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Linking Power Quality to User Satisfaction: The Moderating Role of Service Quality

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ABSTRACT

This confirmatory research aims to analyze the influence of electrical system performance, both technical and non-technical dimensions, on user satisfaction perceptions at the University of Papua (UNIPA), Manokwari, West Papua. As a major higher education institution in Eastern Indonesia, the reliability of electrical power infrastructure is a key driver in supporting academic and operational activities. This study uses a Partial Least Squares Structural Equation Modeling (PLS-SEM) approach with a purposive sampling technique on 100 respondents consisting of lecturers, educational staff, and students based on the intensity of use of campus facilities. The results of the structural model evaluation indicate that electrical power quality has a direct and significant effect on service quality and user satisfaction. The main findings reveal substantial R-Square values, namely 0.639 for the Service Quality variable and 0.939 for User Satisfaction. The findings revealed that electrical quality significantly influenced both service quality and user satisfaction. However, service quality did not have a significant direct effect on user satisfaction and did not significantly moderate the relationship between electrical quality and user satisfaction. These results suggest that, in the context of campus utility services, users prioritize the technical performance of electricity over complementary service attributes when forming satisfaction judgments.

INTRODUCTION

The availability and quality of electrical services are one of the basic prerequisites in supporting higher education activities. In the campus environment, the electrical system not only supplies energy for lighting and administrative equipment but also supports research activities, laboratories, technology classrooms, servers/ICT, and other critical supporting facilities for the learning process and university operations (Glover et al., 2012). Disruptions in electricity supply, voltage fluctuations, or low reliability indices can disrupt academic processes, reduce productivity, and incur unexpected costs for repairs and equipment replacement (Kundur, 1994).

The electrical system is an essential infrastructure in supporting the continuity of academic activities, research, and administrative services in higher education institutions. At the University of Papua (UNIPA) Manokwari, electricity is the backbone for the operation of various facilities, ranging from classrooms, laboratories, data centers, to public services. The reliability of the electrical system significantly determines the comfort and efficiency of academic activities. However, based on initial observations, the reality on the ground shows that the electricity supply at UNIPA still faces various challenges, such as voltage fluctuations, unannounced power outages, limited backup systems (generators/UPS), and slow technical responses. This condition has the potential to reduce productivity and user satisfaction with campus facilities, especially among students, lecturers, and educational staff (Owolabi et al., 2024).

Although electricity is included in campus supporting services, its influence on the perception of institutional quality as a whole cannot be ignored. User satisfaction is an important indicator in assessing the quality of infrastructure services. According to (Kotler & Keller, 2016), satisfaction arises when the services received meet or exceed user expectations. Therefore, a systematic analysis is needed to measure the performance of the electrical system and the extent to which it affects user satisfaction at UNIPA. The University of Papua has geographical characteristics, a tropical climate, and infrastructure conditions in eastern Indonesia that can be factors influencing the performance of the campus electrical system, including challenges in distribution, maintenance, and equipment protection. Weather conditions and climate variability have been shown to affect the reliability of electricity distribution, which poses a serious threat to the continuity of electricity supply along the distribution network (Aldhubaib et al., 2023). In addition, studies on the resilience of distribution networks show that environmental disturbances and extreme weather conditions can worsen the performance of the electrical system if technical mitigations are not adequately implemented (Rouholamini et al., 2025).

The transformation of campus energy needs due to increased use of laboratory equipment and information technology demands detailed performance analysis so that technical interventions and policies can be directed appropriately. Meanwhile, the relationship between electricity distribution reliability and user satisfaction indicates that the reliability aspect of the system plays an important role in users' perceived service quality (Neto et al., 2022). Nevertheless, studies linking technical performance measures of the electrical system with user satisfaction measurements in higher education environments, especially in the context of Papua, appear to be limited, thus this research fills that knowledge gap.

This research is practically expected to produce recommendations for improving maintenance, capacity planning, and service policies to enhance the continuity of campus operations and user satisfaction. Service quality management based on the SERVQUAL framework has been shown to significantly affect student satisfaction in the context of higher education, where service quality dimensions such as reliability, responsiveness, assurance, empathy, and tangible facilities correlate positively with student satisfaction (Amoako et al., 2023; Stankovska et al., 2024).

Scientifically, this research integrates technical indicators with user satisfaction variables based on the service quality framework (SERVQUAL) or its adaptation for infrastructure services, thus providing methodological contributions to facility management and energy management studies in higher education institutions. In addition, the review of the reliability of the electrical power system emphasizes the importance of maintenance strategies and planning to support the continuity of reliable and safe power network operations (Alvarez-Alvarado et al., 2022).

The main issue in this research is the unavailability of empirical data measuring the relationship between electrical system performance and user satisfaction levels in the campus environment of the University of Papua. Without this information, improvement efforts or policy-making by facility managers (University Leadership) tend to be unmeasurable. Based on this description, this study aims to analyze the performance of the electrical system (technical and non-technical) on user satisfaction perceptions using the Partial Least Squares (PLS) approach, as well as to formulate management recommendations that can enhance service quality and user and stakeholder satisfaction at UNIPA.

LITERATURE REVIEW

Performance of the Electrical System in Educational Facilities

A reliable and efficient electrical system is an important component in the operations of higher education institutions. According to (Kolokotsa et al., 2025), electrical reliability in the campus environment not only affects user comfort but also directly impacts the quality of learning and the productivity of the academic community. Common performance indicators used to assess electrical systems include voltage stability, frequency of outages, speed of disturbance handling, lighting quality, and the presence of backup systems such as generators or UPS (Jahangiri & Fotuhi-Firuzabad, 2008).

