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Optimizing Energy Efficiency and Power Quality Through A Web-Based Audit Platform

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ABSTRACT: Energy efficiency and power quality are crucial for sustainable campus operations, particularly in higher education institutions seeking to minimize energy waste and ensure compliance with national electrical and safety standards. This study aimed to develop and evaluate a web-based audit platform for optimizing energy efficiency and power quality. Grounded in the Technology Acceptance Model (TAM) and ISO/IEC 25010 software-quality standards, the research employed a survey design complemented by semi-structured interviews to assess platform acceptability among a purposive sample of 35 faculty, staff, and experts. Results indicate robust acceptability, with overall mean ratings exceeding 4.4 on a 5-point Likert scale across all constructs, and Cronbach's alpha values ranging from 0.710 to 0.865, confirming instrument reliability. One-sample t-tests ($p < 0.001$) demonstrated significantly positive perceptions. A multiple regression model accounted for 78.2% of the variance in behavioral intention ($R^2 = 0.782$), with work compatibility ($r = 0.838$) and perceived usefulness ($r = 0.795$) as the strongest predictors. Compliance features effectively embedded PEC and OSHS standards, and platform reliability and maintainability were highly rated ($M > 4.5$). The findings support the platform's feasibility as a sustainable infrastructure and environmental performance tracking tool, recommending institutional adoption to enhance campus energy management, system safety, and operational efficiency at the university.

KEYWORDS: Energy audit, energy efficiency, power quality, technology acceptance model, web-based platform

I. INTRODUCTION

An electrical system has many interconnected components that perform a specific purpose (Schavemaker & Van der Sluis, 2025), and these systems can range from simple to complex. The electrical installation should be designed and constructed to be safe by complying with standards, codes, and accepted engineering practices (Khan & Das, 2024). Several current standards and guidelines exist for planning and designing electrical power systems for commercial, industrial, and utility applications. The more complex the electrical system, the more critical the design phase becomes. Ham Electric (2021) suggests that if the electrical system is poorly designed, it will endanger both people and property. At the very least, it would be unreliable and inefficient. Engineers must detail their designs to ensure safety and performance (Brauer, 2022). Furthermore, conducting periodic energy audits, systematic assessments of energy use, power quality, and equipment performance, helps to identify inefficiencies, establish performance baselines, and guide targeted improvements. For instance, Bosu et al. (2023) conducted an energy audit and techno-economic assessment of a university residential building with integrated solar technologies, revealing significant reductions in energy consumption and environmental impact; similarly, their evaluation of an industrial site demonstrated how targeted efficiency measures can lower both costs and emissions; and Lawal et al., (2024) highlighted the economic and environmental benefits of household energy audits, underscoring their role in optimizing load management and reducing waste.

The rationale for conducting an electrical system and facility design review of the private university in Mandaue City through a comprehensive energy audit stems from the growing importance of energy efficiency, sustainability, and safety in educational institutions. At the private university, preliminary walkthrough audits revealed average illuminance levels of only ≈250 lux in lecture halls and corridors—well below the 300 lux target recommended for academic spaces (Domingo et al., 2023); non-inverter split-type air-conditioning units, many over ten years old, were found to consume roughly 63 % of total energy in teaching buildings (Chan et al., 2021); and uncontrolled plug loads—dominated by computers and laboratory instruments—account for approximately 35 % of campus electricity use (Lopez et al., 2017). These specific problems—substandard lighting levels, dominant and inefficient HVAC loads, and high standby/plug-load waste underscore the urgent need for a detailed energy audit and electrical design review at the university to optimize consumption, ensure reliable infrastructure, and foster a safer, more conducive learning environment.

Educational institutions play a vital role in training future generations (Husamah et al., 2024) and spreading knowledge, yet with growing concerns about climate change, resource depletion, and rising energy costs, universities must lead in adopting sustainable practices (Rebelatto et al., 2020). Any institution's electrical system design and facilities directly impact its energy consumption, operational costs, and environmental footprint (Rebelatto et al., 2020).

