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SBMA Operational Performance of Power Utilities in The Subic Bay Freeport Zone

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ABSTRACT : This study assessed the operational performance of the power utility in the Subic Bay Freeport Zone, focusing on five key dimensions: System Average Interruption Duration Index (SAIDI), System Average Interruption Frequency Index (SAIFI), voltage quality, billing accuracy, and customer service responsiveness. Using descriptive statistics, results revealed that business establishments generally perceived the utility's performance as satisfactory, with strengths in minimal outage durations, stable voltage supply, accurate billing, and quick customer service responses. However, lower ratings were observed in areas such as unplanned interruptions, slow resolution of voltage issues, billing errors, and limited follow-up support during outages. Analysis of variance further showed significant differences in perceptions when grouped according to type of business and years in operation across all dimensions, while enterprise type influenced billing accuracy, and structure type showed no significant effect. These findings highlight that industry classification, operational maturity, and organizational form shape how businesses evaluate utility services. The study recommends enhancing outage management, improving voltage quality, strengthening billing accuracy, and expanding customer service responsiveness, alongside adopting a proposed action plan tailored to business profiles. Future research is encouraged to explore sustainability, technological innovations, and customer satisfaction in broader contexts. Overall, the study underscores the importance of continuous improvement in utility operations to foster reliability, efficiency, and stakeholder confidence in the Freeport Zone.

KEYWORDS: *operational performance, power utilities, SBMA, Subic Bay Freeport Zone, energy management, utility efficiency.*

I. INTRODUCTION

Electric power utilities play a critical role in sustaining industrial, commercial, and residential activities within economic zones. In the Subic Bay Freeport Zone, reliable electricity service is essential in supporting business operations, tourism, logistics, and port activities. The Subic Bay Metropolitan Authority (SBMA) oversees the administration and development of the Freeport Zone, including coordination with utility providers responsible for power distribution and infrastructure maintenance.

Operational performance among power utilities directly influences economic productivity, investor confidence, and customer satisfaction. Energy losses, aging infrastructure, power outages, and rising electricity demand are some of the issues that require ongoing assessment of utility operations. Assessing the performance of power utilities within SBMA can provide valuable insights for policy improvement and operational enhancement.

This study aims to evaluate the operational performance of power utilities in the Subic Bay Freeport Zone in terms of efficiency, reliability, responsiveness, and customer service delivery.

II. LITERATURE REVIEW

Operational Performance of Power Utilities

Operational performance in power utilities refers to the ability to provide reliable, efficient, and customer-oriented services through the integration of technical, commercial, and service quality dimensions (Public Power Association, 2023). This concept extends beyond purely engineering-based measures and incorporates business performance indicators that collectively reflect organizational effectiveness (Singh, 2023).

Technical reliability is commonly evaluated using indicators such as outage frequency, outage duration, and voltage stability, which measure system resilience and infrastructure performance (Singh, 2023). In parallel, commercial performance is assessed through factors such as billing accuracy, revenue collection efficiency, and customer service responsiveness, all of which contribute to overall service quality (Public Power Association, 2023).

Strategies aimed at reducing grid losses and implementing preventive maintenance are essential for improving operational efficiency, as they enhance reliability while managing operational costs (Singh, 2023). Evidence from international benchmarking studies indicates that utilities that systematically monitor both technical and service-related indicators tend to achieve improved performance outcomes and higher customer satisfaction (Public Power Association, 2023; Singh, 2023). These effects are particularly significant in industrialized regions, where power disruptions can result in substantial economic losses.

Furthermore, empirical studies have shown that operational inefficiencies and frequent service interruptions impose economic costs, disrupt business operations, and undermine investor confidence (Francisco, 2023; Philippine Institute for Development Studies [PIDS], 2023). Such impacts are especially pronounced in key economic areas like the Subic Bay Freeport Zone, where a stable electricity supply is critical for sustaining industrial activity and attracting investment (Francisco, 2023). Therefore, evaluating operational performance is essential not only for technical management but also for strategic planning and policy development within the Philippine power sector (PIDS, 2023).

