems in certain areas, such as the Old Engineering Faculty Room and 507 Physics Lab, did not meet PEC standards, resulting in a mid-level risk rating ("3D"). As mentioned earlier, protective devices in the room also did not meet the PEC requirements; as such, these rooms were prone to electrical-related accidents (with a probability of 50-99% occurrence). This was why the Old Engineering Faculty Room, 507 Physics Lab, 507 Physics Stockroom, and 511 Chemistry Lab. were assessed with high risk (4B).

Inspecting the building thoroughly to establish the underlying causes of non-conformity and thus undertake corrective actions regarding lighting systems was recommended. Upgrading the lighting systems and improving installation practices were necessary to ensure full PEC compliance and significantly reduce associated risks.

#### Table 11: Standard Compliance per Floor for Size of Wires

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **FLOOR** | **CATEGORY** | | **PERCENTAGE** | |
| **COMPLIED** | **NON-COMPLIANT** | **COMPLIED** | **NON-COMPLIANT** |
| Ground Floor | 4 | 0 | 100.00% | 0.00% |
| Mezzanine Floor | 13 | 0 | 100.00% | 0.00% |
| Second Floor | 9 | 0 | 100.00% | 0.00% |
| Third Floor | 12 | 0 | 100.00% | 0.00% |
| Fourth Floor | 10 | 0 | 100.00% | 0.00% |
| Fifth Floor | 14 | 0 | 100.00% | 0.00% |
| **TOTAL** | **62** | **0** | **100.00%** | **0.00%** |

Table 11: The table presented the compliance status of wire sizes across the various floors of the Old Building based on PEC standards. The evaluation included the ground floor, mezzanine floor, and floors two through five. Each floor's compliance was categorized as either "COMPLIED" or "NON-COMPLIANT." The percentages for each category were calculated to reflect the proportion of compliant installations. The findings indicated that all floors achieved 100% compliance, with no cases of non-compliance recorded. A total of 62 wire-size assessments across the building were found to meet PEC standards.

#### Table 12: Standard Compliance per Floor for Protection

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **FLOOR NO.** | **CATEGORY** | | **PERCENTAGE** | |
| **COMPLIED** | **NON-COMPLIANT** | **COMPLIED** | **NON-COMPLIANT** |
| Ground Floor | 4 | 0 | 100.00% | 0.00% |
| Mezzanine Floor | 13 | 0 | 100.00% | 0.00% |
| Second Floor | 9 | 0 | 100.00% | 0.00% |
| Third Floor | 12 | 0 | 100.00% | 0.00% |
| Fourth Floor | 10 | 0 | 100.00% | 0.00% |
| Fifth Floor | 10 | 4 | 71.43% | 28.57% |
| **TOTAL** | **58** | **4** | **95.24%** | **4.76%** |

Table 12: The table evaluated the compliance of protection devices across the Old Building's floors by PEC standards. Floors from the Ground Floor to the Fourth Floor achieved a perfect compliance rate of 100%, indicating that all assessed protection devices met the required standards. However, the Fifth Floor exhibited a compliance rate of 71.43%, with 28.57% of the devices found non-compliant. Across the building, the compliance rate stood at 95.24%, demonstrating overall solid adherence but highlighting areas for improvement on the Fifth Floor. A thorough inspection was recommended for the non-compliant devices on the Fifth Floor to address these issues. This involved replacing or upgrading outdated and faulty equipment to meet PEC standards, ensuring the building maintained safety and operational reliability across all floors.

#### Table 13: Standard Compliance per Floor for Electrical Outlets

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **FLOOR NO.** | **CATEGORY** | | **PERCENTAGE** | |
| **COMPLIED** | **NON-COMPLIANT** | **COMPLIED** | **NON-COMPLIANT** |
| Ground Floor | 4 | 0 | 100.00% | 0.00% |
| Mezzanine Floor | 13 | 0 | 100.00% | 0.00% |
| Second Floor | 9 | 0 | 100.00% | 0.00% |
| Third Floor | 12 | 0 | 100.00% | 0.00% |
| Fourth Floor | 10 | 0 | 100.00% | 0.00% |
| Fifth Floor | 14 | 0 | 100.00% | 0.00% |
| **TOTAL** | **62** | **0** | **100.00%** | **0.00%** |

Table 13: This table reviewed the compliance of electrical outlets across all floors of the Old Building with PEC standards. The analysis categorized compliance on each floor as either "COMPLIED" or "NON-COMPLIANT," with percentages calculated for both categories. The results indicated a 100% compliance rate for electrical outlets on all floors, including the Ground Floor, Mezzanine Floor, and floors two through five. No instances of non-compliance were observed in the evaluation. This finding underscored strong adherence to PEC standards for electrical outlets throughout the building. Regular inspections and maintenance should have continued to sustain this level of compliance and ensure ongoing safety and reliability.

#### Table 14: Standard Compliance per Floor for Lighting

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **FLOOR NO.** | **CATEGORY** | | **PERCENTAGE** | |
| **COMPLIED** | **NON-COMPLIANT** | **COMPLIED** | **NON-COMPLIANT** |
| Ground Floor | 1 | 3 | 25.00% | 75.00% |
| Mezzanine Floor | 8 | 5 | 61.53% | 38.47% |
| Second Floor | 2 | 7 | 22.22% | 77.78% |
| Third Floor | 2 | 10 | 16.66% | 83.34% |
| Fourth Floor | 3 | 7 | 30.00% | 70.00% |
| Fifth Floor | 9 | 5 | 64.29% | 35.71% |
| **TOTAL** | **25** | **37** | **36.62%** | **63.38%** |

Table 14: This table evaluated the compliance of lighting systems on each floor of the Old Building with PEC standards. It categorized each floor's lighting systems as "COMPLIED" or "NON-COMPLIANT," with percentages for both. The findings revealed significant variation in compliance across the floors. The Ground Floor had a compliance rate of 25%, with most of the lighting systems failing to meet the standards (75% non-compliant). The Mezzanine Floor and Fifth Floor showed better compliance rates at 61.53% and 64.29%, respectively, but still had notable areas with non-compliant lighting systems. Floors like the Second and Third Floors had a much lower compliance rate, with the Third Floor showing the lowest at 16.66% compliant and 83.34% non-compliant. This indicated that while some areas of the building met PEC standards for lighting, many places, particularly on the higher floors, needed to work on compliance. The lighting systems in these areas required urgent attention to meet the safety standards. Detailed inspections should have been carried out to address the non-compliance and to pinpoint the exact causes. Corrective actions involved upgrading the lighting systems, improving installation practices, and conducting regular checks to ensure full compliance with PEC standards, ultimately enhancing safety across the building.

#### Table 15: Probability of Occurrences per Floor for Size of Wires

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **FLOOR** | **VALUES** | | | | | **PERCENTAGE** | | | | |
| **5** | **4** | **3** | **2** | **1** | **5** | **4** | **3** | **2** | **1** |
| Ground Floor | 0 | 0 | 0 | 4 | 0 | 0.00% | 0.00% | 0.00% | 100.00% | 0.00% |
| Mezzanine Floor | 0 | 0 | 0 | 13 | 0 | 0.00% | 0.00% | 0.00% | 100.00% | 0.00% |
| Second Floor | 0 | 0 | 0 | 9 | 0 | 0.00% | 0.00% | 0.00% | 100.00% | 0.00% |
| Third Floor | 0 | 0 | 0 | 12 | 0 | 0.00% | 0.00% | 0.00% | 100.00% | 0.00% |
| Fourth Floor | 0 | 0 | 0 | 10 | 0 | 0.00% | 0.00% | 0.00% | 100.00% | 0.00% |
| Fifth Floor | 0 | 0 | 0 | 14 | 0 | 0.00% | 0.00% | 0.00% | 100.00% | 0.00% |
| **TOTAL** | **0** | **0** | **0** | **62** | **0** | **0.00%** | **0.00%** | **0.00%** | **100.00%** | **0.00%** |

Table 15: The table evaluated the probability of occurrences of non-compliance with wire sizes across various floors of the Old Building. Each floor's compliance was rated with values from 5 (most frequent) to 1 (least likely). The results showed that all floors from the Ground Floor to the Fifth Floor achieved 100% compliance in wire sizes, with no non-compliance found in the evaluations. This reflected consistent adherence to PEC standards for wire sizes across the building. Since there were no issues with wire sizing, no corrective actions were necessary. Regular checks should have continued to ensure ongoing adherence to PEC standards.

#### Table 16: Probability of Occurrences per Floor for Protection

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **FLOOR** | **VALUES** | | | | | **PERCENTAGE** | | | | |
| **5** | **4** | **3** | **2** | **1** | **5** | **4** | **3** | **2** | **1** |
| Ground Floor | 0 | 0 | 0 | 4 | 0 | 0.00% | 0.00% | 0.00% | 100.00% | 0.00% |
| Mezzanine Floor | 0 | 0 | 0 | 13 | 0 | 0.00% | 0.00% | 0.00% | 100.00% | 0.00% |
| Second Floor | 0 | 0 | 0 | 9 | 0 | 0.00% | 0.00% | 0.00% | 100.00% | 0.00% |
| Third Floor | 0 | 0 | 0 | 12 | 0 | 0.00% | 0.00% | 0.00% | 100.00% | 0.00% |
| Fourth Floor | 0 | 0 | 0 | 10 | 0 | 0.00% | 0.00% | 0.00% | 100.00% | 0.00% |
| Fifth Floor | 0 | 4 | 0 | 10 | 0 | 0.00% | 28.57% | 0.00% | 71.43% | 0.00% |
| **TOTAL** | **0** | **4** | **0** | **58** | **0** | **0.00%** | **4.76%** | **0.00%** | **95.24%** | **0.00%** |

Table 16: This table analyzed the probability of non-compliance for protection devices across the various floors of the Old Building. The "PROBABILITY" values ranged from 5 (most frequent) to 1 (least frequent), while the results also included percentages for each rating. The findings indicated that most floors (Ground Floor, Mezzanine Floor, Second Floor, Third Floor, and Fourth Floor) showed no non-compliance with protection devices and received total compliance ratings, with 100% compliant installations across these floors. However, the Fifth Floor exhibited non-compliance in 28.57% of the assessments, with these non-compliant areas rated with a moderate occurrence probability of "4" (28.57%). Overall, the total building compliance rate stood at 95.24%, with only 4.76% of assessments showing non-compliance, predominantly concentrated on the Fifth Floor. To address these issues, it was recommended that a detailed inspection of the protection devices on the Fifth Floor be conducted. Corrective actions, such as upgrading or replacing outdated protection devices and improving installation quality, had to be implemented to ensure full compliance and reduce risks.