Several studies have examined the efficiency and reliability of electrical systems in campus areas. For example, research by (Tanjung, 2020) evaluated the distribution of electrical loads in faculty buildings to identify potential disturbances and overloading. Similar studies at Diponegoro University showed that

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consumption patterns and poorly monitored electrical systems could increase the risk of network disturbances and energy waste (Rahmawati et al., 2024).

User Satisfaction with the Electrical System

User satisfaction with the electrical system is assessed based on how well the service meets expectations in supporting academic and administrative activities. From a service management perspective, satisfaction is influenced by perceived quality, reliability, and comfort experienced by users (Kotler & Keller, 2016). Research by (Neto et al., 2022) indicates that electrical instability is one of the factors contributing to low user satisfaction with campus facilities.

The SERVQUAL model and the expectation–perception approach are often used to measure user satisfaction with public infrastructure, including electricity. However, in the context of campus electricity, the integration of technical variables (electric performance) with perceptual variables (user satisfaction) has not been systematically explored, especially in higher education institutions in eastern Indonesia such as West Papua.

Partial Least Square

Structural Equation Modeling (SEM) is a multivariate analysis technique used to identify linear relationships between latent variables and structural equation indicators or observed variables that cannot be measured directly simultaneously (Anggita et al., 2019). SEM is an extension of path analysis that allows researchers to test causal relationships between variables comprehensively and simultaneously (Abdullah, 2015). According to (Sandri, 2021), one of the main advantages of SEM is its ability to explain complex relationships between variables, including the direct and indirect effects of one variable on another. In general, SEM is divided into two main approaches, namely covariance-based SEM (CB-SEM) and variance-based SEM (VB-SEM), one of which includes the *Partial Least Square* (PLS) method (Haryono & Wardoyo, 2012).

Partial Least Square (PLS) is an alternative approach in SEM used to analyze the relationship between latent constructs and a number of indicators simultaneously. This method does not require the assumption of multivariate normal distribution, does not depend on a specific measurement scale, and can be applied to relatively small sample sizes, so it is often referred to as a soft *modeling* approach (Joseph F. Hair et al., 2017). PLS was developed to overcome the limitations of the *Ordinary Least Squares* (OLS) regression method, which determines the regression line by minimizing the sum of squares of differences between actual and predicted values, especially in data facing constraints such as small sample size, the existence of extreme data, multicollinearity, or missing data. These problems can be minimized through the application of *bootstrapping* techniques in PLS (Ghozali, 2011).

Conceptual Framework

In this research, the development of hypotheses and a conceptual model is carried out based on previous research by (Likumahwa, 2025) which studied the effect of electricity quality on user satisfaction, proven to play a role in influencing customer satisfaction levels from a technical aspect. However, in this study, the researcher attempts to examine the effect of electricity quality on user satisfaction from both technical and non-technical aspects. The technical aspects discussed in this study are voltage, frequency, and disturbances, while the non-technical aspects discussed in this study are price, accessbility, and assurance.

Electricity quality is one of the crucial factors that determine user satisfaction levels with energy provider services. Electricity quality is defined as the ability of the power system to provide power with voltage, frequency, and continuity parameters that comply with applicable standards (Targosz & Manson, 2008). In the context of user satisfaction, several dimensions of electricity quality that are often studied include voltage stability, frequency stability, as well as the frequency and duration of disturbances (interruptions).

Stable electrical voltage is one of the main indicators of power quality. Significant voltage deviations, whether in the form of sags or swells, can cause damage to electronic equipment and reduce the performance of electrical machines. Research by (Neto et al., 2022) in developing a customer satisfaction evaluation model based on voltage stability found that the more frequently customers experience voltage deviations, the lower their satisfaction level with the electricity provider significantly decreases. In addition, customers tend to have a tolerance threshold for voltage variations. If the voltage variation is still within standard limits (±5%–10% of nominal voltage), its impact on satisfaction is relatively small. However, when it exceeds that threshold, the decrease in user satisfaction increases sharply. Therefore, voltage becomes one of the dimensions in the electricity quality variable.

Electric frequency is another fundamental aspect of power quality. Frequency deviations can disrupt the performance of electrical equipment, especially in the industrial sector that uses synchronous machines (Machowski et al., 2020). Research by (Liubčuk et al., 2025) shows that frequency fluctuations have a significant impact on industrial customer satisfaction, although its effect on household customers is relatively smaller compared to voltage and supply continuity variables. Thus, frequency in this conceptual model has weights that vary depending on the type of user. For residential customers, frequency deviations may not be felt directly, but for industrial customers, frequency stability is very determining of their satisfaction.

Power disturbances or interruptions, whether in the form of short outages or long outages, are the factors most easily felt by users. Research shows that the frequency and duration of outages are inversely related to customer satisfaction (Reports, 2013). In other words, the more frequent and longer the outages occur, the lower the user satisfaction. The continuity of electricity supply without significant disturbances contributes to increased customer satisfaction in electricity service distribution, while reliability indicators such as frequency and duration of disturbances directly affect consumer perceptions of service quality (Neto et al., 2022). In addition, empirical research on urban electricity services found that the duration and frequency of outages negatively affect the satisfaction of rural electricity customers, providing evidence that frequent or long disturbances impact service perceptions (Andria et al., 2023).

Besides technical factors, non-technical aspects such as price/cost efficiency also play an important role in shaping electricity user satisfaction on campus. Research by (Rekettye & Pintér, 2006) shows that the perception of electricity prices is related to customer satisfaction levels, where consumers generally tend to be more accepting of costs that are deemed commensurate with the services received. Furthermore, studies in developing countries found that electricity price adjustments reflecting improved service quality can sustainably increase electricity user satisfaction (Mori, 2021). Empirical research in Indonesia also emphasizes that price is one of the significant factors influencing electricity customer satisfaction, along with other variables such as service quality and distribution (Ahsan et al., 2024).