II. METHODOLOGY

Web-based energy management platforms unify data collection, analysis, and reporting to optimize energy efficiency and power quality in complex electrical systems. Grounded in David Boddy's Information Systems Management Theory, these platforms serve as strategic Management Information Systems, delivering timely and accurate data that drive informed decision making and resource allocation. At the same time, adherence to the ISO/IEC 25010:2011 Software Quality Model ensures that the platform meets stringent criteria for functionality, reliability, usability, efficiency, maintainability, and security (ISO/IEC, 2011).
Furthermore, the legal foundations reinforce the theoretical and conceptual framework in Figure 1.

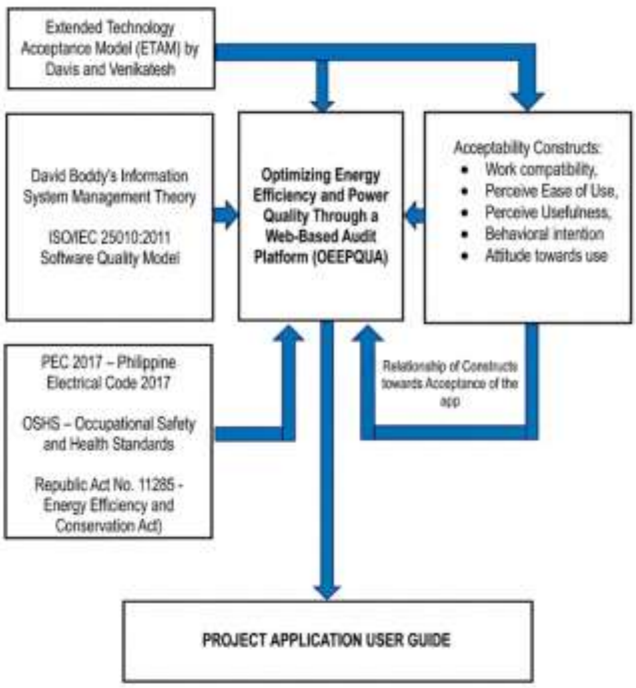

Figure 1

Theoretical - Conceptual Framework of the Study

The web-based energy audit platform's acceptability and work compatibility refer to the degree to which the platform's features and workflows fit seamlessly with users' existing tasks and processes—higher compatibility reduces disruption and fosters adoption (Chin & Lin, 2015). Perceived ease of use refers to the extent to which users believe (Hulu et al., 2024) that interacting with the platform will be effortless, thereby lowering barriers to initial engagement and ongoing use (Davis, 1989). Perceived usefulness captures users' beliefs that employing the platform will enhance their performance in energy auditing by speeding up data retrieval, simplifying compliance checks, or clarifying efficiency insights, and is a strong predictor of intention to use (Davis, 1989). Attitude toward use encompasses the overall positive or negative feelings users hold about the system, which mediates their perceived ease and usefulness, influencing their willingness to adopt (Davis, 1989). Finally, behavioral intention measures users' stated likelihood of employing the platform in their routines; as the most proximal determinant of actual usage in TAM studies, stronger behavioral intention correlates with higher adoption rates (Davis, 1989). Operationalizing these constructs provides a robust lens for predicting and explaining user engagement with the audit platform, ensuring it meets both technical and human-centered requirements for optimizing energy efficiency and power quality (Olaitan, 2025).