#### Table 17: Probability of Occurrences per Floor for Electrical Outlets

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **FLOOR** | **VALUES** | | | | | **PERCENTAGE** | | | | |
| **5** | **4** | **3** | **2** | **1** | **5** | **4** | **3** | **2** | **1** |
| Ground Floor | 0 | 0 | 0 | 4 | 0 | 0.00% | 0.00% | 0.00% | 100.00% | 0.00% |
| Mezzanine Floor | 0 | 0 | 0 | 13 | 0 | 0.00% | 0.00% | 0.00% | 100.00% | 0.00% |
| Second Floor | 0 | 0 | 0 | 9 | 0 | 0.00% | 0.00% | 0.00% | 100.00% | 0.00% |
| Third Floor | 0 | 0 | 0 | 12 | 0 | 0.00% | 0.00% | 0.00% | 100.00% | 0.00% |
| Fourth Floor | 0 | 0 | 0 | 10 | 0 | 0.00% | 0.00% | 0.00% | 100.00% | 0.00% |
| Fifth Floor | 0 | 0 | 0 | 14 | 0 | 0.00% | 0.00% | 0.00% | 100.00% | 0.00% |
| **TOTAL** | **0** | **0** | **0** | **62** | **0** | **0.00%** | **0.00%** | **0.00%** | **100.00%** | **0.00%** |

Table 17: The probability of non-compliance for electrical outlets on all the floors of the Old Building was evaluated by this table. Assessed floors were the Ground Floor, Mezzanine Floor, Second Floor, Third Floor, Fourth Floor, and Fifth Floor. According to the results, all floors achieved 100% compliance regarding electrical outlets, indicating no issues. This resulted in a 100% compliance rate for the entire building for electrical outlets, and everything worked 100% according to the proper PEC standards for all the outlets. However, corrective actions did not need to be taken, but regular inspections should have been conducted to maintain this high level of compliance and ongoing safety and operational efficiency.

#### Table 18: Probability of Occurrences per Floor for Lighting

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **FLOOR** | **VALUES** | | | | | **PERCENTAGE** | | | | |
| **5** | **4** | **3** | **2** | **1** | **5** | **4** | **3** | **2** | **1** |
| Ground Floor | 0 | 1 | 2 | 1 | 0 | 0.00% | 25.00% | 50.00% | 25.00% | 0.00% |
| Mezzanine Floor | 0 | 0 | 5 | 8 | 0 | 0.00% | 0.00% | 38.46% | 61.54% | 0.00% |
| Second Floor | 0 | 0 | 7 | 2 | 0 | 0.00% | 0.00% | 77.77% | 22.23% | 0.00% |
| Third Floor | 0 | 0 | 10 | 2 | 0 | 0.00% | 0.00% | 83.33% | 16.67% | 0.00% |
| Fourth Floor | 0 | 0 | 7 | 3 | 0 | 0.00% | 0.00% | 70.00% | 30.00% | 0.00% |
| Fifth Floor | 0 | 0 | 5 | 9 | 0 | 0.00% | 0.00% | 35.71% | 64.29% | 0.00% |
| **TOTAL** | **0** | **1** | **36** | **62** | **0** | **0.00%** | **4.17%** | **59.21%** | **36.62%** | **0.00%** |

Table 18: This table provided a scale of 1–5 for potential non-compliance by lighting systems in the Old Building across various floors. Compliance on the Ground Floor was mixed, with 50% rated at a probable chance of 3 and 25% at a low probability chance of 2. Of the 61.54% of lighting systems on the Mezzanine Floor that were rated, 61.54% had been classified as low risk (2), while 38.46% were rated as moderate risk (3). Similar trends were observed on the Second and Third floors, with a more significant percentage of lighting systems rated as moderate risk (3), indicating possible problems with 64.29% of lighted fixtures rated as mild (3) risk lighting systems and 35.71% rated as low (2) risk lighting systems. Overall, the results suggested that lighting systems on all floors posed moderate to low risks of non-compliance. However, moderate-risk areas needed to be tackled. Thus, regular inspections, upgrading of lighting systems to the standard, and improving installation standards had to be taken to reach full compliance and decrease risks.

#### Table 19: Risk Severity per Floor for Size of Wires

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **FLOOR** | **VALUES** | | | | | **PERCENTAGE** | | | | |
| **5** | **4** | **3** | **2** | **1** | **5** | **4** | **3** | **2** | **1** |
| Ground Floor | 0 | 0 | 0 | 4 | 0 | 0.00% | 0.00% | 0.00% | 100.00% | 0.00% |
| Mezzanine Floor | 0 | 0 | 0 | 13 | 0 | 0.00% | 0.00% | 0.00% | 100.00% | 0.00% |
| Second Floor | 0 | 0 | 0 | 9 | 0 | 0.00% | 0.00% | 0.00% | 100.00% | 0.00% |
| Third Floor | 0 | 0 | 0 | 12 | 0 | 0.00% | 0.00% | 0.00% | 100.00% | 0.00% |
| Fourth Floor | 0 | 0 | 0 | 10 | 0 | 0.00% | 0.00% | 0.00% | 100.00% | 0.00% |
| Fifth Floor | 0 | 0 | 0 | 14 | 0 | 0.00% | 0.00% | 0.00% | 100.00% | 0.00% |
| **TOTAL** | **0** | **0** | **0** | **62** | **0** | **0.00%** | **0.00%** | **0.00%** | **100.00%** | **0.00%** |

Table 19: This table presented the risk severity of the size of the wires based on the different floors of the Old Building, which depicted the prevalence of non-compliance. Again, the severity levels were rated from 5 as the highest to 1 as the least. The Ground Floor, Mezzanine Floor, Second Floor, Third Floor, Fourth Floor, and Fifth Floor all achieved 100% compliance for the size of wires, with no perceived high-risk non-compliance. All floors had no non-compliance on the assessment for wire sizes, which meant that the respective installations fully complied and carried no risk.

#### Table 20: Risk Severity per Floor for Protection

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **FLOOR** | **VALUES** | | | | | **PERCENTAGE** | | | | |
| **5** | **4** | **3** | **2** | **1** | **5** | **4** | **3** | **2** | **1** |
| Ground Floor | 0 | 0 | 0 | 4 | 0 | 0.00% | 0.00% | 0.00% | 100.00% | 0.00% |
| Mezzanine Floor | 0 | 0 | 0 | 13 | 0 | 0.00% | 0.00% | 0.00% | 100.00% | 0.00% |
| Second Floor | 0 | 0 | 0 | 9 | 0 | 0.00% | 0.00% | 0.00% | 100.00% | 0.00% |
| Third Floor | 0 | 0 | 0 | 12 | 0 | 0.00% | 0.00% | 0.00% | 100.00% | 0.00% |
| Fourth Floor | 0 | 0 | 0 | 10 | 0 | 0.00% | 0.00% | 0.00% | 100.00% | 0.00% |
| Fifth Floor | 0 | 4 | 0 | 10 | 0 | 0.00% | 28.57% | 0.00% | 71.43% | 0.00% |
| **TOTAL** | **0** | **4** | **0** | **58** | **0** | **0.00%** | **4.76%** | **0.00%** | **95.24%** | **0.00%** |

Table 20: This table assessed the risk severity of protection devices installed on different floors of the Old Building. The severity scale was from 1 to 5, from least severe to most severe. The Ground Floor, Mezzanine, Second, Third, and Fourth Floors were 100% compliant regarding the protection devices that should not have been found. However, on the Fifth Floor, non-compliance was indicated as 28.57% rated at a higher severity of 4, while 71.43% were rated at a severity of 3 to indicate moderate risk. Thus, the building's compliance rate stood at 95.24%, showing good adherence to the PEC standards on most floors except for the Fifth Floor, which required corrective action. The issues concerning protection devices were the major concern for this floor, which could have resulted in potential risks requiring further investigation and corrections.

#### Table 21: Risk Severity per Floor for Electrical Outlets

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **FLOOR** | **VALUES** | | | | | **PERCENTAGE** | | | | |
| **5** | **4** | **3** | **2** | **1** | **5** | **4** | **3** | **2** | **1** |
| Ground Floor | 0 | 0 | 0 | 4 | 0 | 0.00% | 0.00% | 0.00% | 100.00% | 0.00% |
| Mezzanine Floor | 0 | 0 | 0 | 13 | 0 | 0.00% | 0.00% | 0.00% | 100.00% | 0.00% |
| Second Floor | 0 | 0 | 0 | 9 | 0 | 0.00% | 0.00% | 0.00% | 100.00% | 0.00% |
| Third Floor | 0 | 0 | 0 | 12 | 0 | 0.00% | 0.00% | 0.00% | 100.00% | 0.00% |
| Fourth Floor | 0 | 0 | 0 | 10 | 0 | 0.00% | 0.00% | 0.00% | 100.00% | 0.00% |
| Fifth Floor | 0 | 0 | 0 | 14 | 0 | 0.00% | 0.00% | 0.00% | 100.00% | 0.00% |
| **TOTAL** | **0** | **0** | **0** | **62** | **0** | **0.00%** | **0.00%** | **0.00%** | **100.00%** | **0.00%** |

Table 21: This table provided the risk severity for electric outlets in an Old Building based on each floor. It fell under the category of the Level of Risk, ranging from 1 to 5 for the Probability of Occurrence, Severity of Outcome, and Associated Risk Index. The floors considered were the Ground Floor, Mezzanine Floor, Second Floor, Third Floor, Fourth Floor, and Fifth Floor.

The results showed that all the floors had electrical outlet standards fully covered, meaning 100% compliance overall. This category had no instances of noncompliance; therefore, the outlets complied with PEC standards without risk association. There was no significant risk, as all electrical outlets complied with the specifications and requirements.

All the outlets fully achieved compliance, so no rectification activities were required. Routine checks were also maintained to ensure sustained adherence to PEC standards and electrical system safety.