Then, the ease of electrical access such as the availability of reliable electrical connections, sufficient power outlets, and responsive technical and maintenance services contributes to a better service experience and increases electricity user satisfaction in the Papua University environment. Studies show that the dimension of 'tangibles' reflecting physical evidence of electricity service quality, including connection facilities and network infrastructure, significantly influences electricity customer satisfaction (Neolaka et al., 2022). In addition, research on electricity distribution services in other regions also indicates that aspects of supply continuity, service access, and responsiveness to customer requests also affect satisfaction with electricity services (Mussa & Salum, 2022).

Moreover, the dimension of assurance is closely related to the trust of the academic community in electricity providers. Assurance of supply reliability, protection for high-value campus equipment, and certainty of continuous service will enhance users' sense of security and trust in electricity services. Research shows that the assurance dimension in the electricity service quality model contributes to customer satisfaction levels, as it encompasses aspects of trust and assurance of service quality perceived by customers (Albar, 2024; Mussa & Salum, 2022; Santosa Tri Prabawa, 2024). This is very important because damage to laboratory equipment due to poor electricity quality can cause significant losses for the university, both financially and in terms of educational service quality.

Thus, the conceptual model in this research, which incorporates price, ease of access, and assurance into the non-technical dimensions of electricity quality, becomes relevant in the context of higher education. The integration of these two aspects makes this research more comprehensive and presents novelty, as there has not been much research linking technical aspects of power quality with non-technical aspects of service quality simultaneously in the higher education sector. Therefore, the conceptual model used in this research is shown in Fig. 1:

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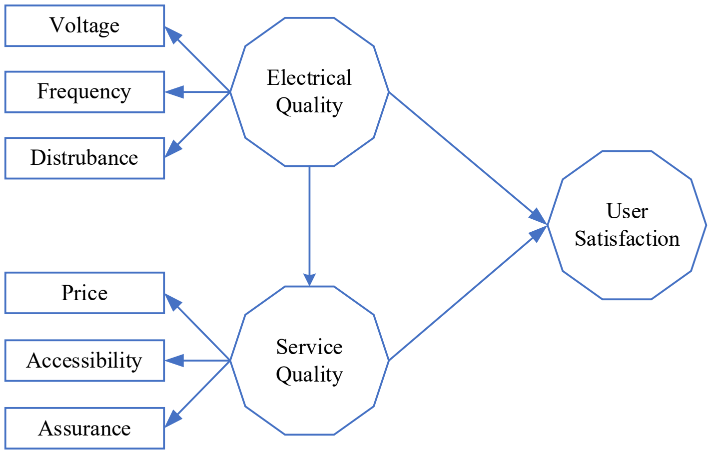

Fig. 1. Conceptual Framework

METHOD

This study employed an explanatory quantitative research design using the Partial Least Squares Structural Equation Modeling (PLS-SEM) approach. The justification for using PLS-SEM lies in its ability to handle complex relationship models involving numerous latent variables and indicators, as well as its robustness in dealing with data that do not follow a normal distribution. To assess statistical significance, this study applied the bootstrapping technique.

The sampling technique employed in this study was purposive sampling involving 100 respondents from Universitas Papua. The respondents consisted of lecturers, administrative staff, and students who met the predetermined inclusion criteria. The inclusion criteria were: (1) being an active lecturer, administrative staff member, or student at Universitas Papua; (2) regularly using campus facilities; and (3) having direct experience with electricity services within the UNIPA campus environment. Respondents who submitted incomplete questionnaires or had limited exposure to campus electricity services were excluded from the study. The application of these criteria was intended to ensure that participants possessed sufficient knowledge and experience to provide reliable assessments regarding electrical quality, service quality, and user satisfaction. Respondent characteristics can be seen in table 1.

Table 1. Respondent Characteristics

Characteristics	Frequency	Percentage (%)
Students	60	60%
Lecturers	25	25%
Administrative Staff	15	15%

The respondents consisted of students, lecturers, and administrative staff who regularly utilized campus facilities. The inclusion of these groups was intended to capture diverse perspectives regarding electricity services within the university environment. Then, the sample that will become the respondents will be given a questionnaire about "Analysis of Electrical System Performance on User Satisfaction in the Environment of the University of Papua (UNIPA) Manokwari." In determining the sample size, according to

(Chin. W. W., 1998), it is stated that the sample used in PLS can use two options, namely:

1. 10 times the largest formative indicator or;
2. 10 times the number of latent variables in the structural model.

The number of latent variables in this research is 3. Referring to the second point, the minimum sample that must be taken in this research is 10 × 3 = 30 samples. However, to prevent defective data, the sample is increased to 100 samples. Thus, the total sample is 100 people consisting of students, lecturers, and educational staff of UNIPA.

Validity testing was conducted to evaluate the accuracy and precision of the measurement instrument. Reliability testing was used to assess the extent to which the measurement scale exhibits a relatively stable level of consistency when repeatedly measuring the same subjects. Furthermore, partial least squares analysis was used to test the hypotheses.

The variables, dimensions, and indicators used in this research can be seen in Table 2, where there are 3 dimensions and 19 indicators that measure electrical quality, 3 dimensions and 15 indicators that measure service quality, and 5 indicators that measure user satisfaction.

All indicators were measured using a five-point Likert scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree). The questionnaire items were adapted from established studies and adjusted to the context of electrical services at Universitas Papua.

