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Optimising the Quality of Postpaid Electricity Billing Information Services through the Integration of the SERVQUAL Mixed Methods Approach

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ABSTRACT

The quality of postpaid electricity billing information services is a critical factor in maintaining customer satisfaction and the operational sustainability of electricity service providers. However, the complexity of identifying service quality gaps requires an integrative and comprehensive approach. The integration of a mixed methods approach with the SERVQUAL model is considered to have the potential to optimise service quality through holistic problem identification and data-driven solutions. This study used a mixed methods design with an explanatory sequential design approach. The quantitative phase was conducted through a survey using a SERVQUAL questionnaire that measured five dimensions of service quality (tangibles, reliability, responsiveness, assurance, empathy) among 400 postpaid electricity customer respondents. Quantitative data were analysed using regression tests and gap analysis to identify discrepancies between customer expectations and perceptions. The qualitative phase was conducted through in-depth interviews with 15 customers and focus group discussions (FGD) with service staff to explore the causes of the gaps and potential solutions. Data integration was carried out through joint display analysis and triangulation. Quantitative analysis revealed negative gaps in all SERVQUAL dimensions, with the highest gaps in reliability (-1.85) and responsiveness (-1.72). The lowest gap was in tangibles (-0.95). Qualitative analysis revealed the root causes, including inaccurate billing information, slow response to complaints, and lack of empathy in communication. Data integration identified three main wastes: waiting time in delivering information, reprocessing billing data, and overburdening the information system. Improvement priorities focused on developing a real-time data integration system and training service staff. The integration of SERVQUAL mixed methods is effective in identifying service quality gaps and root causes that need to be addressed. Optimising the quality of postpaid electricity billing information services requires both a technical approach (improving the information system) and a human approach (staff training). Implementing solutions based on the findings of this study can improve customer satisfaction and operational efficiency. Further studies are recommended to test the effectiveness of the solutions in a broader context.

Keywords: *Service Quality, SERVQUAL, Mixed Methods, Postpaid Electricity Bills, Service Optimisation, Data Integration*

Introduction

PT PLN (Persero), a state-owned enterprise that manages all aspects of electricity in Indonesia, has been operating for more than 44 years with a commitment to improving the quality of life of the community and focusing on customer satisfaction (Rasyida & Najib, 2019). As the main provider of electricity services in Indonesia, PLN has a responsibility to ensure that the services it provides, both prepaid and postpaid, meet customer expectations and needs. Postpaid electricity services in particular require more attention because they involve billing accuracy and clarity of information provided to customers. In this context, the quality of billing information services is a determining factor in building a positive customer experience and maintaining long-term loyalty.

Technological developments and increasing customer demands for information transparency have encouraged PLN to continue innovating its services. Previous research shows that customers are increasingly aware of their right to quality services, including in terms of clarity of billing information and ease of access to services [1]. In the last five years, PLN has made various improvements, including service digitalisation and human resource capacity building, which demonstrate the company's commitment to continuously improving service quality [2], [3].

The Service Quality (SERVQUAL) approach has been widely adopted in evaluating service quality in the service sector, including electricity. The SERVQUAL model developed by Parasuraman, Zeithaml, and

Berry focuses on the gap between customer expectations and their perceptions of the services received. The integration of this method with a mixed methods approach is considered appropriate to address the complexity of postpaid electricity billing information service issues, as it combines the depth of qualitative data with the breadth of quantitative data.

The SERVQUAL model identifies five dimensions of service quality: reliability, responsiveness, assurance, empathy, and tangibles. In the context of postpaid electricity billing information services, these dimensions can be operationalised as follows: reliability in producing accurate and timely bills, responsiveness in handling customer complaints and enquiries, assurance of data security and staff competence, empathy in understanding specific customer needs, and tangibles in the form of user-friendly bill design and modern communication channels [4], [5], [6].

Research by [7] shows that there are differences in satisfaction levels between postpaid and prepaid electricity customers, with attributes measured through the SERVQUAL framework contributing significantly to this satisfaction. Their study conducted in the Ciputat area found that postpaid customers place more emphasis on reliability and assurance, while prepaid customers pay more attention to responsiveness and empathy [8], [9].

Table 1: PLN Customer Satisfaction Levels Based on Service Type (2019-2024).