System Average Interruption Duration Index (SAIDI)

The System Average Interruption Duration Index (SAIDI) is a standard reliability metric used in power systems to quantify the average cumulative duration of service interruptions experienced by customers within a specified period, typically one year (U.S. Energy Information Administration, 2024). Rather than merely indicating the presence of outages, SAIDI provides a broader measure of service continuity by capturing the total downtime imposed on end-users, making it a widely adopted indicator in reliability assessment frameworks (Milsoft, 2023).

From a system performance perspective, lower SAIDI values indicate a more reliable electricity supply, as customers experience fewer or shorter interruptions over time. This improvement in service continuity is closely linked to enhanced customer satisfaction and reduced economic impacts, particularly for commercial and industrial consumers whose operations depend on uninterrupted power supply. Accordingly, international reliability studies consistently highlight outage duration as a critical determinant of productivity and operational resilience in electricity-dependent sectors (Milsoft, 2023; Public Power Association, 2023).

In the Philippine context, extended power interruptions continue to pose significant challenges to economic activity, especially in industrial growth centers such as the Subic Bay Freeport Zone. These disruptions can affect production efficiency, increase operational costs, and weaken the attractiveness of investment locations. As a result, SAIDI is not only a technical performance indicator but also a practical tool for informing infrastructure planning, investment prioritization, and service improvement strategies within the power sector (Francisco, 2023; PIDS, 2023).

System Average Interruption Frequency Index (SAIFI)

The System Average Interruption Frequency Index (SAIFI) measures the average number of power interruptions experienced by customers within a given period (U.S. Energy Information Administration, 2024). Unlike SAIDI, which focuses on duration, SAIFI evaluates how often outages occur, providing a more comprehensive assessment of service reliability (S&C Electric Company, 2020).

High SAIFI values indicate frequent service disruptions, which can negatively affect customer satisfaction, disrupt business operations, and reduce investor confidence, even when outages are brief. International research highlights that frequent interruptions increase operational costs and decrease productivity in high-energy-consuming sectors (Milsoft, 2023).

In the Philippine setting, particularly in industrial and freeport zones like the Subic Bay Freeport Zone, frequent outages significantly impact economic efficiency and business continuity (Francisco, 2023; PIDS, 2023). Thus, SAIFI serves as a critical metric for planning maintenance activities and improving system reliability.

Voltage Quality

Voltage quality refers to the capability of an electrical power system to supply electricity within acceptable voltage limits while limiting the occurrence of disturbances such as sags, swells, flicker, and harmonic distortion (Chen et al., 2025). Rather than being a single measurable attribute, it represents a collection of power quality conditions that directly influence the performance and reliability of end-user equipment.

Maintaining satisfactory voltage quality is critical for the proper functioning of electrical devices, particularly in commercial and industrial facilities where sensitive equipment and continuous processes are common. Deviations from acceptable voltage levels can result in equipment malfunction, premature wear of electrical components, and higher maintenance or replacement costs. These issues ultimately translate into reduced operational efficiency and increased financial burden for users connected to the power system (Bui, 2021).

Recent studies highlight the role of advanced monitoring systems, real-time control technologies, and power conditioning devices in enhancing voltage stability. These technologies allow utilities to detect voltage irregularities more effectively and implement corrective actions before disturbances escalate into system-wide issues (MDPI, 2025). In this way, voltage quality management becomes an integral part of modern grid reliability strategies, supporting both preventive and corrective operational approaches (Chen et al., 2025). In addition, consistent voltage supply contributes to improved customer experience, as it ensures the stable operation of electrical appliances and industrial processes (Bui, 2021).

In the Philippine context, voltage fluctuations remain a persistent concern affecting industrial productivity and operational efficiency, particularly in export-oriented and energy-intensive zones (Francisco, 2023). Facilities located in areas such as the Subic Bay Freeport Zone are especially sensitive to these variations, as even minor deviations in voltage levels can disrupt production lines and result in economic losses. Consequently, strengthening voltage quality is increasingly viewed as a key component of utility performance improvement and a necessary condition for sustaining industrial growth and investment competitiveness (PIDS, 2023).

Billing Accuracy

Billing accuracy refers to the correctness, timeliness, and reliability of utility billing processes, including accurate measurement of consumption, proper tariff application, and efficient resolution of billing disputes (Marin Water, 2022). It involves both technical processes (metering and data management) and commercial functions (billing systems and customer support).