Table 2. Variables, Dimensions, and Indicators

Variables	Dimensions	Indicators	Code	Reference
Electrical Quality	Voltage	Electric voltage on campus rarely experiences drop's or increases that disrupt	VO1	(Alvarez-Alvarado et al., 2022); (Neto et al., 2022); (Kolokotsa et al., 2025)
		The electric voltage received is in accordance with the established standards	VO2	
		Damage to electronic equipment due to electric voltage issues on campus	VO3	
		The electric voltage on campus is stable and supports teaching and learning activities	VO4	
		Your electrical equipment functions well without being disturbed by voltage fluctuations	VO5	
		The impact of voltage fluctuations on the use of electronic devices on campus is very significant	VO6	
	Frequency	The frequency of power outages has decreased in recent years on campus	FR1	
		Rarely experiences equipment disruptions due to electrical frequency instability on campus	FR2	
		The duration of power outages affects your daily activities	FR3	
		The campus electricity you use has a stable frequency according to standards	FR4	
		The campus frequently experiences power outages in the last month	FR5	
		The impact of electrical frequency on the use of devices	FR6	
	Distrubance	Power outages on campus rarely occur	DI1	
		Electrical disturbances such as voltage spikes or drops on campus are quite fatal	DI2	
		Experiencing service disruptions due to electrical disturbances in the last month	DI3	
		Believe that the frequency of electrical disturbances affects overall satisfaction with electrical services	DI4	
		Power outages that occur usually do not last long	DI5	
		The campus's response time in handling electrical disturbance issues is quite good	DI6	

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Variables	Dimensions	Indicators	Code	Reference
		If a disturbance occurs, campus technicians respond quickly	DI7	
Service Quality	Price	Electricity usage at UNIPA is managed efficiently	PR1	
		Efforts to save electricity on campus are felt to be effective	PR2	
		Electrical facilities are comparable to the cost of education/campus services	PR3	
		Electricity management at UNIPA is conducted transparently	PR4	
		The benefits of available electrical facilities are in line with the operational costs incurred by the campus	PR5	
	Accessibility	Electrical facilities are available in all lecture rooms, offices, and laboratories	AC1	
		Access to electricity is easy for students and lecturers to support academic activities	AC2	
		Sockets, lighting, and electrical networks are sufficiently available on campus	AC3	(Alvarez-Alvarado et al., 2022); (Mussa & Salum, 2022)
		Information regarding maintenance/power outage schedules is clearly communicated to users	AC4	
		Campus electrical facilities can be accessed at any time according to academic needs	AC5	
	Assurance	Feel safe using electrical facilities on campus	AS1	
		Campus electrical installations are installed according to safety standards	AS2	
		The campus guarantees the reliability of electricity in supporting academic activities	AS3	
		Confident that campus electrical facilities can support academic activities sustainably	AS4	
		Sure's that the campus electrical system is managed according to the correct procedures	AS5	
User Satisfaction		Satisfied with the electrical technician services at UNIPA	US1	
		Electrical facilities support the comfort of learning, teaching, and working on campus	US2	
		In general, I am satisfied with the quality of the electrical system at UNIPA	US3	(Kotler & Keller, 2016); (Andria et al., 2023); (Neto et al., 2022)
		Willing to recommend UNIPA as a campus with good electrical facilities	US4	
		The electrical facilities on campus meet my expectations as a user	US5	

Research Hypothesis
The hypothesis used in this research can be seen in Figure 1. Where the figure shows the design of the research hypothesis, the formulation of the hypotheses is as follows:
H1: The quality of electricity has an effect/impact on user satisfaction.
H2: The quality of electricity has an effect/impact on service quality.
H3: Service quality has an effect/impact on user satisfaction.
H4: Service quality moderates the effect between electricity quality and user satisfaction.

RESULTS AND DISCUSSION

Research Results
Evaluation of Measurement Model
The evaluation of the measurement model aims to describe the relationship between latent variables and their indicators through reliability and validity testing. In this research, the validity assessment is focused on discri0 minant validity as the basis for model evaluation. Validity

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testing is conducted by referring to the outer loading value and Average Variance Extracted (AVE). Based on the results presented in Table 3, there are several indicators that do not meet the criteria because they have an outer loading value of less than 0.7, thus considered not to provide adequate contribution to the model. Therefore, the indicators VO4, FR3, PR1, PR5, AC4, and AS5 need to be eliminated from the measurement model. After improvements were made to the indicators by eliminating those that are invalid (< 0.7), there are still indicators that have an outer loading value of less than 0.7, namely VO6, FR5, FR6, DI1, and DI2, which must be removed again for model improvement. After improvements were made to the indicators by removing the invalid indicators (< 0.7), all indicators in the model are now valid because they have an outer loading value of > 0.7.

Table 3. Outer Loading Value Latent Variables

Variables	Dimensions	Indicators	Outer Loading	Modification_1	Modification_2
Electrical Quality	Voltage	VO1	0.803	0.775	0.738
		VO2	0.832	0.884	0.924
		VO3	0.824	0.879	0.923
		VO4	0.544	Eliminated	Eliminated
		VO5	0.832	0.800	0.761
		VO6	0.721	0.689	Eliminated
	Frequency	FR1	0.783	0.790	0.852
		FR2	0.823	0.820	0.876
		FR3	0.521	Eliminated	Eliminated
		FR4	0.822	0.799	0.774
		FR5	0.746	0.684	Eliminated
		FR6	0.715	0.626	Eliminated
	Distrubance	DI1	0.710	0.642	Eliminated
		DI2	0.723	0.649	Eliminated
		DI3	0.789	0.784	0.801
		DI4	0.700	0.706	0.739
		DI5	0.854	0.830	0.844
		DI6	0.813	0.803	0.820
		DI7	0.767	0.789	0.774
Service Quality	Price	PR1	0.659	Eliminated	Eliminated
		PR2	0.864	0.876	0.876
		PR3	0.724	0.796	0.796
		PR4	0.816	0.799	0.799
		PR5	0.632	Eliminated	Eliminated
	Accessibility	AC1	0.826	0.833	0.833
		AC2	0.803	0.782	0.782
		AC3	0.731	0.760	0.760
		AC4	0.461	Eliminated	Eliminated
		AC5	0.770	0.770	0.770
	Assurance	AS1	0.815	0.842	0.842
		AS2	0.820	0.814	0.814
		AS3	0.742	0.704	0.704
		AS4	0.765	0.808	0.808
		AS5	0.648	Eliminated	Eliminated
User Satisfaction		US1	0.791	0.791	0.792
		US2	0.804	0.783	0.787
		US3	0.886	0.887	0.889
		US4	0.795	0.789	0.785
		US5	0.789	0.786	0.781