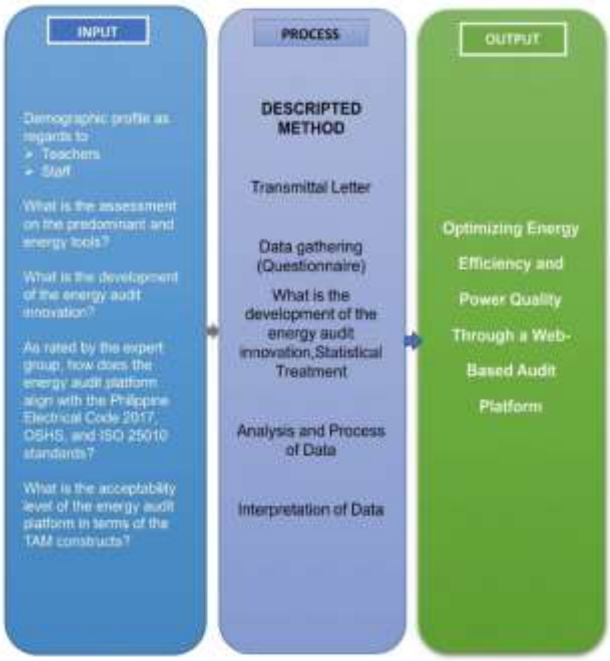

Figure 2

Flow of the Study

The Process Flow. The research begins with preparing a transmittal letter requesting permission to conduct the study in the private university facilities, following established institutional research protocols (Creswell & Creswell, 2018). Next, the researcher develops survey instruments grounded in the Technology Acceptance Model (TAM) (Davis, 1989; Elangovan et al., 2024), the Philippine Electrical Code 2017 (Republic Act No. 11285, 2019), the Occupational Safety and Health Standards (DOLE, 2019), and ISO/IEC 25010:2011 software-quality criteria (ISO/IEC, 2011). These instruments were deployed via Google Forms to capture user feedback on platform usability, performance efficiency, and data security features (Wu et al., 2024).

Collected responses were exported to Microsoft Excel for preliminary cleaning, then analyzed in SPSS to compute reliability (Cronbach's $\alpha \geq 0.70$) and descriptive statistics, and in R for inferential tests (ANOVA, regression) (Tavakol & Dennick, 2011; Vavouris et al., 2024). Weighted means and standard deviations summarize respondent perceptions. Finally, these quantitative findings guide iterative refinements to the audit platform's power-monitoring algorithms, fault-detection routines, efficiency dashboards, and user engagement modules (Rozentāle et al., 2022). The study's results underpin targeted recommendations to enhance compliance with electrical safety and efficiency standards and support smarter, data-driven energy management practices.

The Output Flow. The study's findings and recommendations lead to the following outcomes: 1) The proposed energy audit platform, 2) The adoption of the technology, and 3) full support of the adoption and implementation of Optimizing Energy Efficiency and Power Quality Through a Web-Based Audit Platform.

The respondents of this study comprised 35 faculty/experts and staff from the university in Mandaue City for the Academic Year 2024-2025. Participants involved for the duration needed to complete the online questionnaire through Google Forms.

The researcher utilized a comprehensive list of faculty and staff to select respondents and applied quota sampling. Table 1 presents the distribution of the study participants, as reflected in the table, which has a sample size of 35.

Table 1

Distribution of Respondents

(n = 35)

Respondents Group	Respondents Male	%	Female	%	Total	Percentage %
Faculty/experts	28	80.00	3	8.57	31	88.57
Staff	4	11.43	0	0	4	11.43
Total	**32**	**85.29**	**3**	**14.71**	**35**	**100%**

In this study, descriptive statistics (e.g., frequency, weighted mean, standard deviation, and percentage analysis) was employed to illustrate the demographic profiles of key stakeholders involved in energy management. The descriptive statistics, including frequency counts, weighted means, standard deviations, and percentage analyses, will profile key stakeholders (facility engineers, maintenance staff, energy managers, and administrators) by age, gender, education, and expertise, following established digital survey practices (Sánchez-Tabernero et al., 2024).

III. RESULTS AND DISCUSSION

Assessing the predominant energy audit tools involves evaluating key electrical parameters (voltage, current, and power factor), lighting parameters (illuminance and luminous efficacy), and energy data logging characteristics (sampling rate and storage capacity). Comprehensive analysis ensures robust accuracy and reliability in monitoring, diagnostics, and optimization processes (Tekler et al., 2022).

Within a web-based audit platform, electrical parameters are continuously monitored and analyzed to drive energy efficiency and power-quality improvements. The voltage and current waveforms are sampled in real time to compute instantaneous real (P), reactive (Q), and apparent (S) power, enabling precise power-factor ($PF = P/S$) calculations that inform corrective actions (e.g., capacitor-bank switching) to minimize losses and avoid utility penalties (Tekler et al., 2022). Total harmonic distortion (THD) metrics identify nonlinear loads that degrade quality, prompting the deployment of filters or load-balancing strategies (Ali et al., 2024).