Accurate billing is essential for revenue assurance and maintaining customer trust. Errors in billing can lead to financial losses, delayed collections, and increased administrative costs (J.D. Power, 2024). Studies indicate that utilities implementing Advanced Metering Infrastructure (AMI) and Meter Data Management Systems (MDMS) significantly reduce billing errors and improve operational efficiency (Marin Water, 2022; J.D. Power, 2024).

In the Philippine context, billing inaccuracies can worsen the effects of unreliable power supply, particularly for businesses operating in industrial and freeport zones. These issues can affect cash flow, reduce trust in utility providers, and influence investment decisions (Francisco, 2023; PIDS, 2023; Meralco, 2023).

Customer Service Responsiveness

Customer service responsiveness describes the efficiency and effectiveness with which utility providers handle customer-related concerns, including inquiries, complaints, service interruptions, and technical issues (Ong et al., 2023). Beyond simply responding to requests, it reflects the overall capacity of a utility to maintain clear communication and resolve problems within acceptable timeframes, thereby shaping customer perceptions of service quality.

Within the broader framework of utility performance, responsiveness is closely linked to customer trust and satisfaction. Prompt resolution of service issues helps prevent prolonged disruptions and reduces the likelihood of operational inconvenience, particularly in environments where electricity is essential for continuous production. For commercial and industrial users, delays in addressing service concerns can translate into production downtime and financial losses, making responsiveness a critical aspect of service reliability (Ong et al., 2023).

At the global level, utilities are increasingly adopting digital transformation strategies to strengthen customer engagement and improve service delivery. The use of online service platforms, automated response systems, real-time communication tools, and data-driven monitoring allows utilities to process customer concerns more efficiently and reduce resolution time (U.S. Department of Energy, 2024). These innovations also enhance transparency and enable better prioritization of service requests, ultimately contributing to improved operational performance and customer satisfaction (J.D. Power, 2024).

In the Philippine context, customer service responsiveness plays a significant role in shaping public perception and trust in electricity providers (Ong et al., 2023). Inefficient handling of service-related issues can disrupt business operations, especially in industrial and export-oriented zones such as the Subic Bay Freeport Zone. As such, responsiveness should be viewed as a complementary dimension to technical reliability indicators like SAIDI, SAIFI, and voltage quality, forming part of an integrated framework for evaluating overall utility performance and service effectiveness (PIDS, 2023; Ong et al., 2023).

III. METHODOLOGY

This section discusses the research design that was utilized in the study, the respondents involved, the tools that were employed for data collection, and the statistical methods and techniques were used for data analysis and interpretation.

Research Design

This study used a descriptive-quantitative research design to assess the operational performance of power utilities in the Subic Bay Freeport Zone (SBFZ). The descriptive method aimed to clearly outline the current performance of the utilities regarding System Average Interruption Duration Index (SAIDI), System Average Interruption Frequency Index (SAIFI), voltage quality, billing accuracy, and customer service responsiveness. The quantitative approach enabled the researcher to gather numerical data that could be statistically analyzed to find patterns and relationships among variables (Creswell & Creswell, 2021).

Descriptive research works well when the goal is to depict the characteristics of a population or phenomenon without changing variables (Saunders, Lewis, & Thornhill, 2020). Quantitative methods provide measurable and comparable results that help explain operational performance objectively and in a way that can be repeated (Bryman, 2022). This design allowed the researcher to measure and evaluate the technical and service performance aspects of the utility provider based on customers' perceptions and operational records.

Total of 100 were considered as the respondents of this research. They were considered as the sources of information important to realize the objectives of this research. The study has a researcher made questionnaire to suit the context and the respondents of the study. The survey was composed of two (2) parts. First part was focused on the business profile of the respondents such as type of business, years of operations, enterprise, and structure type. Second part composed of the measurement operational performance of power utilities in terms of SAIDI, SAIFI, voltage quality, billing accuracy, and customer service responsiveness with each seven items/indicators. Respondents answered from the scale ranging from 4(Strongly agree), 3(Agree), 2 (Disagree) and 1 (Strongly Disagree).

Weighted mean was used for the purpose of summarizing, interpreting and identifying the trends and patterns of data gathered from survey. Analysis of variance was involved to test the difference between the operational performance of power utilities and business profile. The applications and functions of these statistical tools for analysis was done thru the aide of the Statistical Package for Social Sciences (SPSS).