Furthermore, convergent validity can be evaluated based on the Average Variance Extracted (AVE) value. Table 4 displays the AVE values for each latent variable in this study.

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Table 4. Average Variance Extracted Value

Variables	Average Variance Extracted	Description
Electrical Quality	0.656	Valid
Service Quality	0.653	Valid
User Satisfaction	0.653	Valid

In addition, the validity of the model can also be evaluated through discriminant validity testing, where each indicator is expected to have a higher correlation with the latent variable it measures compared to other latent variables. The assessment of this discriminant validity is conducted through cross loading value analysis, as presented in the following Table 5.

Table 5. Cross Loading Value

Variables	Dimensions	Indicators	Electrical Quality	Service Quality	User Satisfaction
Electrical Quality	Voltage	VO1	**0.98**	0.452	0.476
		VO2	**0.840**	0.570	0.774
		VO3	**0.830**	0.552	0.765
		VO5	**0.505**	0.409	0.492
	Frequency	FR1	**0.776**	0.579	0.759
		FR2	**0.846**	0.774	0.829
		FR4	**0.810**	0.596	0.602
	Distrubance	DI3	**0.747**	0.738	0.727
		DI4	**0.831**	0.562	0.767
		DI5	**0.857**	0.791	0.842
		DI6	**0.771**	0.583	0.761
		DI7	**0.710**	0.531	0.630
Service Quality	Price	PR2	0.809	**0.811**	0.805
		PR3	0.529	**0.838**	0.539
		PR4	0.724	**0.759**	0.758
	Accessibility	AC1	0.473	**0.487**	0.374
		AC2	0.392	**0.433**	0.406
		AC3	0.437	**0.485**	0.463
		AC5	0.381	**0.413**	0.366
	Assurance	AS1	0.594	**0.813**	0.600
		AS2	0.540	**0.827**	0.539
		AS3	0.455	**0.490**	0.461
		AS4	0.445	**0.549**	0.460
User Satisfaction		US1	0.734	0.753	**0.792**
		US2	0.787	0.598	**0.854**
		US3	0.878	0.835	**0.889**
		US4	0.747	0.524	**0.785**
		US5	0.662	0.538	**0.781**

Although indicators VO1, VO5, and AC1, AC2, AC3, and AC5 showed relatively smaller differences between their loadings on the intended construct and their cross-loadings on User Satisfaction, these indicators were retained because their loadings on the designated construct remained the highest among the other constructs and exceeded the recommended threshold. Furthermore, these indicators are theoretically important for representing the stress dimension of Electricity Quality.

Furthermore, the reliability of the measurement model is evaluated using composite reliability and Cronbach's alpha values. Based on the results shown in Table 6, all latent variables have composite reliability values above 0.7 and Cronbach's Alpha values exceeding the threshold of 0.6. Thus, it can be concluded that the indicators used are reliable and capable of reflecting the level of accuracy, consistency, and precision in measuring latent variables.

Table 6. Reliability Value

Variables	Composite Reliability	Cronbach's Alpha	Description
Electrical Quality	0.938	0.924	Reliabel
Service Quality	0.904	0.867	Reliabel
User Satisfaction	0.904	0.867	Reliabel

Evaluation of the Structural Model

The coefficient of determination or R-squared (R^2) is a measure used to assess the level of relationship between latent variables in the structural model. The results of the analysis of the coefficient of determination are presented in Table 7 below.

Table 7. Coefficient of Determination

Variables	R-Square
Service Quality	0.639
User Satisfaction	0.939

Based on the analysis results, the R^2 value for the service quality variable is 0.639, which indicates that 63.9% of its variation can be explained by the variables in the study. Meanwhile, the remaining 36.1% is influenced by other factors outside the study. Furthermore, the user satisfaction variable has an R^2 value of 0.939, which indicates that 93.9% of its variation can be explained by the variables in the study, while the remaining 6.1% is explained by other factors outside the study. Referring to (Ghozali, 2014), an R^2 value between 0.33-0.67 indicates that the model used falls into the moderate category or is quite good. Meanwhile, an R^2 value exceeding 0.67 indicates that the model used falls into the substantial or strong category. In this study, the evaluation of the structural model is also conducted through path coefficient analysis between latent variables. The testing includes both direct and indirect effects involving service quality as a moderating variable. The results of the path coefficient analysis are presented in Table 8 below.