Table 2: Electrical parameters

Statements	**Mean**	**Std. Dev.**	**Description**
1. The tool measures voltage levels accurately, even during fluctuations.	4.31	0.57	Strongly Agree
2. The tool effectively detects power factor issues.	4.2	0.71	Agree
3. The tool reliably measures current under various load conditions.	4.22	0.76	Strongly Agree
4. The tool helps in monitoring energy consumption for efficiency analysis.	4.26	0.73	Strongly Agree
OVERALL MEAN	**4.25**	**0.69**	**Strongly Agree**

Legend: 4.21 - 5.00 Strongly Agree, 3.41 – 4.20 Agree, 2.61 - 3.40 Neutral, 1.81 - 2.60 Disagree, 1.00 - 1.80 Strongly Disagree

Table 2 illustrates that the respondents gave the platform's electrical-parameter features very high marks (ratings from 4.20 to 4.31) and an overall mean of 4.25, indicating strong, consistent confidence in its accuracy and reliability for energy-efficiency and power-quality diagnostics.

Table 3: Lighting parameters

Statements	**Mean**	**Std. Dev.**	**Description**
1. The luxmeter accurately measures illumination levels (lux) in workspaces.	4.17	0.77	Agree
2. The luxmeter effectively identifies over-	4.14	0.83	Agree

illuminated or under-lit areas.			
3. The luxmeter assesses lighting uniformity and glare levels effectively.	4.03	0.84	Agree
4. The luxmeter helps determine the need for energy-efficient lighting upgrades.	4.03	0.81	Agree
OVERALL MEAN	**4.09**	**0.82**	**Agree**

Table 3 shows that users consistently rated the platform's lighting tools positively. Illuminance measurement scored highest (M 4.17), followed by area identification (M 4.14), with uniformity/glare assessment and upgrade guidance both at M 4.03, yielding an overall mean of 4.09, which reflects strong confidence in the luxmeter's effectiveness.

Table 4 indicates that the users positively rated the platform's energy-logging features with an overall mean of 4.18, finding them practical and usable. The user-friendly configuration of logging intervals of (M = 4.20) and the accuracy of real-time data capture (M = 4.17) are particularly appreciated. While memory capacity for long-term storage was slightly lower, it was still viewed favorably (M = 4.09). The strongest positive feedback was for the utility of logged reports in making energy-saving decisions (M = 4.26), confirming the platform's direct support for optimization.

Table 4: Energy data logging parameters

Statements	Mean	Std. Dev.	Description
1. It is user-friendly for configuring data logging intervals.	4.2	0.75	Agree
2. It has a reliable memory capacity for long-term energy data logging.	4.09	0.81	Agree
3. It accurately and consistently captures real-time energy data	4.17	0.74	Agree
4. The logged energy data reports support decision-making on energy saving.	4.26	0.87	Strongly Agree
OVERALL MEAN	**4.18**	**0.79**	**Agree**

Modern web-based energy audit platforms unite four key functions: waste mapping, real-time utilization analytics, safety anomaly detection, and automated efficiency controls into a seamless system that continuously optimizes energy use and power-quality performance.

Web-based energy audit platforms minimize energy waste by continuously monitoring voltage and current waveforms to detect standby "phantom" loads, idle equipment draw, and inefficient power-factor conditions, quantifying wasted kilowatt-hours through real-time analytics and interactive dashboards (Tekler et al., 2022).

Table 5 illustrates that users rated the platform's energy-wastage features very highly (overall M = 4.26, SD = 0.82), strongly agreeing it identifies waste sources (M = 4.34), curbs excessive consumption (M = 4.23), and provides actionable insights for reduction (M = 4.20).

The platform correlates real-time power measurements with operational schedules to detect idle or misused equipment, such as motors running at partial load or HVAC cycling, and then recommends load balancing, schedule optimization, and predictive maintenance to cut energy waste and stabilize voltage (Tekler et al., 2022).