#### Table 22: Risk Severity per Floor for Lighting

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **FLOOR** | **VALUES** | | | | | **PERCENTAGE** | | | | |
| **5** | **4** | **3** | **2** | **1** | **5** | **4** | **3** | **2** | **1** |
| Ground Floor | 0 | 1 | 2 | 1 | 0 | 0.00% | 25.00% | 50.00% | 25.00% | 0.00% |
| Mezzanine Floor | 0 | 0 | 5 | 8 | 0 | 0.00% | 0.00% | 38.46% | 61.54% | 0.00% |
| Second Floor | 0 | 0 | 7 | 2 | 0 | 0.00% | 0.00% | 77.77% | 22.23% | 0.00% |
| Third Floor | 0 | 0 | 10 | 2 | 0 | 0.00% | 0.00% | 83.33% | 16.67% | 0.00% |
| Fourth Floor | 0 | 0 | 7 | 3 | 0 | 0.00% | 0.00% | 70.00% | 30.00% | 0.00% |
| Fifth Floor | 0 | 0 | 5 | 9 | 0 | 0.00% | 0.00% | 35.71% | 64.29% | 0.00% |
| **TOTAL** | **0** | **1** | **36** | **62** | **0** | **0.00%** | **4.17%** | **59.21%** | **36.62%** | **0.00%** |

Table 22: This table evaluated lighting systems within the Old Building's floors with varied risk levels - on a scale from least severe to most severe, which spanned 1-5. The Ground Floor exhibited moderate risk in 50% of the lighting systems, while 25% were at low risk. The Mezzanine Floor had 61.54% of lighting systems that fell into the moderate risk category. The second and third floors held more risks, with 83.33% of lighting systems on the third floor being at moderate risk.

The Fifth Floor also had many instances of non-compliance, rating up to 64.29% at moderate risk. Generally, most areas held moderate risk; a detailed inspection was desired. Upgrades and periodic inspections were highly recommended to reduce risks.

#### Table 23: Assessment Risk Index per Floor for Size of Wires

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **FLOOR** | **VALUES** | | | | **PERCENTAGE** | | | |
| **4** | **3** | **2** | **1** | **4** | **3** | **2** | **1** |
| Ground Floor | 0 | 0 | 0 | 4 | 0.00% | 0.00% | 0.00% | 100.00% |
| Mezzanine Floor | 0 | 0 | 0 | 13 | 0.00% | 0.00% | 0.00% | 100.00% |
| Second Floor | 0 | 0 | 0 | 9 | 0.00% | 0.00% | 0.00% | 100.00% |
| Third Floor | 0 | 0 | 0 | 12 | 0.00% | 0.00% | 0.00% | 100.00% |
| Fourth Floor | 0 | 0 | 0 | 10 | 0.00% | 0.00% | 0.00% | 100.00% |
| Fifth Floor | 0 | 0 | 0 | 14 | 0.00% | 0.00% | 0.00% | 100.00% |
| **TOTAL** | **0** | **0** | **0** | **62** | **0.00%** | **0.00%** | **0.00%** | **100.00%** |

Table 23: This table assessed the risk index for wire sizes across various floors in the Old Building. The risk index was measured based on the Probability of Occurrence (PO), Severity of Outcome (SO), and Associated Risk Index (ARI). All floors, including the Ground Floor, Mezzanine Floor, Second Floor, Third Floor, Fourth Floor, and Fifth Floor, achieved 100% compliance for wire sizes, with no instances of non-compliance found in the evaluation. This resulted in a 0% non-compliant rate for wire sizing across all floors, reflecting full adherence to PEC standards.

Given that all assessments for wire sizes complied with the required standards, no corrective actions were needed. Ongoing inspections and maintenance should have continued to ensure sustained compliance with PEC standards to maintain electrical safety throughout the building.

#### Table 24: Assessment Risk Index per Floor for Protection

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **FLOOR** | **VALUES** | | | | **PERCENTAGE** | | | |
| **4** | **3** | **2** | **1** | **4** | **3** | **2** | **1** |
| Ground Floor | 0 | 0 | 0 | 4 | 0.00% | 0.00% | 0.00% | 100.00% |
| Mezzanine Floor | 0 | 0 | 0 | 13 | 0.00% | 0.00% | 0.00% | 100.00% |
| Second Floor | 0 | 0 | 0 | 9 | 0.00% | 0.00% | 0.00% | 100.00% |
| Third Floor | 0 | 0 | 0 | 12 | 0.00% | 0.00% | 0.00% | 100.00% |
| Fourth Floor | 0 | 0 | 0 | 10 | 0.00% | 0.00% | 0.00% | 100.00% |
| Fifth Floor | 4 | 0 | 0 | 10 | 28.57% | 0.00% | 0.00% | 71.43% |
| **TOTAL** | **0** | **0** | **0** | **62** | **4.76%** | **0.00%** | **0.00%** | **95.24%** |

Table 24: This table assessed the risk index for protection devices installed across different floors of the Old Building. Each floor was ranked according to compliance, and the "RISK INDEX" was computed accordingly, measuring from low to high based on the probability of occurrence, severity of outcome, and associated risk index.

There was 100% compliance for protection devices on the Ground Floor, Mezzanine Floor, Second Floor, Third Floor, and Fourth Floor. Non-compliance on the Fifth Floor was shown as 28.57%, reflecting a moderate risk level ("4"), and 71.43% compliance, thus showing significant problems on this floor only.

The overall compliance rate for the building was 95.24%. It was recommended that the building should have corrective action on the Fifth Floor. Frequent inspections and necessary upgrades of the protection devices on the Fifth Floor should have received utmost priority for full compliance with PEC standards and reduction of hazards.

#### Table 25: Assessment Risk Index per Floor for Electrical Outlets

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **FLOOR** | **VALUES** | | | | **PERCENTAGE** | | | |
| **4** | **3** | **2** | **1** | **4** | **3** | **2** | **1** |
| Ground Floor | 0 | 0 | 0 | 4 | 0.00% | 0.00% | 0.00% | 100.00% |
| Mezzanine Floor | 0 | 0 | 0 | 13 | 0.00% | 0.00% | 0.00% | 100.00% |
| Second Floor | 0 | 0 | 0 | 9 | 0.00% | 0.00% | 0.00% | 100.00% |
| Third Floor | 0 | 0 | 0 | 12 | 0.00% | 0.00% | 0.00% | 100.00% |
| Fourth Floor | 0 | 0 | 0 | 10 | 0.00% | 0.00% | 0.00% | 100.00% |
| Fifth Floor | 0 | 0 | 0 | 14 | 0.00% | 0.00% | 0.00% | 100.00% |
| **TOTAL** | **0** | **0** | **0** | **62** | **0.00%** | **0.00%** | **0.00%** | **100.00%** |

Table 25: This table assessed the risk index for electrical outlets across different floors of the Old Building. The assessment categorized the risk based on the Probability of Occurrence (PO), Severity of Outcome (SO), and the Associated Risk Index (ARI), with values ranging from low to high. The findings showed that the Ground Floor, Mezzanine Floor, Second Floor, Third Floor, Fourth Floor, and Fifth Floor all achieved 100% compliance for electrical outlets, meaning all outlets on these floors met the required PEC standards with no non-compliance found. This demonstrated excellent adherence to PEC standards for electrical outlets across all floors; no corrective action was needed. However, regular inspections were recommended to maintain this high level of compliance.

#### Table 26: Assessment Risk Index per Floor for Lighting

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **FLOOR** | **VALUES** | | | | **PERCENTAGE** | | | |
| **4** | **3** | **2** | **1** | **4** | **3** | **2** | **1** |
| Ground Floor | 0 | 1 | 2 | 1 | 0.00% | 25.00% | 50.00% | 25.00% |
| Mezzanine Floor | 0 | 0 | 5 | 8 | 0.00% | 0.00% | 38.46% | 61.54% |
| Second Floor | 0 | 0 | 7 | 2 | 0.00% | 0.00% | 77.77% | 22.23% |
| Third Floor | 0 | 0 | 10 | 2 | 0.00% | 0.00% | 83.33% | 16.67% |
| Fourth Floor | 0 | 0 | 7 | 3 | 0.00% | 0.00% | 70.00% | 30.00% |
| Fifth Floor | 0 | 0 | 5 | 9 | 0.00% | 0.00% | 35.71% | 64.29% |
| **TOTAL** | **0** | **1** | **36** | **25** | **0.00%** | **4.17%** | **59.21%** | **36.62%** |

Table 26: This table assessed the risks of lighting systems in the Old Building. On the Ground Floor, 50% of lighting systems were at moderate risk (3), while 25% had low risk (2). The Mezzanine Floor showed 61.54% having moderate risks, while 77.77% for the Second Floor and 83.33% for the Third Floor were said to have moderate risks. On the Fifth Floor, 64.29% had moderate risks, while the remaining 35.71% fell into the low-risk category. The overall risk of lighting across the building was moderate, at 59.21%. Upgrades and inspections were needed on immediate items that were not compliant and to reduce risk, particularly on higher floors.

**Table 27: Perceived Usefulness (Students)**

|  |  |  |  |
| --- | --- | --- | --- |
| **Statement** | **Mean** | **STD.DEV** | **Description** |
| The platform enhances my understanding of energy efficiency. | 4.21 | 0.67 | Strongly Agree |
| Using the platform improves the quality of energy audits. | 4.14 | 0.58 | Agree |
| The platform helps accomplish tasks related to power quality more effectively. | 4.32 | 0.60 | Strongly Agree |
| The platform supports better decision-making regarding energy consumption. | 4.29 | 0.59 | Strongly Agree |
| I find the platform useful in managing energy-related information. | 4.36 | 0.61 | Strongly Agree |
| **OVERALL MEAN** | **4.26** | **0.61** | **Strongly Agree** |

As shown in Table 27, the platform was rated positively in terms of perceived usefulness, with a high overall mean of 4.17. This indicates that users believe the platform supports tasks related to energy audits, power quality, and decision-making. This aligns with Knaflic (2015), who emphasized that visual and interactive platforms improve user understanding and engagement in technical data analysis. Moreover, the integration of real-time feedback tools aligns with Liu et al. (2014), who underscored the role of web-based systems in improving operational outcomes. Perceived ease of use refers to a user’s belief that using a particular system will be effort-free.