Tabel 8. Path Coefficient between Latent Variables

Hipotesis	Path Coefficient	OriginalSample (β)	T Statistics (|O/STDEV|)	P Values	Description
H1	Electrical Quality → Service Quality	0,799	18.182	0.000	Significant
H2	Electrical Quality → User Satisfaction	0,879	16.584	0.000	Significant
H3	Service Quality → User Satisfaction	0,109	1.720	0.086	Not Significant
H4	Electrical Quality → Service Quality → User Satisfaction	0,087	1.759	0.079	Not Significant

In this study, the significance alpha used is 5% where t stat = 1.96. Based on the direct measurement results in Table 8, 4 hypotheses have significant effects. The first hypothesis with t stat = 18.182 > 1.96 or P Value = 0.000 < 0.05, thus H1 is accepted, which means the electrical quality variable has a significant effect on service quality. The second hypothesis with t stat = 16.584 > 1.96 and P Value = 0.000 < 0.05, thus H2 is accepted, which means the electrical quality variable has a significant effect on user satisfaction. The third hypothesis with t stat = 1.720 < 1.96 and P Value = 0.086 > 0.05, thus H3 is rejected. The rejection of the third hypothesis indicates that service quality does not have a significant effect on user satisfaction. This finding indicates that although users may assess service quality as good, their satisfaction is still more determined by the quality of electricity received. In the electricity sector, technical aspects such as supply continuity and voltage stability are the main factors that shape user satisfaction. Therefore, service quality acts as a supporting factor not the main determining factor of user satisfaction. The fourth hypothesis with a t stat value = 1.759 < 1.96 and a P Value = 0.079 > 0.05, thus H4 is rejected where the test results show that service quality does not moderate the effect of electrical quality on user satisfaction. This indicates that the effect of electrical quality on user satisfaction is direct and does not depend on the high or low quality of service. This condition can be explained because electricity is a core service that is directly felt by users, so disturbances in electrical quality cannot be compensated by good service quality. This finding is in line with the characteristics of the electricity sector, where technical aspects are more dominant than service aspects in shaping user satisfaction.

Discussion

Effect of Power Quality on Service Quality (H1)

The results of the hypothesis testing indicate that power quality has a significant effect on service quality at Universitas Papua. This finding confirms that the technical performance of the electrical system, including voltage

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stability, frequency stability, and the minimization of disturbances, constitutes a fundamental basis for shaping users' perceptions of electricity service quality on campus. Conceptually, electricity services differ from conventional services because electricity represents a core utility service, the outcomes of which are directly experienced by users without intermediaries (Alvarez-Alvarado et al., 2022). When voltage conditions are stable and power interruptions are infrequent, users tend to perceive that electricity services are well managed, responsive, and reliable. This result is consistent with the findings of (Neto et al., 2022), who reported that technical reliability indicators of power distribution systems directly influence customers' perceptions of service quality.

In the university context, reliable electricity enables academic activities to operate without disruption, including technology-based teaching and learning processes, laboratory activities, and digital administrative services. (Kolokotsa et al., 2025) emphasized that energy reliability in higher education institutions plays a critical role in enhancing overall perceptions of campus facility service quality.

Therefore, these findings support Hypothesis H1 and demonstrate that improvements in electricity service quality at Universitas Papua cannot be achieved without improving the technical quality of the power supply itself.

Effect of Power Quality on User Satisfaction (H2)

The analysis results reveal that power quality has a positive and significant effect on user satisfaction, with strong path coefficients and statistical significance. This finding indicates that user satisfaction with electricity services in the campus environment is largely determined by technical aspects rather than non-technical factors.

Customer satisfaction arises when perceived performance meets or exceeds expectations (Kotler & Keller, 2016). In electricity services, users' primary expectations relate to stable, reliable, and uninterrupted power supply. Frequent outages or poor power quality disrupt academic activities, increase the risk of damage to electrical and laboratory equipment, and reduce productivity, thereby directly lowering user satisfaction.

This result aligns with the study by (Andria et al., 2023), which demonstrated that the frequency and duration of power outages have a significant negative impact on customer satisfaction. Similarly, (Neto et al., 2022) found that voltage stability and supply continuity are among the most important determinants of customer satisfaction in electricity distribution services.

At Universitas Papua, dependence on electricity has increased significantly due to the growing use of digital learning platforms, technology-based laboratories, and campus information systems. Consequently, power quality has become a critical factor that directly shapes user experience and satisfaction levels.

Effect of Service Quality on User Satisfaction (H3)

In contrast to the previous hypotheses, the results show that service quality does not have a significant effect on user satisfaction. This suggests that although service aspects such as technician responsiveness, friendliness, and ease of access are important, they are insufficient to significantly improve user satisfaction when the technical quality of electricity supply is inadequate.

This phenomenon can be explained by the nature of electricity as a public utility service, in which users tend to emphasize outcome-based evaluations rather than process-based evaluations. (Alvarez-Alvarado et al., 2022) highlighted that in electricity services, technical reliability plays a more dominant role in shaping customer satisfaction than service interaction quality.

This finding is also consistent with the study by (Mussa & Salum, 2022), which reported that service quality dimensions primarily function as supporting factors, while power reliability and power quality remain the main determinants of electricity customer satisfaction.

Thus, although improvements in service quality remain necessary, the results indicate that user satisfaction with electricity services at Universitas Papua is predominantly driven by technical performance rather than administrative or procedural factors.

The non-significant effect of service quality on user satisfaction suggests that users within the university setting may prioritize the technical performance of electricity services over complementary service attributes. Unlike sectors characterized by intensive service interactions, electricity services are primarily evaluated based on their reliability, stability, and ability to support daily activities. Consequently, improvements in service quality alone may not necessarily translate into higher satisfaction levels when technical aspects remain the dominant concern.

The Moderating Role of Service Quality (H4)

The moderation analysis demonstrates that service quality does not moderate the relationship between power quality and user satisfaction. This implies that the influence of power quality on user satisfaction is direct and does not depend on the level of service quality.