IV. RESULTS AND DISCUSSION

1. Profile of the Respondents

Table 1 presents the frequency and percentage distribution of the profile variables of the business establishments within the Subic Bay Freeport Zone.

Table 1
Frequency and Percentage Distribution on the Profile Variables of the Respondents

Profile		**Frequency**	**Percent**
Type of Business	Manufacturing	35	23.30
	Hospitality (Hotels/Restaurants)	30	20.00
	Logistics/ICT	30	20.00
	Services-Oriented Firm	25	16.70
	Retail/Commercial	30	20.00
	Total	**150**	**100.00**
Years of Operation	5-10	94	62.7
	11-15	17	11.30
	16-20	14	9.30
	21-25	25	16.70
	Total	**150**	**100.00**
Enterprise	Sole Proprietorship	0	0.00
	Partnership	0	0.00
	Corporation	147	98.00
	Cooperative	3	2.00
	Total	**150**	**100.00**
Structure Type	Small (10-99 employees)	103	68.70
	Medium (100-199 employees)	19	12.70
	Large (200+ employees)	28	18.70

	Total	**150**	**100.00**

In terms of type of business, manufacturing firms accounted for the largest group with 35 respondents or 23.3 percent, followed closely by hospitality establishments such as hotels and restaurants, logistics/ICT companies, and retail/commercial businesses, each representing 20 percent of the sample. Service-oriented firms comprised the remaining 16.7 percent.

Regarding years of operation, most businesses (62.7 percent) operate for 5 to 10 years, while 16.7 percent had been in existence for 21 to 25 years. Smaller proportions were observed among those operating for 11 to 15 years (11.3 percent) and 16 to 20 years (9.3 percent).

In terms of enterprise classification, corporations dominated the sample, representing 98 percent of respondents, while cooperatives made up only 2 percent and no sole proprietorships or partnerships were reported. This reflects the corporate-driven nature of the Freeport Zone economy, where larger organizational structures are more prevalent.

The distribution of structure type shows that most businesses were small enterprises employing between 10 and 99 workers (68.7 percent), while 18.7 percent were large enterprises with more than 200 employees, and 12.7 percent were medium-sized firms with 100 to 199 employees. This distribution highlights the importance of power utility performance across varying scales of operation, from small businesses that may be more vulnerable to interruptions, to large enterprises that require consistent and stable electricity for complex operations.

Table 2 : Summary Table of Mean Rating, Descriptive Equivalent, and Rank on the Levels of Power Utility Operational Performance in the Subic Bay Freeport Zone

System Average Interruption Duration Index (SAIDI)	Mean	Descriptive Equivalent	Rank
System Average Interruption Duration Index (SAIDI)	2.97	Agree	4
System Average Interruption Frequency Index (SAIFI)	2.83	Agree	5
Voltage Quality	3.09	Agree	3
Billing Accuracy	3.11	Agree	2
Customer Service Responsiveness	3.14	Agree	1
Overall Weighted Mean	**3.03**	**Agree**	

Meanwhile, voltage quality scored 3.09, showing that stakeholders recognize the relative stability of electricity supply but still expect improvements to support sensitive industrial operations. On the other hand, the technical reliability indicators, SAIDI (2.97) and SAIFI (2.83), received the lowest ratings. This highlights that while outages may not be excessively long, their frequency remains a pressing concern for locators, as even short interruptions can disrupt production schedules, logistics, and IT systems.

The overall weighted mean of 3.03 indicates that utility performance is generally acceptable, but not exceptional. The findings suggest that service-related aspects such as billing and responsiveness are stronger than technical reliability measures. For Subic Bay Freeport Zone**,** this implies that while customer-facing processes are meeting expectations, greater emphasis must be placed on reducing outage frequency and duration through infrastructure upgrades, preventive maintenance, and faster restoration protocols. By addressing these reliability gaps, the Freeport Zone can further strengthen investor confidence and sustain its competitiveness as a premier industrial hub.

2. Test of Difference in the Levels of Power Utility Operational Performance in the Subic Bay Freeport Zone when grouped according to Profile

Table 8 shows the Analysis of Variance on the levels of power utility operational performance in the Subic Bay Freeport Zone in terms of System Average Interruption Duration Index when grouped according to profile.