Table 5: Energy wastage

Statements	Mean	Std. Dev.	Description
1. The web-based energy audit platform tool effectively identifies sources of unnecessary energy use.	4.34	0.75	Strongly Agree
2. The web-based energy audit platform helps reduce excessive energy consumption in key areas.	4.23	0.90	Strongly Agree
3. The web-based energy audit platform provides actionable insights to minimize energy wastage.	4.2	0.82	Agree
OVERALL MEAN	**4.26**	**0.82**	**Strongly Agree**

Table 6: Suboptimal Equipment Utilization

Statements	Mean	Std. Dev.	Description
1. The web-based energy audit	4.14	0.72	Agree

platform identifies inefficient usage of electrical and mechanical equipment.			
2. The web-based energy audit platform supports optimization of operating schedules for equipment.	4.2	0.86	Agree
3. The web-based energy audit platform helps in reallocating equipment loads to prevent overuse or underuse.	4.23	0.83	Strongly Agree
OVERALL MEAN	**4.19**	**0.80**	**Agree**

Table 6 shows that respondents rated the platform's suboptimal equipment-utilization features positively (overall M = 4.19, SD = 0.80), agreeing that it can identify inefficient electrical and mechanical operations (SD = 0.72) and optimize equipment schedules (SD = 0.86), while strongly agreeing that it enables dynamic load reallocation to prevent overuse or underuse (SD = 0.83).

Table 7: Potential Safety Hazards

Statements	Mean	Std. Dev.	Description
1. The web-based energy audit platform tool detects abnormal operating conditions that may lead to hazards.	4.23	0.80	Strongly Agree
2. The web-based energy audit platform helps prevent risks like overheating, short circuits, or fire.	4.29	0.81	Strongly Agree
3. The web-based energy audit platform provides early warnings for hazardous conditions.	4.2	0.86	Agree
OVERALL MEAN	**4.24**	**0.82**	**Strongly Agree**

Table 7 shows that users rated the platform's safety features highly (overall M = 4.24), strongly agreeing that it detects abnormal conditions (M = 4.23) and prevents hazards such as overheating and fire (M = 4.29), and agreeing that it issues timely early warnings (M = 4.20).

The platform embeds PEC 2017 limits (e.g., voltage variation, harmonic distortion thresholds, and grounding requirements) into its real-time analytics, automatically flagging deviations and suggesting corrective actions (e.g., filter installation, power-factor correction) to maintain compliance and optimize energy efficiency (Bureau of Philippine Standards, 2017). Simultaneously, it integrates OSHS-mandated safety protocols (e.g., lockout-tagout workflows, protective device checks, and hazard alerts) into its user interface to ensure that audits are conducted without endangering personnel (Department of Labor and Employment, 2017). This dual alignment with electrical and occupational standards underpins both robust power-quality diagnostics and safe, efficient operation (Tekler et al., 2022).

Table 8: Data on facility equipment and operation

Statements	Mean	Std. Dev.	Description
1. The web-based energy audit platform provides comprehensive data on electrical load and equipment operation.	4.43	0.60	Strongly Agree
2. The web-based energy audit platform supports compliance with PEC 2017 standards for equipment monitoring and reporting.	4.43	0.69	Strongly Agree
3. The web-based energy audit platform enables systematic identification of energy use patterns in critical facility systems.	4.4	0.64	Strongly Agree
OVERALL MEAN	**4.42**	**0.64**	**Strongly Agree**

Table 8 illustrates that the users "Strongly Agree" that the platform delivers comprehensive load and equipment data (M=4.43), supports PEC 2017 compliance (M=4.43), and systematically uncovers energy-use patterns in critical systems (M=4.40). The high overall mean (4.42, SD = 0.64) reflects strong confidence in its ability to integrate diverse facility operations for enhanced energy efficiency and power-quality management.

Based on the one-sample t-test results presented in Table 9, all five constructs (work compatibility, perceived usefulness, perceived ease of use, behavioral intention, and attitude towards use) yielded p-values of 0.000, which are significantly below the 0.05 threshold. This indicates that the mean ratings for each construct are significantly higher than the neutral value of 3, suggesting that the university users have a positive perception of the web-based audit platform. Therefore, it can be concluded that the platform significantly achieves high levels of user acceptance and effectiveness across all measured dimensions.