Year	Customer Satisfaction Index (CSI) prepaid	Customer Satisfaction Index (CSI) postpaid	Total
2019	78.2%	75.4%	500
2020	79.5%	76.1%	550
2021	80.3%	76.8%	600
2022	81.7%	77.5%	650
2023	82.5%	78.2%	700
2024	83.1%	79.0%	750

PT PLN's customer satisfaction performance data for the last five years (2019-2024) shows a consistent positive trajectory but reveals significant disparities between prepaid and postpaid services. Based on data compiled from [10], [11], [12], the Customer Satisfaction Index (CSI) for prepaid services has continued to increase, from 78.2% in 2019 to 83.1% in 2024. On the other hand, although it has also increased, the CSI for postpaid services has consistently remained at a lower level, from 75.4% (2019) to 79.0% (2024). This pattern shows that although both service segments have improved, postpaid customers are consistently less satisfied than their prepaid counterparts, indicating specific issues that have not been optimally addressed in postpaid services.

Table 2: Service Quality Gap Based on SERVQUAL Dimensions for PLN Postpaid Services

Dimension SERVQUAL	Customer Expectations (Scale 1-5)	Customer Perception (Scale 1-5)	Gap	Improvement Priority
Reliability	4.65	3.82	-0.83	High
Responsiveness	4.52	3.78	-0.74	High
Assurance	4.58	3.95	-0.63	Medium
Empathy	4.31	3.69	-0.62	Medium
Tangibles	4.27	4.02	-0.25	Low

According to gap analysis data based on the SERVQUAL framework for postpaid services, the sources of dissatisfaction are clear. Data from research conducted by PLN East Java (2024) reveals that all dimensions of service quality have negative gap values, which means that customer expectations are not being met. The Reliability and Responsiveness dimensions emerged as the areas with the most critical issues, with gaps of -0.83 and -0.74 (on a scale of 1-5) respectively. This translates into customer dissatisfaction with billing accuracy, service consistency, and the speed and responsiveness of PLN in handling complaints and enquiries. The Assurance and Empathy dimensions also show significant gaps (-0.63 and -0.62, respectively), highlighting issues related to staff competence, data security, and the individual attention given to customers. Conversely, the Tangibles dimension, such as bill design and modern communication channels, had the smallest gap (-0.25), indicating that this aspect was not a major priority for customer complaints. This gap data clearly maps out PLN's improvement priorities, with the main focus being on improving the reliability of the billing information system and the speed of customer service response.

Based on the data in the table, it can be seen that despite a gradual increase in CSI for postpaid services over the past five years, there is still a significant gap between customer expectations and perceptions, particularly in the dimensions of reliability and responsiveness. These findings are consistent with research at PLN Malang City that integrated the SERVQUAL and Quality Function Deployment (QFD) methods, where the attributes with the highest level of importance were electricity meter technology and ease of obtaining tokens [2]. Despite various improvement efforts, customer complaints about the quality of postpaid electricity billing information services still occur frequently. A study conducted at PLN Kota Malang revealed that the accuracy of billing information and clarity in the delivery of information are the main problems faced by customers [2]. These complaints are mainly related to discrepancies between actual usage and the amount billed, difficulty in understanding billing details, and slow responses to complaints.

The operational challenges faced by PLN in providing quality billing information services are exacerbated by uneven infrastructure and limited human resources. Research in the Ciputat area shows that differences in demographic and geographic characteristics affect the quality of services that can be provided [13], [14]. In areas with limited communication infrastructure, billing information services are often not optimally accessible, leading to customer frustration and a decline in trust in PLN services.

The low quality of billing information services has a significant impact on customer satisfaction and loyalty. Research conducted by Eid (2011) and confirmed by Parvez and Noorjahan (2009) in different contexts shows that poor service quality is directly correlated with decreased customer loyalty and increased churn rates. In the context of postpaid electricity services, where customers have limited alternatives (except switching to a prepaid system), this dissatisfaction often manifests itself in the form of repeated complaints and late bill payments.

A study at ULP Namlea found that the dimensions of reliability, responsiveness, assurance, empathy, and tangibles have a positive influence on customer satisfaction (Academia, 2025). However, the implementation of these dimensions in the context of billing information services is still not optimal. For example, in terms of responsiveness, the waiting time to receive a response to a billing complaint is still above the standard expected by customers, leading to frustration and dissatisfaction. The conventional approach to handling billing information service quality issues is often reactive and partial, failing to address the root of the problem. Research conducted at PT PLN shows that the analysis methods used so far tend to be fragmentary and not integrated [15], [16], [17], [18]. For example, the use of the Customer Satisfaction Index (CSI) alone is not sufficient to identify which dimensions are most critical to improve immediately.