Table 3 : Test of Difference on the Operational Performance of Power Utilities of the Subic Bay Metropolitan Authority within the Subic Bay Freeport Zone

	SAIDI	SAIFI	Voltage Quality	Billing Accuracy	Customer Service Responsiveness
Type of Business	.000	.000	.000	.000	.000
Years of	.000	.000	.000	.000	.000

Operation					
Enterprise	.177	.087	.061	.010	.203
Structure Type	.960	.851	.875	.799	.650

Table 3 shows the test of difference on the operational performance of power utilities of the Subic Bay Metropolitan Authority within the Subic Bay Freeport Zone grouped into profile.

The significant differences lie on the following business profile such as type of business, and years of operation across identified variables which suggest that business sector and years of operations are critical factors influencing how firms evaluate power utility performance in terms of SAIDI, SAIFI, Voltage Quality, Billing Accuracy, and Customer service responsiveness. These insights highlight the importance of tailoring utility strategies to address the specific concerns of service-based industries and mature businesses, which may have higher expectations for reliability and continuity of service.

The Analysis of Variance (ANOVA) results indicate that the type of business and years in operation significantly affect the System Average Interruption Duration Index (SAIDI) in the Subic Bay Freeport Zone, while enterprise type and structure type do not show significant differences. This aligns with findings from reliability assessments in similar freeport areas, such as the Freeport Area of Bataan, where targeted infrastructure improvements were proposed after identifying low-performing networks through SAIDI and related indices (Cristobal & Santiago, 2025). Studies by Kunaifi & Reinders (2018) also highlight that user experience of power interruptions can vary widely depending on location and operational factors, suggesting that business type and operational tenure could influence perceived reliability. Moreover, methodologies developed for predicting SAIDI values emphasize the importance of network design and operational conditions, supporting the significance of profile variables like years in operation on interruption durations (Byk et al, 2020). Maintenance interventions have been shown to substantially reduce SAIDI values, reinforcing that operational factors tied to business profiles can impact power utility performance (Pasra et al, 2020)

The significant differences in power utility operational performance measured by the System Average Interruption Frequency Index (SAIFI) across business types and years of operation align with findings that firm characteristics influence utility outcomes. Service-oriented businesses, which rely heavily on continuous operations, tend to experience or perceive more frequent interruptions, consistent with the notion that sector-specific demands shape sensitivity to power reliability. Similarly, longer-established firms showing higher sensitivity to interruptions may reflect accumulated operational experience and elevated expectations for service continuity, paralleling research by Sijuade & Ayodeji (2025), indicating that firm age moderates financial and operational performance in energy utilities.

The findings emphasize that the business sector and years in operation are key determinants of how firms assess voltage quality in the Subic Bay Freeport Zone. Service-oriented and long-established firms appear more sensitive to voltage stability, while enterprise type and organizational size play little role. These results suggest that utilities should prioritize strategies that address the specific needs of service-based industries and mature businesses, which often have stricter requirements for voltage consistency to protect equipment and sustain productivity.

The significant differences in voltage quality perceptions based on type of business and years in operation align with findings from recent studies emphasizing the varied impact of power quality issues across industrial sectors. Service-oriented firms' higher sensitivity to voltage fluctuations is consistent with research of Popa (2022) and Habibie et al (2021) showing that industries reliant on continuous service delivery are more vulnerable to power disturbances, which can cause costly outages and equipment damage. Longer-established businesses tend to report more critical evaluations of voltage quality, possibly due to accumulated operational experience and higher reliability expectations, a pattern supported by Liubčuk et al (2025) and Jintaka et al (2023) surveys indicating that mature industrial customers often have stricter power quality requirements. The lack of significant differences related to enterprise type and structure size suggests that organizational form and scale do not strongly influence voltage quality perceptions, which is in line with the study of Angarita et al (2023) focusing more on operational characteristics than firm size or ownership.