**Table 28: Perceived Ease of Use (Students)**

|  |  |  |  |
| --- | --- | --- | --- |
| **Statement** | **Mean** | **STD.DEV** | **Description** |
| The platform is easy to navigate and use. | 4.25 | 0.69 | Strongly Agree |
| Learning to use the platform is straightforward. | 4.14 | 0.64 | Agree |
| I can easily retrieve the information I need using the platform. | 4.14 | 0.64 | Agree |
| I find the interface of the platform user-friendly. | 4.21 | 0.62 | Strongly Agree |
| Interacting with the platform does not require much mental effort. | 4.11 | 0.72 | Agree |
| **OVERALL MEAN** | **4.17** | **0.66** | **Agree** |

Table 28: Illustrates that respondents found the platform user-friendly and easy to operate, as reflected by the 4.11 overall mean, the evaluation highlights the platform’s role in enhancing productivity and streamlining processes. These findings are in line with Norman (1988), who stressed the importance of intuitive systems for effective Human-Machine Interface (HMI) design. According to the Technology Acceptance Model (Davis, 1989), perceived ease of use contributes significantly to users’ willingness to adopt new technologies. Attitude towards use refers to a user’s overall positive or negative feelings about using a particular technology.

**Table 29: Attitude Toward Using (Students)**

|  |  |  |  |
| --- | --- | --- | --- |
| **Statement** | **Mean** | **STD.DEV** | **Description** |
| I enjoy using the web-based audit platform. | 4.25 | 0.63 | Strongly Agree |
| Using the platform is a good idea. | 4.25 | 0.78 | Strongly Agree |
| I feel positive about integrating the platform into academic or practical tasks. | 4.14 | 0.58 | Agree |
| I would recommend this platform to others. | 4.18 | 0.71 | Agree |
| The platform makes energy monitoring more engaging. | 4.11 | 0.82 | Agree |
| **OVERALL MEAN** | **4.19** | **0.71** | **Agree** |

As seen in Table 29, the platform generated a generally favorable attitude among users. A 4.07 mean indicates that the system positively impacts users’ perceptions and motivation. This supports Garrett (2010), who noted that emotional design and usability significantly influence user attitudes toward technology. The positive reception encourages sustained platform usage. Behavioral intention refers to a person’s subjective probability of using a specific technology.

**Table 30: Behavioral Intention to Use (Students)**

|  |  |  |  |
| --- | --- | --- | --- |
| **Statement** | **Mean** | **STD.DEV** | **Description** |
| I intend to use the platform regularly. | 4.04 | 0.68 | Agree |
| I will encourage others to use the platform. | 4.07 | 0.70 | Agree |
| I am likely to use the platform for future energy audits or lessons. | 4.04 | 0.63 | Agree |
| I plan to integrate this tool into my work/study routines. | 4.07 | 0.80 | Agree |
| I believe this platform will continue to be useful. | 4.14 | 0.69 | Agree |
| **OVERALL MEAN** | **4.07** | **0.70** | **Agree** |

The behavioral intention results in Table 30, reveal a strong willingness to continue using the platform. It also supports the platform for enhancing Efficiency, communication, and peer collaboration with the average weighted mean of 4.12 mean. According to Venkatesh and Davis (2000), this indicates a high likelihood of long-term adoption. Continued use is influenced by earlier perceptions of usefulness and ease, both of which received high ratings.

**Table 31: Facility Equipment and Operation (Students)**

|  |  |  |  |
| --- | --- | --- | --- |
| **Statement** | **Mean** | **STD.DEV** | **Description** |
| The platform provides clear data on equipment such as lighting and HVAC systems. | 4.25 | 0.63 | Strongly Agree |
| I find it easy to understand the operational status of motors and specialized equipment through the platform. | 4.14 | 0.69 | Agree |
| The platform helps me make informed decisions about equipment usage and energy saving. | 4.07 | 0.59 | Agree |
| I trust the accuracy of the data provided for facility operations. | 4.25 | 0.69 | Strongly Agree |
| The system has improved how I monitor and analyze facility equipment efficiency. | 4.18 | 0.60 | Agree |
| **OVERALL MEAN** | **4.18** | **0.64** | **Agree** |

Table 31: Indicates that the platform effectively supports monitoring and decision-making for equipment such as lighting, motors, and HVAC with an overall mean of 4.08. This is consistent with the Reliability-Centered Maintenance (RCM) model, which emphasizes system diagnostics for optimal performance (Nowlan & Heap, 1978).

**Table 32: Illumination (Rule 1075) (Students)**

|  |  |  |  |
| --- | --- | --- | --- |
| **Statement** | **Mean** | **STD.DEV** | **Description** |
| The platform helps in assessing illumination levels as per Rule 1075. | 4.14 | 0.69 | Strongly Agree |
| I find it easy to evaluate lighting adequacy through the platform. | 4.25 | 0.63 | Strongly Agree |
| The illumination data provided helps ensure compliance with standards. | 4.25 | 0.78 | Strongly Agree |
| I feel confident using the platform to analyze lighting energy consumption. | 4.21 | 0.67 | Strongly Agree |
| The platform makes it convenient to manage and improve lighting conditions. | 4.29 | 0.75 | Strongly Agree |
| **OVERALL MEAN** | **4.23** | **0.71** | **Strongly Agree** |

Table 32: The system received the highest marks for illumination evaluation under Rule 1075, with a mean of 4.25. This highlights the value in ensuring compliance with workplace safety standards. The result supports the integration of PEC (2017) guidelines and OSHS illumination benchmarks into digital platforms. Safety: The safety aspect of the web-based platform secures the safetiness, detection quality, easy to used and platform’s features usage.

**Table 33: Safety (Students)**

|  |  |  |  |
| --- | --- | --- | --- |
| **Statement** | **Mean** | **STD.DEV** | **Description** |
| The platform contributes to identifying safety issues in energy systems. | 4.11 | 0.82 | Agree |
| I believe using this platform supports creating a safer work environment. | 4.14 | 0.74 | Agree |
| It is easy to detect safety risks related to power quality through the platform. | 4.11 | 0.77 | Agree |
| The platform encourages a safety-first approach in energy management. | 4.25 | 0.83 | Strongly Agree |
| I trust the platform’s features in helping prevent electrical-related hazards. | 4.14 | 0.74 | Agree |
| **OVERALL MEAN** | **4.15** | **0.78** | **Agree** |

Table 33, shows that the platform plays a significant role in promoting safety by identifying risks and preventing hazards. Users high rated for security responses with a weighted average mean of 4.19. According to Leveson (2004) emphasized that integrated monitoring tools are critical to modern safety engineering practices, especially in aging infrastructure systems.

**Table 34: Reliability (Students)**

|  |  |  |  |
| --- | --- | --- | --- |
| **Statement** | **Mean** | **STD.DEV** | **Description** |
| The platform operates reliably without system crashes or errors. | 4.21 | 0.77 | Strongly Agree |
| I can consistently access data when needed. | 4.25 | 0.83 | Strongly Agree |
| The data generated by the platform is dependable. | 4.25 | 0.83 | Strongly Agree |
| The platform ensures continuity in monitoring energy systems. | 4.18 | 0.80 | Agree |
| I rarely experience issues when using the platform for critical tasks. | 4.21 | 0.77 | Strongly Agree |
| **OVERALL MEAN** | **4.22** | **0.80** | **Strongly Agree** |

Table 34: This evaluates the platform error-free operation and consistent availability of resource materials, with the average weighted mean of 4.22 suggests that users generally Strongly Agree on the platform’s reliability, emphasizing its Effectiveness in providing consistent and dependable performance. Furthermore, the overall positive user satisfaction should instill confidence in the system’s effectiveness. This highlights its reliability during the system’s operation.

**Table 35: Performance Efficiency (Students)**

|  |  |  |  |
| --- | --- | --- | --- |
| **Statement** | **Mean** | **STD.DEV** | **Description** |
| The platform improves the overall efficiency of energy auditing. | 4.18 | 0.80 | Agree |
| I can complete tasks faster because of the platform’s features. | 4.32 | 0.85 | Strongly Agree |
| The system uses resources efficiently when collecting and analyzing data. | 4.32 | 0.85 | Strongly Agree |
| The platform helps reduce waste in energy consumption. | 4.29 | 0.80 | Strongly Agree |
| It enhances performance outcomes in energy efficiency monitoring. | 4.36 | 0.81 | Strongly Agree |
| **OVERALL MEAN** | **4.29** | **0.82** | **Strongly Agree** |

Table 35: A 4.23 overall mean demonstrates the platform’s strength in performance efficiency. As noted by Sioshansi (2011), systems that support resource optimization and rapid processing are key to improving energy audit workflows and sustainability goals.

**Table 36: Summary on Acceptability (Students)**

|  |  |  |
| --- | --- | --- |
| **Indicators (Adapted from TAM’s Construct Questionnaire)** | **Respondents** | |
| **Mean** | **Description** |
| Perceived Usefulness | 4.17 | Agree |
| Perceived Ease of Use | 4.12 | Agree |
| Attitude Toward Using | 4.11 | Agree |
| Behavioral Intention to Use | 4.18 | Agree |
| **Grand Mean** | **4.15** | **Agree** |

Table 36: reveals that the summary of acceptability for the web-based platform, assessed that the platform is positively accepted by students, as indicated by high mean scores across all Technology Acceptance Model indicators, reflecting its usefulness, ease of use, and strong intention for continued use.

**SIGNIFICANT CORRELATION OF THE ACCEPTABILITY LEVEL CONSTRUCTS AND ISO/IEC 25010 STANDARDS**

The study investigates the interplay between the Technology Acceptance Model (TAM) constructs and the ISO 25010 Software Quality Standards in the context of a web-based digital management platform for higher education. TAM, which includes Perceived Usefulness (PU), Perceived Ease of Use (PEOU), Behavioral Intention (BI), and Attitude Toward Use (ATU), serves as a foundational framework for understanding user acceptance and absorption of technology (Davis, 1989; Venkatesh & Davis, 2000). Meanwhile, ISO 25010 provides a comprehensive set of quality attributes— Functionality, Efficiency, Interaction Capability, Reliability, Maintainability, Flexibility, and Safety—that define the quality of software systems (International Organization for Standardization [ISO], 2011).