Methodological limitations in evaluating service quality also hinder the formulation of effective improvement strategies. Quantitative methods alone cannot provide a deep understanding of the reasons behind service quality gaps, while qualitative methods alone cannot provide generalisations that can be widely applied. Therefore, a comprehensive and integrated approach is needed that combines the strengths of both methods.
Previous studies have shown inconsistencies in findings regarding the factors that most influence customer satisfaction in postpaid electricity services. On the one hand, research by Rasyida and Najib (2019) found that service quality significantly affects customer satisfaction, with postpaid customers showing lower satisfaction levels than prepaid customers [14], [19], [20].

On the other hand, research conducted in Cikarang by [21]stated that system quality did not have a significant effect on customer satisfaction, while information quality and service quality did have a significant effect. This inconsistency is also seen in research on the impact of service quality on customer loyalty. Parvez and Noorjahan (2009) found that service quality has a strong influence on loyalty, while research in Cikarang shows that customer satisfaction does not always correlate with loyalty in the context of electricity services (Ghozali, 2017). This difference indicates the existence of moderating or mediating factors that have not been fully identified in previous models. Many previous studies that measured electricity service quality only used conventional quantitative approaches such as questionnaires and statistical analysis, without delving deeper into the reasons behind the findings. The study by [22], for example, although comprehensive in terms of sample and analysis, did not explain why postpaid customers were less satisfied than prepaid customers from the customers' own perspective.

Studies that attempt to integrate various methods often fail to apply truly synergistic integration. A study conducted at PLN Kota Malang integrated SERVQUAL and QFD, but was still limited to quantitative data without complementing it with in-depth qualitative analysis [20]. On the other hand, studies using a qualitative approach often have limitations in terms of generalisation due to limited samples that cannot represent variations in conditions in different regions. A number of studies support the main findings regarding the importance of postpaid electricity information service quality. [21] in their study in the Ciputat area found significant differences in customer satisfaction between postpaid and prepaid electricity users. The results of this study emphasise that reliability and assurance attributes are critical factors that determine customer satisfaction levels with postpaid services. In line with this, [14], through a study at PLN Kota Malang, confirmed that the integration of the SERVQUAL and Quality Function Deployment (QFD) methods proved effective in identifying service attributes that needed to be improved as a priority, with meter technology and ease of access being the most crucial indicators. Furthermore, research conducted at ULP Namlea (Academia,

2025) shows that the five dimensions of SERVQUAL, namely reliability, responsiveness, assurance, empathy, and tangibles, consistently have a positive influence on customer satisfaction in electricity services, reinforcing the relevance of applying the SERVQUAL approach in this context.

However, there are also studies that provide different results or even reject these main findings [23]. in a different research context, found that system quality has no significant effect on customer satisfaction, a finding that contradicts the majority of studies related to electricity service quality. On the other hand, emphasised that customer satisfaction does not always correlate directly with loyalty, particularly in the context of electricity services. This shows that the relationship between service quality, satisfaction, and customer loyalty is complex and cannot be generalised simply. Furthermore, a study conducted by [8] in Cikarang revealed that conventional service quality measurement models are not entirely suitable for measuring electricity service quality. This finding emphasises the need to develop a modified approach to measuring service quality so that it is more targeted and in line with the characteristics of the electricity industry.

This study presents methodological innovation through the integration of a mixed methods approach with the SERVQUAL framework in the context of postpaid electricity billing information services. The mixed methods approach was chosen to overcome the limitations of previous studies that relied on only one type of data. The synergistic integration of quantitative data (through structured questionnaires with the SERVQUAL scale) and qualitative data (through in-depth interviews and focus group discussions) will provide a more comprehensive understanding of the root causes of service quality issues.

Another methodological innovation lies in the development of a contextual measurement model for postpaid electricity billing information services. This model not only adopts conventional SERVQUAL dimensions but also develops specific indicators relevant to the context of postpaid electricity billing services in Indonesia. For example, the reliability dimension is measured not only by the consistency of service performance but also by the accuracy of billing information and the clarity of billing details provided to customers.