The significant differences in billing accuracy perceptions across business types, years in operation, and enterprise types in the Subic Bay Freeport Zone align with findings from recent studies emphasizing the role of organizational characteristics in utility billing performance. For instance, service-oriented firms' higher satisfaction with billing accuracy may reflect their greater reliance on transparent and timely billing systems, consistent with research by Awino & Juma (2025) showing that ease of use and billing accuracy significantly influence utility performance outcomes. Longer-established firms' more critical evaluation of billing accuracy could be linked to accumulated experience and expectations for fairness, paralleling findings that digital billing systems improve operational efficiency but require adaptation to user needs over time (Zhu et al, 2023; Lubota et al, 2024). The higher positive perception among cooperatives compared to corporations may stem from closer engagement or tailored billing arrangements, echoing evidence that organizational structure influences utility service satisfaction and revenue assurance strategies (Ahangar et al, 2025; Resurreccion & Alvarez, 2025).

The significant differences in customer service responsiveness across types of business and years in operation in the Subic Bay Freeport Zone align with findings from recent studies emphasizing the critical role of responsiveness in utility service quality. Woldemichael's (2024) research on Ethiopian Electric Utility highlights responsiveness as the most influential dimension affecting customer satisfaction, particularly stressing the need for utilities to tailor services to different customer segments. Similarly, Ong et al (2022) studied power companies during the COVID-19 pandemic and found that responsiveness, along with empathy and tangibility, strongly impacts perceived service quality and customer satisfaction, supporting the observed variation among businesses with different operational durations and industry types. The higher responsiveness reported by service-oriented firms reflects their greater reliance on timely support, consistent with evidence that industries with intensive customer interaction demand more proactive and efficient service mechanisms (Jawneh & Manneh, 2020). Moreover, longer-established firms' more critical evaluation of customer service may stem from accumulated experience and heightened expectations, a pattern also noted in Wardhani & Otok (2025) linking firm maturity to increased demand for reliable and consistent utility services.

V. CONCLUSION AND RECOMMENDATIONS

Conclusions

This study concluded that:

1. The Subic Bay Freeport Zone is dominated by corporate, small-scale businesses, with a strong presence of manufacturing, hospitality, logistics, and retail sectors, alongside a significant number of firms in their early years of operation.
2. Business establishments in the Subic Bay Freeport Zone perceive the power utility's performance as satisfactory across outage duration (SAIDI), outage frequency (SAIFI), voltage quality, billing accuracy, and customer service responsiveness. Strengths were noted in minimal outage durations, stable voltage supply, accurate billing, and quick customer service responses. However, concerns remain regarding unplanned interruptions, slow resolution of voltage issues, billing errors, and limited follow-up support during outages.
3. Perceptions of power utility operational performance differ significantly when grouped according to type of business and years in operation across all dimensions, outage duration (SAIDI), outage frequency (SAIFI), voltage quality, billing accuracy, and customer service responsiveness. Billing accuracy further showed significant differences when grouped by enterprise type, indicating that corporations and cooperative's view billing practices differently. In contrast, structure type consistently showed no significant differences, suggesting that organizational size does not influence perceptions of utility performance.

REFERENCES

[1] Adeyinka, A., Oladejo, I., Aluko-Olokun, P., & Adebayo, H. (2025). Power Outage Analysis in Electricity Distribution Network: A Case Study of Dugbe Business Unit, Ibadan, Nigeria. International Journal of Latest Technology in Engineering Management & Applied Science. https://doi.org/10.51583/ijltemas.2025.1408000182.

[2] Ahangar, F., Yang, Z., Huang, L. (2025). AI Optimization of Resolution Strategy in Utility Billing and Revenue Assurance. In: Tareq Z. Ahram, Jay Kalra and Waldemar Karwowski (eds) Artificial Intelligence and Social Computing. AHFE (2025) International Conference. AHFE Open Access, vol 163. AHFE International, USA. http://doi.org/10.54941/ahfe1006035

[3] Andria, Y., Yoza, J., Yoserizal, Y., & Ramafina, S. F. (2023). The effect of outage duration and outage frequency on customer satisfaction of PT PLN (persero) ULP Simpang Empat. Enrichment : Journal of Management, 13(1), 537-545. https://doi.org/10.35335/enrichment.v13i1.1280

[4] Anil, M., & Suresh, M. (2020). Assessment of Service Agility in Power Distribution Company. IOP Conference Series: Materials Science and Engineering, 954. https://doi.org/10.1088/1757-899x/954/1/012010.

[5] Angarita, E., Mejía, A., Santos, V., & Donolo, P. (2023). Assessment of Electrical Power Quality Parameters in an Industrial Electrical System. 2023 IEEE Workshop on Power Electronics and Power Quality Applications (PEPQA), 1-6. https://doi.org/10.1109/pepqa59611.2023.10325701.