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These findings reinforce the argument that in electricity services, technical failures cannot be compensated for by good service practices. Even when service personnel are responsive and service procedures are well organized, user satisfaction will remain low if power outages are frequent or power quality is poor. This aligns with the characteristics of electricity as an essential service, where technical performance is the primary concern of users (Alvarez-Alvarado et al., 2022). Accordingly, service quality serves only as a complementary factor rather than a determining one in shaping user satisfaction in electricity services.

The moderation analysis revealed that service quality did not significantly alter the relationship between electrical quality and user satisfaction. This finding indicates that users' evaluations of electricity services are predominantly shaped by the actual technical performance of the electrical system, regardless of their perceptions of complementary service attributes. Therefore, in the context of higher education institutions, maintaining stable voltage levels, consistent frequency, and minimizing disturbances may be more critical for enhancing user satisfaction than improvements in perceived service quality.

Theoretical Implications

This study contributes to the existing literature by integrating technical dimensions of electrical quality with non-technical dimensions of service quality within a higher education context. The findings further suggest that, for core utility services such as electricity, technical performance may outweigh service-related perceptions in shaping user satisfaction. These results extend existing service quality frameworks by highlighting the context-dependent nature of satisfaction determinants.

Unlike many SERVQUAL-based studies conducted in sectors characterized by intensive service interactions, the present findings indicate that users primarily evaluate electricity services based on their technical performance, including voltage stability, frequency consistency, and the absence of disturbances. Consequently, this study provides empirical evidence that the relative importance of service quality dimensions may vary depending on the nature of the service being assessed.

MANAGERIAL IMPLICATIONS

Based on the findings of this study, several managerial actions can be proposed to improve electrical quality and enhance user satisfaction within the university environment.

Short-term Actions

In the short term, university management should prioritize routine inspections of electrical installations and supporting equipment to identify potential issues before they escalate into major disruptions. Regular calibration and testing of backup generators are also necessary to ensure operational readiness during power interruptions. In addition, implementing preventive maintenance programs can help maintain the reliability and stability of the electrical system, thereby minimizing disturbances that may negatively affect user satisfaction.

Medium-term Actions

For medium-term improvements, the university should consider installing Automatic Voltage Regulators (AVRs) in strategic locations to maintain voltage stability and protect sensitive equipment from fluctuations. Furthermore, developing structured maintenance schedules supported by clear operational procedures may improve the effectiveness of maintenance activities and optimize the utilization of available resources.

Long-term Actions

In the long term, the implementation of smart metering systems is recommended to facilitate real-time monitoring of electricity consumption and system performance. Such systems can provide valuable information for identifying inefficiencies and supporting evidence-based decision-making. Moreover, the development of a comprehensive energy management system would enable the university to establish policies, targets, and continuous improvement strategies aimed at achieving sustainable energy utilization and improving the overall quality of electricity services on campus.

Overall, the findings suggest that strategies to improve user satisfaction with campus electricity services at Universitas Papua should prioritize improvements in the technical quality of the power supply, particularly voltage stability, frequency control, and the reduction of power disturbances. While service-related aspects such as accessibility and assurance remain important, they cannot substitute for the role of reliable and high-quality electricity supply.

These results contribute to the literature on energy management in higher education institutions, emphasizing the importance of a system reliability-based approach to enhancing user satisfaction and productivity (Kolokotsa et al., 2025; Neto et al., 2022).

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LIMITATIONS AND FUTURE RESEARCH

Limitation

This study has several limitations. First, the research was conducted in a single higher education institution, which may limit the generalizability of the findings to other contexts. Second, the study relied on self-reported perceptions obtained through questionnaires, which may be subject to response bias. Third, the cross-sectional nature of the study restricts the ability to infer causal relationships among the investigated constructs. Finally, other potential determinants of user satisfaction, such as institutional support and environmental factors, were not included in the present model.

Future Research

Future studies are encouraged to involve multiple universities from different geographical regions to enhance external validity. Longitudinal research designs may provide deeper insights into changes in user perceptions over time. Additionally, incorporating objective indicators of electrical performance, such as voltage fluctuation records and outage frequency data, may complement perception-based measures and strengthen the robustness of future investigations.

CONCLUSION

Based on the research results using the Partial Least Square (PLS) method, the evaluation results of the measurement model obtained show that there are 28 indicators that meet the modeling criteria. The R^2 value for the service quality variable is 63.9%, its variation can be explained by the variables in this study, while the remaining 36.1% is influenced by other factors outside the study. Then, for the user satisfaction variable, the R^2 value is 93.9%, its variation can be explained by the variables in the research model, while the remaining 6.1% is explained by other factors outside the model. Based on the structural evaluation results, it was found that the electrical quality variable has a direct and significant effect on the service quality variable. Then the electrical quality variable has a direct and significant effect on the user satisfaction variable. Meanwhile, the service quality variable has no effect on the user satisfaction variable and the service quality variable does not moderate the effect of electrical quality on user satisfaction.

The findings of this study contribute to the literature on energy management and service quality by demonstrating that technical aspects of electricity services are more influential than service-related perceptions in determining user satisfaction within higher education institutions. This suggests that satisfaction determinants may vary across service contexts, thereby emphasizing the importance of considering the distinctive characteristics of core utility services.

The study demonstrates that the integration of technical electrical quality dimensions and service-related dimensions provides a more comprehensive understanding of user satisfaction in campus utility settings. Importantly, the findings highlight that technical performance remains the primary determinant of satisfaction, thereby offering new insights into energy management practices within higher education institutions.