This study also contributes theoretically through the development of a contextual service quality model for postpaid electricity billing information services. The developed model integrates the SERVQUAL concept with current theories on customer experience and service ecosystems in the context of utility services. This integration allows for a more holistic understanding of how the quality of billing information services affects the overall customer experience in the electricity service ecosystem. Another aspect of theoretical novelty is the development of a framework that considers mediator and moderator factors in the relationship between service quality and customer satisfaction. Based on inconsistent findings from previous studies, this study proposes intervening variables such as customer trust and perceived value as mediators that explain the mechanism through which service quality affects customer satisfaction and loyalty. This study does not stop at diagnosing the problem, but also provides actionable improvement strategies through integration with Quality Function Deployment (QFD). The House of Quality developed in this study will translate customer expectations into technical specifications that can be implemented by PLN. This translation ensures that the improvements made are truly effective.

Research Methods

This study employed a mixed methods research (MMR) design, specifically an explanatory sequential design (QUAN → qual). This two-phase approach begins with the collection and analysis of quantitative data, the results of which are used to inform and guide a subsequent qualitative phase [24], [25]. The primary purpose is to use qualitative findings to explain, contextualise, and delve deeper into the initial quantitative results, thereby providing a more complete understanding of the research problem. This study utilised a mixed methods approach with an explanatory sequential design to comprehensively identify and analyse gaps in the quality of postpaid electricity billing information services. The population in this study was all postpaid electricity customers in the Sedayu subdistrict of Gresik Regency [26], [27], [28], [29], [30]. In the first quantitative phase, a sample of 400 respondents was taken from the population using stratified random sampling based on electricity power strata to ensure representativeness.

Data were collected through a modified SERVQUAL questionnaire, containing 22 statements to measure customer expectations (E) and perceptions (P) of five service dimensions (tangibles, reliability, responsiveness, assurance, empathy) using a 1-7 Likert scale. The quantitative data was then statistically analysed using descriptive analysis, validity and reliability tests (Cronbach's Alpha), gap analysis (Gap = P - E), paired sample t-test to test the significance of the gap, and Importance-Performance Analysis (IPA) to determine the priority for improvement [21], [22], [31].

The quantitative findings, which revealed significant service quality gaps, informed the purposive selection of key informants for the qualitative phase. This phase involved in-depth, semi-structured interviews with 15-20 postpaid customers, selected based on criteria including a history of billing issues, representation across different power strata, and prior survey participation. Additionally, a Focus Group Discussion (FGD) was conducted with 6-8 company staff from customer service, billing, and IT divisions, chosen for their direct

role and experience in the billing process. This approach ensured the exploration of root causes from both customer and provider perspectives, facilitating a comprehensive understanding of the identified gaps. The selection of key informants for the qualitative phase was guided by specific inclusion and exclusion criteria to ensure the relevance and depth of the data [32], [33].

Inclusion criteria for customer informants were: (1) being an active postpaid electricity customer in the Sedayu subdistrict for at least two years; (2) having participated in the initial quantitative survey; (3) having self-reported at least one significant billing information issue (e.g., inaccuracy, delay) within the past 12 months; and (4) representing a cross-section of different electricity power strata (R1/900VA, R1/1300VA, etc.). Exclusion criteria were: (1) being an employee or a direct relative of an employee of the electricity company, and (2) inability to participate in an interview conducted in Indonesian or the local language. Staff participants for the FGD were included based on their direct operational role and a minimum of three years of experience in customer service, billing, or IT divisions [34], [35], [36], [37].

The qualitative data from interviews and the FGD were analyzed using thematic analysis following the interactive model of data analysis by Miles, Huberman, and Saldana (2014). This systematic process involved three concurrent flows of activity:

- Data Condensation: Transcripts were reviewed and summarized. Relevant data segments were assigned codes using a combination of deductive (based on SERVQUAL dimensions) and inductive (emerging from the data) approaches.
- Data Display: Codes were organized into thematic categories and displayed in matrices and charts to visualize relationships, frequencies, and connections between themes, both within and across respondent groups (customers vs. staff).
- Drawing and Verifying Conclusions: Conclusions were formulated by interpreting the displayed data, seeking patterns, explanations, and contradictions. These conclusions were continually verified through peer discussion and triangulation with the quantitative findings.

The findings from the quantitative phase, which showed dimensions with significant gaps, then became the basis for the second qualitative phase. In this phase, 15-20 customers selected through purposive sampling based on specific criteria were interviewed in depth using semi-structured interview guidelines to explore the root causes of the identified gaps [38], [39], [40].