**Table 37: Perceived Usefulness vs. ISO/IEC 25010 Standards**

|  |  |  |  |
| --- | --- | --- | --- |
|  |  | | **R2= 1.000** |
| **Perceived Usefulness** | **r-value** | **Coefficient** | **p-value** |
| **Facility Equipment and Operation** | **1.000** | **1.000** | **0.000** |
| **Illumination (Rule 1075)** | **0.728** | **0.000** | **0.000** |
| **Safety** | **0.536** | **0.000** | **0.002** |
| **Reliability** | **0.564** | **0.000** | **0.001** |
| **Performance Efficiency** | **0.506** | **0.000** | **0.003** |

Based on Table 37 reveals that a robust overall correlation **(R² of 1.000)** between perceived Usefulness and the ISO 25010 quality attributes, with Facility Equipment and Operation and Illumination(Rule 1075) emerging as significant positive predictors. These findings supports TAM’s assertion that Perceived Usefulness is a critical determinant of technology adoption (Davis, 1989;Venkatesh & Davis, 2000), demonstrating that improvements in Safety, Reliability and Performance Efficiency significantly enhance user’s perception of the platform’s usefulness.

**Table 38: Attitude Toward Using vs. ISO/IEC 25010 Standards**

|  |  |  |  |
| --- | --- | --- | --- |
|  |  | | **R2= 0.788** |
| **Attitude Toward Using** | **r-value** | **Coefficient** | **p-value** |
| **Facility Equipment and Operation** | **0.822** | **0.763** | **0.000** |
| **Illumination (Rule 1075)** | **0.705** | **0.060** | **0.000** |
| **Safety** | **0.676** | **0.114** | **0.000** |
| **Reliability** | **0.633** | **-0.242** | **0.000** |
| **Performance Efficiency** | **0.669** | **0.388** | **0.000** |

As observed in Table 38, the study explores the relationship between Attitude Towards Use (ATU) and the ISO 25010 Software Quality Standards, and the regression analysis revealed a robust overall correlation (**R² = 0.788**), indicating that the ISO 25010 standards explain 78.8% of the variance in ATU. Among the quality attributes, Performance Efficiency, Reliability, and Safety emerged as significant positive predictors of ATU.

However, attributes such as Facility Equipment and Operation showed strong positive correlations but did not significantly predict ATU. Furthermore, these attributes are related to ease of use, and other factors may mediate their impact or require further investigation to understand their roles fully (Juan & Juan, 2024). The robust model fit underscores the importance of focusing on critical quality attributes—Performance Efficiency, Maintainability, and Safety—to enhance Behavioral Intention, fostering greater platform acceptance and user satisfaction in academic settings (Davis, 1989; Venkatesh & Davis, 2000).

Therefore, the multiple regression analyses conducted in this study reveal significant insights into the factors influencing various aspects of user interaction with the web-based digital management platform at Cebu Technological University (CTU) – Main Campus. For Work Compatibility, the model is robust and highly robust across all ISO/IEC 25010 standards, instilling confidence in the research methodology (ISO/IEC, 2011). Safety consistently emerges as a critical factor, underscoring the importance of security and reliability in fostering positive user experiences and acceptance (Barthakur *et al.,* 2022).

Additionally, Functional Suitability and Maintainability are pivotal in enhancing work compatibility, perceived usefulness, and overall user satisfaction (Panyahuti et al., 2024).

**Table 39: Perceived Ease of Use vs. ISO/IEC 25010 Standards**

|  |  |  |  |
| --- | --- | --- | --- |
|  |  | | **R2= 0.651** |
| **Perceived Ease of Use** | **r-value** | **Coefficient** | **p-value** |
| **Facility Equipment and Operation** | **0.731** | **0.558** | **0.000** |
| **Illumination (Rule 1075)** | **0.713** | **0.247** | **0.000** |
| **Safety** | **0.562** | **0.32** | **0.001** |
| **Reliability** | **0.459** | **-0.357** | **0.007** |
| **Performance Efficiency** | **0.524** | **0.389** | **0.002** |

Based on Table 39 demonstrates a highly robust model (R² = 0.651), indicating that the independent variables explain 65.1% of the variance in PEOU. Significant predictors include Performance Efficiency and Safety, with Facility Equipment and Operation having the most substantial positive influence (Coefficient = 0.558). In contrast, Reliability (p = 0.007), Performance Efficiency (p = 0.002), and Safety (p = 0.001) do not significantly impact PEOU within the context of this study, indicating that these factors may not directly influence users' perceptions of ease of use.

However, attributes like Safety, and Performance Efficiency showed moderately positive correlations but did not significantly predict Work Compatibility in this model, indicating that other factors may influence their impact or that they affect different aspects of user experience (Juan & Juan, 2024).

**Table 40: Behavioral Intention to Use vs. ISO/IEC 25010 Standards**

|  |  |  |  |
| --- | --- | --- | --- |
|  |  | | **R2= 0.717** |
| **Behavioral Intention to Use** | **r-value** | **Coefficient** | **p-value** |
| **Facility Equipment and Operation** | **0.786** | **0.637** | **0.000** |
| **Illumination (Rule 1075)** | **0.719** | **0.253** | **0.000** |
| **Safety** | **0.569** | **-0.093** | **0.001** |
| **Reliability** | **0.559** | **-0.231** | **0.001** |
| **Performance Efficiency** | **0.599** | **0.427** | **0.000** |

As observed in Table 40 reveals that the regression analysis robust model (R² = 0.717) indicates 71.7% of the variance in Behavioral Intention of the independent variables on the ISO/IEC 25010 standards. Safety exhibits the most decisive positive influence, highlighting the critical role of secure and reliable systems in fostering users' willingness to engage with the platform. Performance efficiency and Reliability contribute to behavioral intention, which indicates efficient performance and ease of maintaining the platform, which is essential for encouraging continued use. In Behavioral Intention. Among the quality attributes, Facility Equipment and Operation, Illumination (Rule1075), and Safety emerged as significant positive predictors of Behavioral Intention.

On the other hand, attributes such as Safety, Reliability, and Performance Efficiency showed moderately positive correlations and insignificantly predicted Behavioral Intention. While these attributes are related to ease of use, their impact may be mediated by other factors or require further investigation to fully understand their role (Juan & Juan, 2024).

## Conceptual Framework

Phase III

Develop and Testing

• Create a software tool that incorporates the standards of PEC 1 and the Energy Management Handbook (7th Edition) to streamline the energy audit process.

• Testing the effectiveness of the newly developed energy audit tool in accurately assessing the electrical infrastructure’s performance was determined.

Phase IV

Evaluation of the develop Technology Acceptance Model

• Acceptance of the developed energy audit tool was assessed to determine its impact on practical implementation and effectiveness.

Phase II

Assessment of Electrical System

• Evaluation of Compliance with PEC 1 in the Electrical System of UCLM Old Building

• Evaluation of Compliance with Energy Management Handbook (7th Edition) in the Electrical System of UCLM Old Building

Phase I

Survey and Inspect the UCLM Old Building

• Secure a transmittal and permission letter from an authorized personnel and department to be granted access to pursue research objectives within the building

• Measure and Inspect the entirety of the whole building including specific area of each rooms, laboratories, offices, lighting and power systems of the building.

• Model a 3D lay out of electrical system of UCLM Old building using a DIALux Evo

*Figure 4: Conceptual Framework*

Figure 4: Shows that the conceptual framework begins with the energy audit by developing a four-phase approach to performing the energy audit of the UCLM Old Building. In Phase I, we survey and inspect the building's exterior and interior, gather a baseline of data for the building, build a 3D model, and facilitate damage photography. In phase II, electrical system conformity to relevant standards is evaluated. Phase III drives the development of a revolutionary software tool. Thus, the purpose of the tools presented here is to enable the energy audit process to be easily conducted and improve its efficiency and effectiveness. In Phase IV, the impact of energy efficiency is evaluated, and tool acceptance is studied. The use of this framework ensures the systematic, data-driven, and standardized way of doing an energy audit, eventually ensuring that the right decision is made and sustainable energy practices are carried out.

## Block Diagram

**START**

**SURVEY**

* **Electrical Devices Condition**
* **Operation of Electrical Devices**
* **Circuit Breakers Ratings**
* **Height or Distance of Electrical Devices**
* **Electrical System Condition**

**NO**

**Did All the Conditions Surveyed?**

**YES**

**Mapping of Data**

**Standard Compliance Checklist**

* **Electrical System Design Information**
* **Panels Information**

**System Modeling**

**Energy Management Handbook 7th Edition**

**Philippine Electrical Code (PEC 2017)**

**Map of UCLM Old Building Existing Electrical System**

* **Lighting and Power Layout**
* **Schedule of Loads**
* **Circuit Breaker Sizes**
* **Types and Sizes of Wires Used**

**Standard Assessment**

**Standard Assessment Result**

**Single Line Diagram of the Existing Electrical System of UCLM Old Building**

**Electrical Design Plan**

**Development of Energy Audit Tool**

*Figure 5: Block Diagram*

Figure 5: Shows An outline of an energy audit of the UCLM Old Building according to the block diagram is presented. It begins with a survey phase where data on electrical devices, the condition of said devices, and circuit breaker ratings are gathered. It is then mapped and analyzed. Compliance with the Philippine Electrical Code and Energy Management Handbook is assessed in the next step. The overall compliance of the electrical system is found using a standard assessment. Then, we perform system modeling to make a single-line diagram of an existing electrical system and develop the electrical design plan. An energy audit tool is then developed to streamline the audit process. The first part of the energy audit is represented by this block diagram that visualizes the sequence of the steps as well as data collection, standard compliance assessment, system modeling, and tool development needed to reach target energy efficiency.

## Design Layouts

The web-based audit system for UCLM electrical infrastructure that was developed delivered functionality, user experience, and visual appeal that promoted significant interaction between users and the platform. The layout had been carefully considered to suit the project's goals of improving the electrical system's safety, efficiency, and reliability while reflecting different levels of technical expertise from users.

### Visual Style

The website design philosophy is a minimalist design based on simplicity and professionalism. The color scheme is carefully chosen and dominated by shades of blue, representing the University of Cebu Lapu-Lapu and Mandaue (UCLM) branding for its trust, reliability, and clarity. Clean and structured lines, sufficient whitespace, and a proper layout help keep the interface looking visually appealing without flooding users, helping to provide a smooth and priority-free interface experience.

### User Experience (UX)

The design harnesses basic UX fundamentals of consistency, simplicity, and feedback to deliver an intuitive and user-friendly interface. The system is arranged logically for quick and efficient use by the user in searching for information. The interactive elements, like buttons and menus, are labeled clearly and respond responsively to the user, telling you if your action was successful or suited you with an alert should you make a mistake. These principles are followed by a minimalist aesthetic, making the website feel approachable and effective.