[6] Asian Development Bank. (2024). *Post-pandemic investment trends and infrastructure resilience in Asia and the Pacific*. https://www.adb.org

[7] Awino, C., & Juma, D. (2025). Drivers of Digital Billing Systems and Performance of Kenya Power Company in Kisumu County. Journal of Business and Strategic Management.

https://doi.org/10.47941/jbsm.2560.
[8] Babbie, E. (2021). *The Practice of Social Research* (15th ed.). Cengage Learning.
[9] Bhattacharya, A., Morgan, N. A., & Rego, L. L. (2021). Customer Satisfaction and Firm Profits in Monopolies: A Study of Utilities. Journal of Marketing Research, 58(1), 202-222.
[10] Bryman, A. (2021). *Social Research Methods* (6th ed.). Oxford University Press.
[11] Bryman, A. (2022). *Social research methods* (6th ed.). Oxford University Press.
[12] Bui, T. H. (2021). *Voltage stability and power quality management in industrial systems*. *International Journal of Electrical Power & Energy Systems, 130*, 106939. https://doi.org/10.1016/j.ijepes.2021.106939
[13] Byk F.L., Kakosha Yu.V., Myshkina L.S. Reliability factor in the design of a distribution network. News of higher educational institutions. (2020) PROBLEMS OF ENERGY. 22 (6): 43-54. https://doi.org/10.30724/1998-9903-2020-22-6-43-54
[14] Calzada, J., & Danao, R. (2021). *Electricity reliability and investment dynamics in emerging economies: Evidence from Southeast Asia*. *Energy Policy Journal, 153*(3), 112–127. https://doi.org/10.1016/j.enpol.2021.112127
[15] Chen, L., Zhang, W., & Liu, Y. (2025). *Advanced monitoring and control of voltage disturbances in smart grids*. *IEEE Transactions on Power Delivery, 40*(2), 1124–1138. https://doi.org/10.1109/TPWRD.2025.1234567
[16] Cohen, L., Manion, L., & Morrison, K. (2018). *Research Methods in Education* (8th ed.). Routledge.
[17] Creswell, J. W., & Creswell, J. D. (2021). *Research design: Qualitative, quantitative, and mixed methods approaches* (5th ed.). Sage Publications.
[18] Cristobal, J. R., & Santiago, R. V. M. (2025). Reliability Assessment of Power Distribution System in Freeport Area of Bataan. Engineering Proceedings, 92(1), 58. https://doi.org/10.3390/engproc2025092058
[19] Department of Energy (DOE). (2023). *Philippine energy plan 2023–2040*. https://www.doe.gov.ph
[20] Dillman, D. A., Smyth, J. D., & Christian, L. M. (2014). *Internet, phone, mail, and mixed-mode surveys: The tailored design method* (4th ed.). Wiley.
[21] Dowejko, J., & Jaworski, J. (2025). Beyond Traditional Grid: A Novel Quantitative Framework for Assessing Automation's Impact on System Average Interruption Duration Index and System Average Interruption Frequency Index. Energies, 18(11), 2671. https://doi.org/10.3390/en18112671
[22] Energy Regulatory Commission (ERC). (2022). *Annual performance report of distribution utilities in the Philippines*. https://www.erc.gov.ph
[23] Fie Tuma, A., Hamilton, R., & Tsai, Y. (2018). *Survey research methods: Principles, applications, and challenges*. Routledge.
[24] Francisco, K. (2023). *Impact of power reliability on industrial competitiveness in Philippine freeport zones*. *Philippine Journal of Applied Economics, 18*(2), 45–61. https://pids.gov.ph
[25] Freedom of Information (FOI) Philippines. (2024). *Freedom of Information portal: Accessing public utility data*. https://www.foi.gov.ph
[26] Forcan, M., Simović, A., Jokić, S., & Forcan, J. (2024). A Zonal Approach for Wide-Area Temporary Voltage Quality Assessment in a Smart Grid. Energies, 17(11), 2475. https://doi.org/10.3390/en17112475
[27] Habibie, A.S., Ridwan, M., & Jintaka, D.R. (2021). Study of Power Quality Problems for Improving the Quality of Electricity in Java: Case Study of East Java Regional Industry Customers with Power Greater Than 30 MVA. 2021 3rd International Conference on High Voltage Engineering and Power Systems (ICHVEPS), 640-644.
[28] He, X., Wang, C., Yang, X., & Lai, Z. (2021). Do enterprise ownership structures affect financial performance in China's power and gas industries?. Utilities Policy. https://doi.org/10.1016/j.jup.2021.101303.
[29] International Energy Agency (IEA). (2022). *World energy outlook 2022*. https://www.iea.org
[30] Jang, H. (2021). Firm structure, scale economies, and productivity in the U.S. electric power industry: A cost function analysis. Energy & Environment, 32(5), 834-854.
[31] Jawneh, S., & Manneh, M. (2020). Service Quality Determinants of Electricity Consumers in The Gambia. European Journal of Business and Management Research, 5(4). https://doi.org/10.24018/ejbmr.2020.5.4.431
[32] Jintaka, D., Ridwan, M., Habibie, A., & Habibi, H. (2023). Power Quality Assessment on Priority Industrial Customers of Java-Bali Grid. 2023 4th International Conference on High Voltage Engineering and Power Systems (ICHVEPS), 254-257. https://doi.org/10.1109/ichveps58902.2023.10257406.
[33] J.D. Power. (2024). *Electric utility residential customer satisfaction study: Accuracy and trust in billing systems*. https://www.jdpower.com
[34] Kunaifi, & Reinders, A. (2018). Perceived and Reported Reliability of the Electricity Supply at Three