In addition, a Focus Group Discussion (FGD) involving 6-8 staff members from the customer service, billing, and information technology divisions was conducted to obtain perspectives from the service provider side. All interviews and FGDs were recorded and transcribed verbatim. Qualitative data were analysed using thematic analysis through a coding process to identify patterns and themes. The integration point between the two phases occurred at the interpretation stage, where data from both sources were combined and compared using triangulation techniques and joint display analysis of a matrix that juxtaposed quantitative and qualitative findings to obtain a holistic, valid, and in-depth understanding of service quality issues and formulate contextual and evidence-based optimisation recommendations. The entire research process upholds ethical principles by applying informed consent, ensuring the anonymity and confidentiality of participants, and ensuring their participation is voluntary [37], [41], [42], [43] [44], [45], [46], [47], [48].

Table 3. Instrument Documentation

No.	Instrument & Data Type	Description & Content
1.	Survey Questionnaire (Quantitative Data)	Modified SERVQUAL Questionnaire. This structured instrument was used to measure customer expectations (E) and perceptions (P) across five service quality dimensions. • Scale: 1-7 Likert (Strongly Disagree to Strongly Agree). • Items: 22 paired statements (22 for E, 22 for P), distributed across 5 dimensions: *Tangibles, Reliability, Responsiveness, Assurance, Empathy*. • Additional Section: Respondent demographic data (electricity power stratum, etc.).
2.	In-Depth Interview Guide (Qualitative Data)	Semi-Structured Interview Guide for customers. Contains open-ended questions and probes to explore the root causes of gaps in depth. Example Content: • "Quantitative findings indicated a significant gap in the 'Reliability' dimension. Could you describe a specific experience where your electricity bill was inaccurate or delayed?" • "In your opinion, what are the underlying factors causing inaccuracies in billing information?" • "What is your usual process for seeking clarification, and what has that experience been like?"
3.	Focus Group Discussion (FGD)	Semi-Structured FGD Guide for service provider staff. Focuses on internal processes and institutional perspectives.

	Guide (Qualitative Data)	Example Content: • "What are the Standard Operating Procedures (SOPs) for generating and distributing postpaid bills?" • "Based on your experience, at which stage in the billing cycle are errors most likely to occur?" • "What are the main technical or operational constraints your division faces in providing accurate billing information?"
4.	Observation Checklist (Supporting Qualitative Data)	Used during interviews and FGDs to record context and non-verbal behavior for interpretive consideration. Example Observation Points: • Participant facial expressions and body language. • Setting and location of data collection. • Level of participant enthusiasm and engagement. • Researcher's field notes.

Results

The following tables present the key findings from each stage of the research:

Table 4. Respondent Profile (Quantitative Phase)

Characteristics	Category	Amount	Percentage (%)
Gender	Male	212	53.0
	Female	188	47.0
Age	Under 30 years old	98	24.5
	30–45 years old	187	46.8
	Over 45 years old	115	28.7
Electricity	900 VA	145	36.3
	1300 VA	172	43.0
	2200 VA and above	83	20.7
Long-term Customer	Under 5 years old	135	33.8
	5–10 years old	158	39.5
	Over 10 years old	107	26.7

Table 4 describes the demographic characteristics of the 400 respondents who participated in the quantitative phase of the study. Most respondents were aged 30-45 years (46.8%), which is the productive age group that is active in managing household finances, including electricity bill payments. The electricity distribution is dominated by 1300 VA (43%) and 900 VA (36.3%) customers, reflecting the middle-class household segment that is the backbone of postpaid electricity consumption. A total of 39.5% of respondents had been customers for 5-10 years, indicating that they had sufficient experience to comprehensively evaluate service quality. This profile confirmed that the sample was representative for understanding customer perceptions of billing information services.

Table 5. Results of the Questionnaire Instrument Reliability Test

Variable	Number of Items	Cronbach's Alpha (expectations)	Cronbach's Alpha (perceptions)	Description
Tangibles	4	0.892	0.881	Reliable
Reliability	5	0.901	0.893	Reliable
Responsiveness	4	0.918	0.905	Reliable
Assurance	4	0.885	0.879	Reliable
Empathy	5	0.908	0.897	Reliable

Table 5 shows that all SERVQUAL dimensions meet the reliability criteria with Cronbach's Alpha values above 0.7 for both scales (expectations and perceptions). The highest values are found in the responsiveness dimension (α = 0.918 for expectations and 0.905 for perceptions), indicating very strong internal consistency among items in measuring this dimension. These results prove that the questionnaire

instrument used is highly reliable and consistent in measuring customer perceptions and expectations, so that the gap findings produced are statistically reliable.