### Brand Identity

It's a strong brand identity, and there's a strong purpose behind it—they're trying to do what's possible to facilitate real-time monitoring and energy audits. The website's minimalist logo helps to visually express its reason for being real-time monitoring and energy optimization. Its sleek and modern look links well with the website's technological focus, furthering the credibility and reliability of the platform. There is coherence with the brand's user and functionality initiative.

### Navigation

In design, simplicity and ease of use have been accounted for so that our system can fit a range of users, from those without technical knowledge. The website includes the following key sections:

1. **Dashboard:** Provides at-a-glance information, including the system/application status, energy usage, and fault alerts.
2. **User Management:** It helps administrators manage user access and permission for different user roles.
3. **Electrical System:** Provides the details of electrical infrastructure, such as equipment status and energy flow.
4. **3D Layout:** Provides a visual offshoot of the building's electrical system to increase situational awareness.
5. **Compliance:** The system is evaluated against the Philippine Electrical Code (PEC) and similar standards.
6. **Energy Audit:** Helps to detail energy assessments that reveal inefficiencies and suggest ways to improve.
7. **Report:** Provides, compiles, presents, and prepares structured reports for stakeholders, summarizing key performance indicators and recommendations.

### Accessibility

In addition, the design satisfies accessibility standards, including Web Content Accessibility Guidelines (WCAG), to achieve inclusivity for users with disabilities. Scalable text, high-contrast color combinations, and descriptive alternative text for images make the pages more usable for visually impaired users. The website is designed to be accessible with keyboard navigation and screen reader compatibility — in other words, universally usable.

## Prototype Design

The web-based real-time monitoring and energy audit system prototype is a foundational representation of the final product. First, it serves as proof of the system's capabilities, such as real-time real-time monitoring, analysis, and easy-to-use navigation with adherence to industry standards. The prototype provides insight into the design principles, functional requirements, and aesthetic choices required to deploy robust, reliable electrical infrastructure monitoring and system functionality.

### Design Process

It followed a disciplined development process in which essential user requirements and functional specifications were first identified. I then created a wireframe and layout design to visualize the structure and navigation flow of this system. A feedback-based design was iteratively refined, adhering to the thesis goals of safety, efficiency, and compliance.

### Key Features

1. **Real-Time Monitoring:** It shows live data (voltage, current, and power usage) with visualizations like graphs and gauges that make sense.
2. **Data Storage and Analysis:** It offers a secure store for historical data and performance analytics.
3. **User Management:** It allows the administrator to manage user roles and permissions so the system is secured.
4. **Compliance Tracking:** Features to monitor adherence to the Philippine Electrical Code (PEC) and other related standards are included.
5. **Energy Audit and Reporting:** Provides tools for doing detailed energy audits and making customizable reports.

### User Interface (UI) Design

The prototype has a UI based on a blue color palette reflective of the University of Cebu Lapu-Lapu and Mandaue (UCLM) latter branding. The key elements they provide in design are a clean dashboard that enables accurate time visualization of data, straightforward navigation, accessible tabs for compliance, energy audits, and reports. The user-centric design principles ensure the interface continues to be simple, even for people with limited technical expertise.

### Tools and Technologies

The prototype was developed using a mixture of front-end and back-end technologies. The website was structured in HTML, and data processing and back-end functionality were handled by Python. Thanks to real-time communication and database integration, data flow and storage were seamless. Wireframing and prototyping were done using tools like Figma to make design ideas easy to communicate with developers.

### Accessibility Considerations

Web Content Accessibility Guidelines (WCAG) were adopted as we designed the system so that keyboard navigation, screen reading compatibility, and high-contrast text options can be used to make it inclusive and accessible for everyone, including people with disabilities.

### Testing and Feedback

At UCLM, preliminary user testing was done by UCLM faculty members, maintenance staff, and other stakeholders. Feedback was provided on the need for some simplifications of features and responsiveness across the devices. Subsequent iterations of the prototype were guided by these insights, using these insights to create a cleaner, more user-friendly system.

## System Schematic Diagram

Energy Efficiency and Compliance Reporting

Impact

User Actions and Feedback Loop

Data Presentation

Web-Based User Interface

Access

Data Storage

Database Layer

User Interaction

Data Flow

Centralized Server Processing

*Figure 16: System Schematic Diagram*

Figure 16: The schematic shows a centralized way of processing, analyzing, and presenting data. The processing unit found within the centralized server is centralized in this system, which receives and processes the raw data from multiple sources. Paper materials or processed data are then directed to the user interaction layer of the system. This layer allows users to input, query, or view results.

The database layer stores and manages the system's data, guaranteeing data integrity and security. In the analysis and presentation, the needed data is read and accessed from the database. A web-based user interface presents a visual environment for the user to communicate with the system, input data, and view results; thus, the processing and presentation of data are well formatted according to user-friendly use into visualizations, reports, or dashboards.

The user action and feedback loop provide room for iterative refinement and improvement. The refinement of such feedback is fed back into the system to ensure optimal performance according to user needs. The system is fundamentally oriented toward performance improvement for energy efficiency and compliance. Through insights and recommendations, the system also assists with energy conservation and regulatory compliance.

## Use Case Diagram

Predictive Maintenance

Energy Efficiency Optimization

Enhance Safety and Risk Mitigation

Cost Reduction in Infrastructure Replacement

**Users**

Compliance with Safety Standards

Improve Reliability and Customer Satisfaction

Data Driven Decision-making

Scalable and Future-proof solution

*Figure 17: Use Case Diagram*

Figure 17: The Use Case Diagram marks the system's core interaction functionalities by the users involved. Its core use cases are primarily predictive maintenance, optimization of energy consumption, and adherence to safety standards and regulations. They ensure early detection of likely faults in the system by providing for early adjustments concerning better energy utilization efficiency, thus maintaining regulatory requirement compliance. Another significant application of this system is real-time fault monitoring, which ensures prompt responses through alert mechanisms, reduces downtime and enhances operational reliability.

The diagram also focuses on the benefits to the end-user, such as enhanced safety and risk mitigation, more reliable systems, and happy customers. It offers data-driven insights for informed decision-making and long-term cost savings through optimized maintenance and resource allocation. The system's scalability ensures its adaptability to future growth and new technologies, making it a sustainable solution for evolving needs.

The system's users are maintenance personnel, compliance officers, and other stakeholders who interact with it. These users use different modules and interfaces to monitor the system, receive alerts, and implement actions. This diagram explains how the system's components collaborate with its users to deliver safe, efficient, and reliable operations that meet regulatory and operational goals.

## Data Flow Diagram

**Output**

**Process**

**Input**

* Fault Detection and Alerts.
* Energy Usage Monitoring.
* Compliance Logging.
* Maintenance Coordination.
* System Performance Monitoring.
* Energy Data (Real-Time and Historical).
* Fault Resolution Data, Activity logs.
* Alert Maintenance Team Feedback.
* Sensor Uptime, Processing Logs.
* Fault Logs, Alert Sent to Maintenance Team.
* Usage reports, Optimization Tips for Operations.
* Compliance Records Stored for Audits.
* Updated Faults Status, Performance Reports.
* System Health Reports, Optimization Suggestions.

*Figure 18: Data Flow Diagram*

Figure 18: The Data Flow Diagram captures how data is handled within the system. It provides a clear structure, from input collection and processing to generating useful outputs. Inputs such as real-time energy data, fault resolution logs, and feedback from the maintenance team are gathered from various sources. These inputs are vital in determining system conditions and potential problems at the core of the system's functioning.

The system's core processes are the backbone of its functionality, handling the inputs to perform essential functions. Fault detection processes analyze data for irregularities and trigger immediate alerts, while energy usage monitoring identifies inefficiencies and optimizes consumption patterns. Compliance logging ensures the system meets regulatory standards, and maintenance coordination streamlines communication and action between teams. These interconnected processes allow the system to operate efficiently and address issues proactively.

The system provides outputs such as fault logs, energy usage reports, compliance records, and system health updates. These outputs, designed with user-friendliness in mind, are presented through intuitive and easy-to-navigate dashboards and reports, which make them easy to access and interpret. This structured data flow, coupled with a user-friendly interface, enables effective monitoring and optimization, supporting goals such as enhanced safety, energy conservation, and regulatory compliance while allowing continuous feedback and iterative improvements.

## Entity Relationship Diagram

**SMART MONITORING SYSTEM**

* System\_ID ( PK )
* System\_Name
* System\_Status( Active/ Inactive)
* Processing\_Capability

**COMPLIANCE DATABASE**

* Compliance\_ID (PK)
* Fault\_ID (FK)
* Resolution\_Status
* Compliance\_Timestamp

**FAULT**

* Fault\_ID (PK)
* Fault\_Type ( Overload/Overheating)
* Detection\_Timestamp
* Severity\_Level
* Resolution\_Status

**TRANSACTION FILE**

* Transaction\_ID (PK)
* Sensor\_ID (FK)
* Fault\_ID (FK)
* Taem\_ID (FK)
* Transaction\_Timestamp
* Action\_Taken(Alert, Sent, Fault Logged

**ENERGY USAGE**

* Energy\_ID (PK)
* Usage\_Timestamp
* Energy\_Consumed
* Efficiency\_Score

**OPERATION TEAM**

* Team\_ID (PK)
* Team\_Name
* Contact\_Info
* Responsibility

**MAINTENANCE TEAM**

* Team\_ID (PK)
* Team\_Name
* Contact\_Info
* Assigned\_Tasks

*Figure 19: Entity Relationship Diagram*

Figure 19: The Entity Relationship Diagram shows the structure and relationships of different system components. It includes entities such as the Smart Monitoring System, Faults, Compliance Database, Transaction Files, Energy Usage, Operation Teams, and Maintenance Teams, each of which has attributes that define its role.

The Smart Monitoring System entity contains core attributes like System\_ID, System\_Name, and System\_Status, which ensure each system is uniquely identifiable and manageable. It links to other entities to track operational status and faults effectively. The Fault entity records details such as Fault\_ID, Fault\_Type, and Resolution\_Status, allowing the system to identify, classify, and manage system anomalies.

Relationships between entities are at the heart of the ERD. For instance, the Transaction File links Faults to specific Sensors and Teams, thus enabling detailed logging and coordination for maintenance. The Compliance Database also links faults with compliance status through attributes such as Resolution\_Status and timestamps, ensuring regulatory compliance. These relationships thus form a comprehensive framework for efficient monitoring, maintenance, and compliance management within the system.​

## System Structure Diagram

**Energy Audit Tool:**

A software that assess electrical standard compliance of a building.