Table 9: One-Sample t-Test (test if mean > 3)

Construct	**Sig. (2-tailed) < 0.05**	**Remarks**
Work Compatibility	0.000	Significantly higher than neutral
Perceive Usefulness	0.000	Significantly higher than neutral
Perceive Ease of Use	0.000	Significantly higher than neutral
Behavioral Intention	0.000	Significantly higher than neutral
Attitude Towards Use	0.000	Significantly higher than neutral

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Multiple regression analysis is a statistical technique for modeling the relationship between one continuous dependent variable and two or more independent (predictor) variables.

Table 10: Multiple Regression Analysis
(Behavioral Intention $R^2 = 0.78$)

Construct	**R Value**	**Sig (1-tailed)**	**Remarks**
Work Compatibility	0.838	0.000	Very strong positive predictor
Perceive Usefulness	0.795	0.000	Strong positive predictor
Perceive Ease of Use	0.521	0.001	Moderate positive predictor
Attitude Towards Use	0.704	0.000	Strong positive predictor

The multiple-regression model explains a very substantial 78.2 percent of the variance in users' behavioral intention to adopt the platform ($R^2 = 0.782$). All four predictors are highly significant ($p < .01$), with work compatibility exhibiting the strongest relationship ($r = .838$), followed closely by perceived usefulness ($r = .795$) and attitude toward use ($r = .704$). Perceived ease of use, while still significant, has a more moderate effect ($r = .521$). In practical terms, this tells us that users' intentions to engage with the audit platform are driven first and foremost by how well it fits into their existing workflows, then by its usefulness and their positive attitudes toward it, with ease of use playing a supportive—but less central—role.

This study synthesizes the core outcomes of the study on optimizing energy efficiency and power quality via the web-based audit platform at the private university in Mandaue City. Clear, well-organized tables present survey responses, expert assessments, and system performance logs. Each dataset is subjected to rigorous statistical analysis, descriptive measures, reliability testing, and regression, then enriched with narrative explanations that link the findings to the Technology Acceptance Model and relevant regulatory standards. Thus, the results from the empirical basis provide recommendations on how the platform fits into the university operations and inform practical guidelines for its institutional rollout.

User evaluations of core audit tools were uniformly positive: electrical-parameter functions ($M = 4.25$), lighting tools ($M = 4.09$), and energy-logging features ($M = 4.18$) all earned "Agree" to "Strongly agree" ratings for accuracy, reliability, and decision-support utility. In practice, these capabilities translated into actionable insights that facility managers used to reallocate equipment loads, optimize operating schedules, and detect phantom loads collective measures that yielded measurable energy savings and stabilized voltage profiles.

Furthermore, the platform's embedded compliance checks against the Philippine Electrical Code 2017 and OSHS Rule 1075 ensured continuous adherence to voltage-variation, harmonic-distortion, and illuminance standards, while ISO 25010–aligned features (safety, reliability, and maintainability) underpinned robust fault detection, self-healing diagnostics, modular updates, and secure user access.

The high acceptability across Technology Acceptance Model constructs work compatibility ($M = 4.57$), perceived usefulness ($M = 4.43$), perceived ease of use ($M = 4.47$), behavioral intention ($M = 4.54$), and attitude toward use

(M = 4.65) indicates that facility managers not only found the platform technically rigorous and standards-compliant but also intuitively accessible and valuable for ongoing energy-quality optimization. Collectively, these findings confirm the platform's effectiveness as an integrated solution for continuous, data-driven improvements in campus energy performance and electrical reliability.

Overall, the measurement instrument proved reliable and valid, with Cronbach's alpha values ranging from acceptable ($\alpha = 0.710$ for Perceived Ease of Use) to very good ($\alpha = 0.865$ for Behavioral Intention), confirming strong internal consistency across all five constructs. One-sample t-tests further showed that mean scores for work compatibility, perceived usefulness, perceived ease of use, attitude towards use, and behavioral intention all significantly exceeded the neutral midpoint ($p < .001$), indicating uniformly positive user perceptions of the web-based audit platform. Finally, a multiple-regression model accounted for 78.2 percent of the variance in behavioral intention ($R^2 = 0.782$), with work compatibility ($r = 0.838$), perceived usefulness ($r = 0.795$), and attitude towards use ($r = 0.704$) emerging as strong positive predictors and perceived ease of use ($r = 0.521$) playing a moderate yet significant supporting role.

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