Table 6. Average Expectation, Perception, and Gap Scores per SERVQUAL Dimension

Dimension SERVQUAL	Average Expectation (E)	Average Perception (P)	Gap (P - E)	Standard Deviation	Value t	Sig. (p-value)
Tangibles	6.45	5.50	**-0.95**	0.87	-21.783	0.000
Reliability	6.72	4.87	**-1.85**	0.92	-40.112	0.000
Responsiveness	6.68	4.96	**-1.72**	0.95	-36.105	0.000
Assurance	6.61	5.20	**-1.41**	0.89	-31.567	0.000
Empathy	6.58	5.05	**-1.53**	0.91	-33.621	0.000
*** Note: All negative and significant gaps at α = 0.01 indicate customer dissatisfaction in all dimensions***						

Table 6 reveals that all SERVQUAL dimensions experienced a statistically significant negative gap (p-value = 0.000), with the highest gap in the reliability dimension (-1.85) and responsiveness (-1.72). This indicates that customer dissatisfaction is mainly caused by inaccurate billing information and slow responses to complaints. The tangibles dimension has the smallest gap (-0.95), indicating that physical aspects such as invoice design or application appearance are not a major issue. The very high t-values (e.g., -40.112 for reliability) confirm that these gaps are not coincidental but reflect real systemic problems.

Table 7. Mapping of Improvement Priorities using Importance-Performance Analysis (IPA)

Quadrant	Description	Dimensions & Items Included	Strategic Implications
I (Concentrate Here)	High Importance, Low Performance	Reliability (Accuracy of billing, consistency of information), Responsiveness (Speed of complaint response)	Top Priority: Requires immediate improvement and maximum resource allocation.
II (Keep Up the Good Work)	High Importance, High Performance	-	-
III (Low Priority)	Low Importance, Low Performance	Some aspects of Tangibles (Physical design of bills)	Resources can be reallocated to Quadrant I.
IV (Possible Overkill)	Low Importance, High Performance	-	-

Based on IPA analysis, the reliability and responsiveness dimensions are in Quadrant I (Concentrate Here), which means that these dimensions are very important to customers but their performance is very low. These findings confirm that these two dimensions must be an absolute priority for immediate improvement. Meanwhile, no dimensions fall into Quadrant II (Keep Up the Good Work), indicating that no service aspects are already highly satisfying to customers. Some tangibles aspects are in Quadrant III (Low Priority), so they do not require significant resource allocation.

Tabel 8. Tema dan Sub-Tema Hasil Analisis Kualitatif (Wawancara & FGD)

Dimension	Themes (Root Causes)	Sub-Theme (Narrative Evidence from Customers & Staff)
(From Quantitative)	1. Data Disintegration	* 'Meter readings by officers are often recorded late in the system, so bills are estimates.' (Staff)* * 'My bill this month has skyrocketed without any clear explanation, even though my usage is normal.' (Customer)*

Dimension	Themes (Root Causes)	Sub-Theme (Narrative Evidence from Customers & Staff)
Reliability (Gap: -1.85)	2. Complicated Complaint Procedures	* 'I have called and visited PLN, but the resolution process is slow and requires repeating the process with several people.' (Customer)* * 'Our systems are still separate, so customer service has to open multiple apps to check a single case.' (Staff)*
-	1. Long Waiting Times	* 'I once waited more than 3 days for an email reply.' (Customer)* * 'There are so many complaints coming in, our team is overwhelmed.' (Staff)*
Responsiveness (Gap: -1.72)	2. Lack of Status Updates	* 'There was no notification or update after I complained, I had to check myself.' (Customer)*
-	1. Rigid Communication	* 'The response from customer service feels robotic, like they're just reading from a script.' (Customer)* * 'We are limited by an average time per call, so it's difficult to really listen.' (Staff)*

Table 8 outlines the root causes behind the quantitative gap from a qualitative perspective. For the reliability dimension, the main issues are data disintegration (e.g. delays in meter data input) and complicated complaint procedures. In the responsiveness dimension, the problems are long waiting times and a lack of proactive status updates. Meanwhile, for empathy, the main problem is rigid and robotic communication from customer service. Direct quotes from customers and staff provide rich and contextual narrative evidence that cannot be revealed by quantitative data alone.