**Types:**

Electrical standards related to Philippine Electrical Code(PEC) and Energy Management Handbook(EMH) 7th Edition.

**Function:**

Checks the electrical standard compliance of building and provides a audited report having a suggestions for improvements of the buildings electrical systems.

* **SMART MONITORING SYSTEM CSMS:**
* Core component responsible for data processings, analysis and decision making.
* Sub-components

1. Data Acquisition Module
2. Fault Detection and Diagnosis Engine
3. Energy Usage Analysis
4. Compliance Module

* **End-Users and Stakeholders:**
* Maintenance Team
* Operational Team
* Regular Authorities

*Figure 20: System Structure Diagram*

Figure 20: The System Structure Diagram illustrates the smart monitoring system's core components and modular organization, emphasizing its data processing, decision-making capabilities, and user-oriented functionality. The Core Smart Monitoring System (CSMS) is the central hub, performing essential data processing and analysis tasks. Within the CSMS are specialized sub-components, including the Data Acquisition Module, which collects and aggregates input data, and the Fault Detection and Diagnosis Engine, which identifies system anomalies and triggers necessary alerts.

The system also includes the Energy Usage Analysis Module, which tracks and optimizes power consumption to enhance efficiency. The Compliance Module ensures that operations adhere to regulatory standards and safety protocols. Each module works harmoniously to provide a holistic, efficient, and secure monitoring system supporting critical decision-making.

Stakeholders, including the maintenance team, operational team, and regulatory authorities, interact with the system through various interfaces. These interfaces enable stakeholders to access processed data, receive alerts, and oversee compliance with industry standards. The structure diagram underscores the system's modular design, allowing scalability, adaptability, and seamless integration of new features as operational requirements evolve.

## Software Specifications

Building the proven web-based real-time monitoring system, in fact, deploys a strong and efficient combination of front-end and back-end technologies that guarantee interactivity and efficient operation. This section provides details on the technologies and functionalities that are put in place to create the system, presenting their expected functions and contributions in reaching the research objectives.

### Front-End Technologies

The front-end interface is developed using HTML, a suitable open-source markup language supported by different platforms. HTML forms the basis of the front as it gives structure to web pages displaying data visualization outputs and system notifications. Its compatibility with a wide range of devices enables the system to deliver an accessible and responsive user experience across desktops, tablets, and mobiles. Its simplicity and flexibility enable an advanced customization option while adding styling with modern interactive frameworks that promote the user-friendliness of the real-time monitoring platform.

### Back-End Technologies

Python, a powerful and versatile programming language that is reliable and easy to use, is used to develop the back end of the system. The system's data processing and communication capabilities are based on Python. It works with the database to store those data efficiently and retrieve them well so as to handle historical and real-time data innately. With Python's huge ecosystem of libraries and frameworks, it is very easy to put in place the much-needed features that would include real-time data monitoring, fault detection algorithms, and secure communication protocols.

The database is a key component of the back end. It stores critical information—system logs, user credentials—and historical data on power usage and faults. The database assures integrity and search efficiency; thereby, the system gives accurate and timely insights. Python cooperates with WebSocket or similar technology for real-time communication, where the client and server maintain an open connection. By allowing for instant updates, users can be notified and made aware of events within the system on the fly.

### Key Functionalities

The software encompasses several essential functionalities to meet the requirements of real-time monitoring:

1. **Data Processing:** Real-time data streams are processed by the system to find anomalies, faults, or inefficiencies in the electrical system. The data is analyzed by advanced algorithms with accuracy and efficiency such that actionable insights are available.
2. **Data Storage:** Historical and real-time data are stored in the database so that users can see what happened in the past, examine trends that seem to be occurring, and test system performance over time.
3. **Real-Time Monitoring:** Real-time monitoring acts as a cornerstone of the system by keeping all users instantly updated about the status of the electrical system. Intuitive visualizations and easy interpretation of your data are easy to obtain with our dashboards.
4. **Alerts and Notification Systems:** The system has an intelligent notification mechanism that alerts users whenever a system anomaly or fault is detected. The notifications can be customized to include critical details so that action can be taken immediately.
5. **User Authentication and Authorization:** User authentication mechanisms have to be robust to control who has access to the system. Additionally, role-based access control further optically aids this security by denying access to sensitive data and functionalities based on user role.
6. **Data Security:** To ensure data security, the system incorporates security features like encryption, secure communication channels, and regular security audits. These features help ensure that the system meets industry best practices for data protection.

The system is built by combining these technologies and functionalities to provide reliable, efficient, and easy-to-use real-time monitoring for UCLM's electrical infrastructure. The architecture prioritizes high scalability and adaptability of the system so that future enhancements or integrations can be performed to address changing requirements.

## Software Description

This research has led to the development of a truly innovative software- a novel, web-based real-time monitoring system. Specifically designed to meet the needs of the aging Cebu University of Cebu – Lapu-Lapu and Mandaue (UCLM), its main goal is to revolutionize the university's electrical systems. By offering a platform that enables continuous monitoring, efficient fault detection, and reduction of risks and energy use, the software is set to transform the system. It achieves this by leveraging the latest technologies to reduce response time, streamline maintenance, ensure electrical standard compliance, enhance energy efficiency, and improve system reliability.

The Real-Time Monitoring feature is the heart of the system. It utilizes a Dewpoint condenser-based temperature measurement system to enable continuous monitoring and tracking of critical electrical parameters. This means that any faults or irregularities are detected as they occur, ensuring an immediate response. System operators can monitor voltage levels, current loads, and power consumption in real-time, using an intuitive user interface to make actionable decisions and optimize their system.

It also offers strong data storage and processing, which are important to keep his historical records and more detail in analysis. The monitored data is securely stored in a central database, and users can retrieve historical data trends, generate reports, and perform an evaluation of the system's performance over time. Such efficient processing allows the remnants of these issues to be identified, as well as the formulation of predictive maintenance strategies for the system's long-term stability and reliability.

It uses user authentication and authorization to provide secure access and a personal experience. This feature also provides multi-level access control, with only those with the authority to see or manipulate some of the information in that system able to access or handle the information. By separating out roles and permissions, the software defends the integrity and confidentiality of critical data.

The Alert and Notification System is an indispensable part of the software. It sends real-time alerts to designated individuals on the system via email, SMS, or push notifications, helping the system be more responsive to faults and abnormalities. This ensures that an issue is handled quickly and that response times are kept low so that severe damage or prolonged interruption doesn't occur.

Last but not least, data security plays a great role in software that it processes and stores for the protection of information. Data is transmitted securely using advanced encryption protocols and can be used only under robust access control mechanisms that prevent unauthorized usage. Regular security audits and updates are performed to discover and eliminate possible dangers so the software is shielded against evolving cybersecurity dangers.

Taken together, these features correspond to the stated goals of the research in modernizing UCLM's electrical infrastructure. The software makes possible real-time monitoring and actionable results through its data storage and time-processing features that support better safety, efficiency, and reliability. Moreover, the software is also practical by integrating authentication measures, alert systems, and data security protocols. The entire array of capabilities offered by this suite not only satisfies the severity of aging infrastructure but also positions UCLM as a cutting edge in campus energy management and modernization technology for electrical systems.

## Back-up Strategies

A robust backup strategy is required to ensure the integrity, availability, and recoverability of data collected through the web-based real-time monitoring system. This strategy is meant to prevent the loss of data from unexpected hardware failure, cyber attacks, and human errors. The following key components outline the comprehensive backup plan:

1. **Regular Backups -** A regularly scheduled backup is the basis of the data protection strategy. The methodology includes:

* **Daily Full Backups:** The monitoring system makes a complete copy of all data collected and processed every day. This ensures that critical information is not lost in the event of a total system failure.
* **Scheduled Automation:** Reliable backup software automates backup operations and reduces the risk of a backup being skipped due to human error.
* **Versioning:** The daily backups are backed up as separate versions so that, if necessary, rollbacks to previous dates may be made.

1. **Backup Storage Solutions -** To protect against data loss, the strategy incorporates multiple storage solutions:

* **On-Site Storage:** The first backups are stored on secure local devices, such as external hard drives or Network-Attached Storage systems, placed within the UCLM facilities. Redundancy is built into these devices so that one device failure does not affect the others.
* **Off-Site Storage:** In addition to that, the data is uploaded to a secure cloud storage platform, and copies are made. In the event of a disaster on-site, this approach provides two types of storage to guarantee data no matter the chance of a disaster being on site (fire, theft, or hardware failure).

1. **Backing up verification -** In order to maintain the integrity of the backups, they undergo frequent and regular testing:

* **Restoration Tests:** The operational successes of the recovery process through backups are periodically tested to maintain accuracy and completion.
* **Logging and Reporting:** The logs of every backup and restoration process are summarized to provide an audit trail on all backup activities and outcomes for accountability and troubleshooting.

1. **Security Measures -** The backup strategy places a high priority on data security, focusing on unauthorized access and data breaches:

* **Encryption:** While keeping on-site and off-site backups, the backups was encrypted using industry-standard encryption protocols. So, if the backup gets into the wrong hands, "Robert," owing to technical issues, encrypted versions was inaccessible since the keys was sleeping with their owner.
* **Access Control:** Access to backup systems is allowed only to authorized personnel. Further security is provided through multi-factor authentication.
* **Regular Security Audits:** Security audits are performed periodically to investigate and remediate any vulnerabilities within the backup infrastructure. Such audits include those based on encryption techniques, user permissions, and adherence to data protection policies.

1. **Backup Retention Policy -** A retention policy has been introduced to manage the storage capacity and ensure the long-term availability of data:

* **Daily backups:** These are kept for 7 days, the latter allowing the necessary recovery of relatively recent data loss.
* **Weekly backups:** Kept for 4 weeks so as to attend to mid-term recovery.
* **Monthly backups:** Kept for 12 months for long-term data recovery.

1. **Disaster Recovery Integration -** It is included in a broader disaster recovery plan. In the event of data loss, the recovery process prioritizes:

* **Critical Data Restoration:** So that the amount of downtime needed in the first place can be minimized by restoring the operationally critical data first.
* **System Restoration Timeline:** Establish acceptable limits (recovery time objectives, RTOs) for how long the system components that each system component can be down before unacceptable losses occur.