Recommendations for activities that contribute to the electricity of the University of Papua (UNIPA) based on voltage, frequency, and disturbances dimensions. The practices that can be carried out are as follows:

1. Recommendations for Voltage Variable Activities
   a. Installation and Optimization of Automatic Voltage Regulator (AVR)/Stabilizer (For example: installed in priority buildings: rectorate, certain faculties, laboratories, library, ICT server room to keep the voltage within the limits of 220 V ± 5%).
   b. Load Balancing Between Phases (For example: carried out by technicians every 6 months to reduce current imbalance between phases that causes voltage drop; this is suitable for large buildings with many electrical appliances).
   c. Increasing Cable and Panel Capacity/Infrastructure Upgrade (For example: replacing undersized cables, upgrading MCB/ACB if electrical load increases, reducing resistance and preventing voltage drop during high load).
   d. Installing Volt Logger for 24-Hour Monitoring (For example: monitoring voltage fluctuation trends with data used for stabilizer, UPS, or capacity upgrade analysis).
2. Recommendations for Frequency Variable Activities
   a. Periodic Calibration of UNIPA Generator Set (Genset) (For example: done every 3–4 months, controlling governor, genset AVR, and engine speed (RPM), this can keep the frequency stable at 50 Hz ± 0.5 Hz).
   b. Proper Load Synchronization (For example: avoiding frequency differences between machines where the synchronization process must use an automatic synchronizer).
   c. Genset Operator Training (For example: maintenance staff need routine training to maintain rpm settings, fuel pressure, and frequency control systems).
   d. Real-Time Frequency Monitoring (For example: digital frequency meter or smart monitoring panel placed in the main panel room).
3. Recommendations for Disturbance Variable Activities

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a. Installation of UPS on Critical Units (For example: in ICT servers, computer laboratories, administrative rooms, hybrid lecture rooms to prevent data loss, damaged devices, and disrupted academic processes).
b. Preventive Maintenance of Electrical Systems(For example: conducted at least every 3 months, including checking cable connections, cleaning panels from dust and insects, inspecting grounding, and testing MCB and ELCB protection)
c. Installing Surge Protection Devices(For example: to prevent equipment damage due to lightning, this device can also be installed on the main panel and sub-panels of the building.)
d. Mapping Sources of Disturbance(For example: Use a PQ Analyzer to view data on harmonics, sag/swell, lightning impulses, network noise so that this data will become the basis for upgrading the campus network.)
e. Intensive Coordination with PLN UP3 Manokwari(For example: to reduce external disturbances such as outages or network switching, then create an MoU regarding early notification before outages.)

4. Recommendations for Activities for Price Variables (Efficiency)
   a. Annual Energy Audit for All Buildings(For example: identifying points of excessive load (AC, water pumps, computers, lights) and determining priorities for repair and replacement of equipment.)
   b. Energy-Wasting Equipment Replacement Program(For example: replacing conventional lights with LEDs, replacing old AC units with energy-efficient inverter ACs, and standardizing energy-saving computers/laptops in laboratories.)
   c. Peak Load Management(For example: scheduling operational hours for ACs, lab machines, and energy-intensive equipment, scheduling shifts for heavy laboratory equipment usage to avoid congestion during peak load hours.)
   d. Implementation of Smart Metering in Every Building(For example: monitoring electricity usage in real-time, analyzing daily/weekly loads to identify waste, and reducing costs due to power overshoot or tariff discrepancies.)
   e. “UNIPA Energy Saving” Campaign Program(For example: socializing efficient electricity use for lecturers, staff, and students, installing energy-saving posters and automatic reminders in rooms.)
   f. Optimization of Generator and Solar Cell Usage(For example: operating generators only when absolutely necessary and developing a load-sharing scheme with renewable energy to save PLN distribution costs.)
5. Recommendations for Activities for Accessbility
   a. Creation of an Integrated Electricity Disturbance Reporting System (Application/Web)(For example: students/lecturers can report electrical disturbances in real-time, each report goes directly to technicians and is recorded in a monitoring dashboard.)
   b. Campus Electricity Information Center (Energy Helpdesk)(For example: providing a dedicated WhatsApp hotline for electricity and giving information on disturbance status, maintenance schedules, and repair durations.)
   c. Digital Information Board for Outages/Maintenance in Every Faculty(For example: containing PLN outage schedules, building maintenance, or panel replacements, this facilitates the entire community to know daily electricity conditions.)
   d. Mapping of Power Outlet Points and Electrical Facilities(For example: adding power outlets in classrooms, libraries, and public areas and ensuring all rooms have adequate power access.)
   e. Integration with PLN Mobile Reports(For example: coordinating with PLN so that disturbances in the campus area can be responded to more quickly.)
   f. Training on Electrical Equipment Usage for Lecturers & Staff(For example: basic training: MCB, UPS, management of electronic devices to reduce user errors that cause disturbances.)
6. Recommendations for Activities for Assurance Variables
   a. Routine Preventive Maintenance (PM) Program (For example: inspection of distribution panels, MCBs, cables, connectors every 1–3 months and replacement of old cables or equipment with potential short circuits.)
   b. Strengthening the Electrical Protection System (For example: adding good grounding in all buildings, installing surge arresters/SPD to protect IT devices from voltage spikes, and standardizing installations according to PUIL 2020).
   c. Installation of UPS (Uninterruptible Power Supply) for Critical Services (For example in server rooms, laboratories, classrooms, and administrative rooms).
   d. Standardization of SOP for Handling Electrical Disruptions (For example: quick response procedures for disruptions, having emergency shutdown SOPs, and SOPs to prevent voltage drops in laboratories).
   e. Creation of a Power Quality Monitoring Dashboard (For example: monitoring voltage, frequency, load, harmonics, automatic alarms in case of deviations).
   f. Official Cooperation with PLN for Supply Quality Assurance (For example: obtaining service priority for educational areas, coordinating maintenance

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schedules, so that supply facilities are more stable through service transformer upgrades).

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