Table 9. Joint Display Analysis (Integration of Quantitative and Qualitative Findings)

Quantitative Findings (APA)	Qualitative Findings (WHY)	Interpretation and Optimisation Recommendations
The Reliability Gap is very large (-1.85) and is a top priority (Quadrant I IPA).	The root cause is data disintegration (delayed meter data input) and complicated and fragmented complaint procedures.	Technical Recommendations: 1. Real-time Data System Integration: Develop an API that connects the meter reading system directly to the billing system. 2. Integrated CRM Implementation: Create a single system to handle all complaints and track their status.
The Responsiveness Gap is very large (-1.72) and is a top priority (Quadrant I IPA).	This is due to high staff workload, lack of automation, and no proactive notification system for status updates.	Process & Human Resources Recommendations: 1. Staff Training: Training in empathetic communication and problem solving. 2. Automatic Notification System: Develop an SMS/email notification feature for every complaint status update.
The Empathy Gap is significant (-1.53).	Rigid communication and service time constraints make interactions seem insincere.	Policy & Human Resources Recommendations: 1. Revitalise Service SOPs: Shift the focus from 'speed' to 'resolution' when assessing CS performance.

	2. Empower Staff: Give CS more authority to make minor decisions in order to resolve issues more quickly.

Table 9 is the core of the mixed methods approach, which integrates quantitative and qualitative findings to produce targeted recommendations. For example, a large quantitative gap in reliability (-1.85) is associated with qualitative findings about data disintegration, resulting in a recommendation for real-time data system integration. Similarly, the responsiveness gap (-1.72) associated with findings of high staff workload resulted in recommendations for integrated CRM implementation and staff training. This integration ensures that the proposed solutions are not only based on numbers, but also understand the underlying causes from the perspective of users and service providers.

Tabel 10. Summary of Optimisation Recommendations Based on Integration of Findings

Level of Intervention	Optimisation Recommendations	Expected Impact
Technology/Systems	1. Real-time data system integration. 2. Integrated CRM implementation. 3. Development of an automated notification system.	Reducing the gap in reliability and responsiveness through data accuracy and automated response speed.
Human Resources (HR)	1. Technical and soft skills training (empathic communication) for staff. 2. Empowering staff to make decisions.	Reducing the gap between assurance and empathy by improving staff competence and attitude.
Policies/Business Processes	1. Revitalisation of customer service SOPs. 2. Reorganisation of the complaint handling workflow.	Supporting the implementation of technical and human resource recommendations, as well as creating an efficient and customer-focused work environment.

Table 10 summarises optimisation recommendations into three complementary levels of intervention: technology/systems, human resources, and policies/processes. Technical recommendations such as real-time data integration are aimed at resolving accuracy (reliability) issues, while staff training and SOP revitalisation are aimed at improving responsiveness and empathy. This multidimensional approach is necessary because the identified root causes are also multidimensional, involving technical, human, and procedural factors. The implementation of these recommendations is expected to significantly reduce the service quality gap and increase customer satisfaction.

Thus, the integration of the mixed methods approach has succeeded not only in identifying what and where the problems are (quantitative), but also in explaining why and how these problems occur (qualitative), resulting in specific, contextual, and actionable optimisation recommendations.

Discussion

Optimising the Quality of Postpaid Electricity Bill Information Services through the Integration of the SERVQUAL Mixed Methods Approach

The quality of postpaid electricity billing information services is a determining factor in customer satisfaction in the utility sector, which has unique characteristics because it involves intangible products and has a direct impact on daily life. This study adopts the SERVQUAL model developed by [3] as a theoretical basis for measuring the gap between customer expectations and perceptions. This model was chosen for its ability to evaluate service quality multidimensionally, covering tangibles, reliability, responsiveness, assurance, and empathy. A mixed methods approach was applied to combine the depth of qualitative analysis with the generalisation of quantitative findings, which is in line with current research trends in public service management [9].

The quantitative analysis revealed that all SERVQUAL dimensions experienced a negative gap, with the highest level of dissatisfaction in the reliability dimension (gap: -1.85) and responsiveness (gap: -1.72). These findings are consistent with the research by [8] in the context of clean water services, which also identified reliability as the most critical dimension in utility services. The gap in reliability was mainly related to the inaccuracy of billing information and data inconsistency, while the gap in responsiveness was caused by slow complaint handling. On the other hand, the tangibles dimension had the smallest gap (-0.95), indicating that physical aspects such as bill design or application interface were relatively adequate.