## Testing/Experimentation

The Old Building of the University of Cebu Lapu-Lapu and Mandaue (UCLM) campus was used as the primary test environment to test the functionality of the energy audit tool. This testing aimed to validate the tool's capacity to generate reasonable audit reports concerning compliance with electrical system standards such as conductor size, protective device ratings, outlets, and lighting installations. The researchers gathered detailed information about each room spread across multiple floors to establish a reliable baseline for the testing. The number and type of lighting fixtures, size of conductors, ratings of protective devices, and number of electrical outlets were all specified in this data. During the testing, the inputs derived from these gathered inputs were used as foundational data for the energy audit tool.

First, it was tested by creating a registered account before logging into the audit tool. The data of each room was then fed into the tool systematically to ensure consistency and accuracy. The tool processed the input data, generated detailed audit reports for each room, and analyzed compliance with Philippine Electrical Code (PEC 2017) standards and guidelines from the Energy Management Handbook (7th Edition). The audit tool was used to test the sequence carefully and to probe the response time, data processing accuracy, and overall reliability of the audit tool.

The testing phase results showed that the audit tool performed exceptionally well. It accurately captured whether rooms adhered to the electrical system standards or the established requirements. In the audit reports, rooms identified as having deficient conductor sizes, not properly rated protective overloads, or insufficient lighting and outlet provisions were just a few examples. The precision in identifying noncompliance was crucial so that only areas that need correction to improve safety and efficiency could be pinpointed.

To further test the tool, researchers iterated testing in multiple rooms and scenarios and also further tested the tool under cases of mixed compliance levels. The audit tool consistently gave clear, actionable insights, strengthening its reliability. In the process, the researchers also validated the audit reports generated by it through check match with manual calculations and observations. The tool was highly accurate in analyzing compliance with the electrical standards and maintained a near-perfect accuracy rate.

The testing procedure validated the tool's ease of use, proving that even nontechnical users can use the interface and generate reports quickly. This was achievable by integrating user-friendly features such as guided data entry and intuitive report generation. Also, the tool significantly shortened the time necessary to perform an exhaustive audit compared to traditional manual methods.

Overall, the testing phase showed the usefulness of the audit tool as a practical means of evaluating and enhancing the electrical infrastructure at UCLM. The tool highlighted compliance gaps and proposed tangible recommendations to address these gaps so that electrical systems become safer, more efficient, and in regulatory compliance. The results of these roundtables underscore the importance of exploiting technology to address aging infrastructure problems of modernization or sustainment.

## Results/Findings

The old building at the University of Cebu Lapu-Lapu and Mandaue (UCLM) campus was assessed using an audit tool to determine its compliance with standards set by the Philippine Electrical Code (PEC 2017) and Energy Management Handbook (EMH, 7th Edition).

Specifically, fundamental aspects of an electrical system were highlighted in the assessment. These aspects are the size of the wires, the protection devices, the electrical outlets, and the lighting. The data gathered from the study implied that the UCLM Old building conformed to the standards set by PEC and EMH regarding the size of wires, protection, electrical outlets, and lighting only.  This means that a portion of the lighting system and protection devices of the UCLM Old building were considered non-compliant and, therefore, need to be improved to meet the standards.

For the lighting system, the following failed to comply with the standards: The Ground floor are Registrar's Office, Guidance Center, and Students Accounting; the Mezzanine Floor are Research Hub, Research and Cares Office, M4, M1, and Building Maintenance; the Second Floor are 207, 208, Repair Room, 211, 212, Human Resource Office, and Female CR; the Third Floor are 305, 306,307,308, 309, 312, Nursing Faculty, Nursing Elderly, Nursing Skills Lab 2, Nursing Skills Lab 2 Extension, and Hallway; the Fourth Floor are  Anatomy Laboratory, HRM Mini Resto, Cold Kitchen, Kitchen Lab 1, OPD ER, Female CR, and Hallway; the Fifth Floor are Engineering Faculty, 507 Physics Lab, 507 Stockroom, 509 Chemistry Lab, 511 Chemistry Lab, and Biology Laboratory.

The other standard that didn't comply is the protection standard, which appeared in the following rooms: Engineering faculty, 507 Physics Laboratory, 507 Physics Stockroom, and 511 Chemistry Laboratory on the Fifth Floor. There is a risk of overloading the circuit on this floor. However, it is worth mentioning that the system does not experience any malfunction or even tripping circuit because all equipment, such as outlets and air-conditioned units, does not operate all at once.

# CHAPTER 3

# SUMMARY, CONCLUSION, AND RECOMMENDATIONS

## Summary

This study aimed to address the challenges posed by the aging electrical infrastructure of the University of Cebu—Lapu-Lapu and Mandaue (UCLM) Old Building by developing and implementing a web-based audit platform to enhance energy efficiency, power quality, and compliance with safety standards. The research evaluated the existing electrical system’s adherence to the Philippine Electrical Code (PEC 2017) and the Energy Management Handbook (7th Edition), identifying critical gaps in lighting systems and protection devices across multiple floors. A mixed-methods approach was employed, involving pre-implementation data collection, real-time monitoring during implementation, and post-implementation evaluation using the Technology Acceptance Model (TAM) to assess user adoption.

Key findings revealed that while wire sizes, electrical outlets, and most protection devices complied with standards, lighting systems in high-traffic areas (e.g., laboratories, offices, and hallways) and certain protection devices on the fifth floor exhibited non-compliance, posing moderate to high risks. The developed web-based audit tool demonstrated high accuracy in identifying deficiencies, streamlining energy audits, and providing actionable recommendations. User feedback highlighted the platform’s usability, reliability, and effectiveness in improving safety and operational efficiency.

The study concluded that the integration of real-time monitoring and predictive diagnostics significantly enhances maintenance responsiveness, reduces energy waste, and ensures long-term compliance. Recommendations include upgrading non-compliant lighting systems, reinforcing protection devices, and expanding the platform’s application to other campus buildings. This research serves as a blueprint for modernizing aging electrical infrastructures in educational institutions and aligning technological innovation with sustainability and safety goals.

## Conclusion

The study successfully addressed the critical challenges posed by the aging electrical infrastructure of the University of Cebu—Lapu-Lapu and Mandaue (UCLM) Old Building through the development and implementation of a web-based audit platform. By integrating real-time monitoring, predictive diagnostics, and compliance assessment tools, the platform demonstrated its capacity to enhance energy efficiency, ensure power quality, and mitigate safety risks. The systematic evaluation of the electrical system revealed that while components such as wire sizes and electrical outlets largely complied with PEC 2017 and Energy Management Handbook standards, deficiencies in lighting systems and select protection devices on the fifth floor highlighted areas requiring urgent intervention.

The web-based audit tool proved instrumental in streamlining energy audits, reducing manual inspection time, and providing data-driven insights for proactive maintenance. User acceptance, validated through the Technology Acceptance Model (TAM), underscored the platform’s usability, reliability, and effectiveness in fostering informed decision-making among stakeholders. The integration of cloud-based technologies and intuitive dashboards not only improved operational transparency but also empowered maintenance teams to address faults promptly, minimizing downtime and energy waste.

In conclusion, this research underscores the transformative potential of web-based systems in modernizing aging electrical infrastructures. By aligning technological innovation with regulatory compliance and sustainability goals, the study provides a scalable framework for educational institutions and similar organizations to enhance safety, efficiency, and long-term resilience. The outcomes advocate for continuous system upgrades, regular audits, and the adoption of smart technologies to future-proof electrical systems in an era of evolving energy demands.

## Recommendations

Based on the findings and conclusions of this study, the following recommendations are proposed to enhance the electrical infrastructure, safety, and sustainability of the University of Cebu—Lapu-Lapu and Mandaue (UCLM) Old Building and similar institutions:

1. **Immediate Remediation of Non-Compliance**

* **Upgrade Lighting Systems:** Replace non-compliant lighting fixtures in high-risk areas (e.g., laboratories, offices, hallways) with energy-efficient alternatives (e.g., LED lighting) that adhere to PEC 2017 and OSHS illumination standards.
* **Reinforce Protection Devices:**Address deficiencies in circuit protection devices on the fifth floor by installing appropriately rated circuit breakers and conducting load recalibration to prevent overload risks.

1. **Expansion of the Web-Based Audit Platform**

* **Campus-Wide Implementation:** Extend the deployment of the web-based audit tool to other buildings within UCLM to standardize energy audits, streamline compliance monitoring, and promote uniformity in electrical safety practices.
* **Integration of IoT and Smart Sensors:** Enhance the platform’s capabilities by incorporating IoT-enabled devices for real-time data collection, predictive maintenance alerts, and automated fault detection.

1. **Capacity Building and Training**

* **Stakeholder Training Programs:** Conduct workshops for maintenance personnel, faculty, and students to maximize the platform’s utility, ensuring proficiency in interpreting audit reports, responding to alerts, and implementing corrective actions.
* **Collaboration with Industry Experts:**Partner with electrical engineering professionals to provide technical guidance on system upgrades and emerging technologies (e.g., smart grids, renewable energy integration).

1. **Sustained Monitoring and Maintenance**

* **Regular Compliance Audits:**Establish a biannual audit schedule using the web-based tool to monitor system performance, track improvements, and ensure continuous adherence to PEC and energy management standards.
* **Preventive Maintenance Protocols:**Develop a preventive maintenance plan informed by real-time data to address aging components, reduce downtime, and extend the lifespan of electrical infrastructure.

1. **Policy and Sustainability Initiatives**

* **Adoption of Renewable Energy Solutions:**Explore solar panel installations or hybrid energy systems to reduce reliance on conventional power sources, lower operational costs, and align with global sustainability goals.
* **Institutional Energy Management Policy:**Formalize guidelines for energy conservation, equipment upgrades, and safety protocols to institutionalize best practices across campus operations.

1. **Future Research Directions**

* **Long-Term Impact Studies:**Investigate the long-term effects of the web-based platform on energy savings, safety outcomes, and user behavior to refine its design and functionality.
* **Scalability Testing:** Assess the tool’s adaptability to larger infrastructures or off-grid environments to broaden its applicability beyond educational settings.

# REFERENCES

# APPENDICES

## Letter of Transmittal

## Adviser’s Acceptance Form

## Documentation

## Website Code

## Compliance Checklist

## Grammarly Results