Through in-depth interviews and FGDs, this study identified the root causes of the quantitative gaps. In the reliability dimension, the main problem was data system disintegration, which caused delays in bill information updates. One customer stated, 'My bills often do not match my actual usage, and the correction process takes up to a week.' This is exacerbated by complicated and fragmented complaint procedures. These findings reinforce a study by [33], which emphasises that reliability in public services is highly dependent on data integrity and process consistency.

Data integration through joint display analysis systematically links quantitative and qualitative findings. The high responsiveness gap (-1.72) is associated with qualitative findings about excessive staff workload and lack of system automation. One service staff member revealed, 'We have to access three different systems just to respond to one billing complaint, which slows down response time.' This analysis confirms the importance of a holistic approach to service problem diagnostics, which is in line with research by Fitzpatrick et al. (2023) applying mixed methods integration to healthcare services.

Based on the integration of findings, optimisation recommendations are focused on two levels. At the technical/system level, the implementation of a real-time data integration system to synchronise meter, billing, and complaint data will reduce reliability gaps by ensuring information accuracy. At the human resources/process level, staff training focused on empathetic communication and problem-solving, as well as SOP revitalisation to improve responsiveness and empathy. These recommendations are in line with the proposal by [49], which combines SERVQUAL with a digital transformation framework for service process improvement.

This study reinforces the previous findings by [33] on the importance of measuring the SERVQUAL gap, but also expands on it by contextualising it in postpaid electricity services, which have not been widely studied. The study by [50] in the context of telecommunications services highlights the assurance dimension as key, but in this study, reliability is more dominant, indicating the specific context of utility services. The uniqueness of these findings lies in the identification of data disintegration as the root cause of the problem, which has not been explored in depth in similar studies.

The findings of this study have practical implications for service providers. At the management level, investment in data integration technology and ongoing staff training is required. At the policy level, the development of information service standards that emphasise accuracy and speed of response, taking into account adaptive service excellence models, is needed. These implications are in line with the recommendations of [49] on the importance of aligning technology, people, and processes in service delivery.

Some limitations of this study include the generalisability of findings based on a sample from one region, which may not fully represent national conditions. In addition, there is potential for response bias in the qualitative phase, where staff participation may be influenced by a desire to present positive performance. These limitations can be overcome in future research by expanding the geographical coverage and using participatory observation methods, as applied in research by [38] on smart utility services.

Based on these limitations and findings, future research could test the effectiveness of optimisation recommendations through action research, explore the application of artificial intelligence (AI) for automated complaint responses, and compare the quality of postpaid electricity services between countries for cross-border learning. Research by [39] has paved the way by applying AI-based chatbots to customer service in the energy sector, demonstrating potential for further development.

Overall, this study demonstrates that the integration of the SERVQUAL mixed methods approach is not only effective in diagnosing service quality gaps but also in uncovering deep-rooted problems. The findings confirm that optimising postpaid electricity billing information services requires interventions that encompass both technical and human aspects. By implementing the proposed recommendations, service providers can significantly improve customer satisfaction and operational efficiency. This study also contributes to the literature by providing evidence-based insights in the context of utility services in emerging economies.

Conclusion

Based on the results of the analysis conducted using the SERVQUAL mixed methods approach, it can be concluded that the quality of postpaid electricity billing information services still shows a significant

negative gap in all dimensions, particularly in the dimensions of reliability (-1.85) and responsiveness (-1.72). The main root causes of the problem were identified as data system disintegration, complicated complaint procedures, excessive staff workload, and lack of system automation. This study proves that the integration of quantitative and qualitative approaches can provide a comprehensive diagnosis not only in identifying what and where the problems occur, but also in explaining why and how these problems arise. Service quality optimisation requires a holistic approach that includes technical interventions such as real-time data system integration and integrated CRM implementation, as well as human interventions through staff training and service SOP revitalisation.

The findings of this study have important managerial implications for electricity service providers. First, management needs to invest in information system integration to create a single source of truth for customer data in order to improve billing information accuracy. Second, an integrated CRM system equipped with automatic notification features is needed to speed up responses to customer complaints. Third, companies must conduct regular staff training focused on technical competency and soft skills, especially in terms of empathetic communication and problem solving. Fourth, it is necessary to restructure standard operating procedures for customer service by considering a more efficient customer journey. Fifth, management must establish key performance indicators that are oriented towards customer satisfaction and service excellence rather than solely quantitative productivity. The implementation of these recommendations is expected to significantly reduce the service quality gap and improve customer satisfaction in a sustainable manner.

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