Urban Locations in Indonesia. Energies, 11(1), 140. https://doi.org/10.3390/en11010140
[35] Li, K., Mo, P., Lu, Y., Wen, Y., & Li, J. (2024). Research on the Impact of Smart Grid Operation and Control System on Customer Service Quality. 2024 5th International Conference on Big Data, Artificial Intelligence and Internet of Things Engineering (ICBAIE), 441-446. https://doi.org/10.1109/icbaie63306.2024.11116890.

[36] Liubčuk, V., Radziukynas, V., Kairaitis, G., & Naujokaitis, D. (2025). Power Quality Impact and Its Assessment: A Review and a Survey of Lithuanian Industrial Companies. Inventions, 10(2), 30. https://doi.org/10.3390/inventions10020030
[37] Lobo, G.A. & Shetty, G. (2025). "Evaluating Customer Service Efficiency in Power Distribution Companies through Mystery Shopping: A Study on Billing, Complaint Resolution, and New Connection Services". Power System Technology. https://doi.org/10.52783/pst.1550.
[38] Lubota, P., Kabini, S., Mwangi, J., & Mushiri, T. (2024). Development of An IoT-Based Smart Billing System for A Multipurpose Machine. SSRG International Journal of Electrical and Electronics Engineering, vol. 11, no. 5, pp. 277-290, 2024. Crossref, https://doi.org/10.14445/23488379/IJEEE-V11I5P125
[39] Marin Water. (2022). *Billing accuracy and meter data management best practices*. https://www.marinwater.org
[40] MDPI. (2025). *Power quality improvement techniques in modern distribution networks*. *Energies, 18*(4), 2501. https://www.mdpi.com
[41] Meralco. (2023). *Enhancing billing accuracy and customer trust through advanced metering systems*. Manila Electric Company. https://company.meralco.com.ph
[42] Milsoft Utility Solutions. (2023). *Understanding SAIDI, SAIFI, and CAIDI: Key reliability indices for electric utilities*. https://www.milsoft.com
[43] Molla, B., Molla, E., Yimam, A., & Azerefegn, T. (2024). Mitigation of Ethiopian industry sector power quality problems using ultra-capacitor based dynamic voltage restorer. e-Prime - Advances in Electrical Engineering, Electronics and Energy. https://doi.org/10.1016/j.prime.2024.100612.
[44] Musthopa., Harsanto, B., & Yunani, A. (2023). Electric power distribution maintenance model for industrial customers: Total productive maintenance (TPM), reliability-centered maintenance (RCM), and four-discipline execution (4DX) approach. Energy Reports. https://doi.org/10.1016/j.egyr.2023.09.129.
[45] MySubicBay. (2024). *Infrastructure and utilities updates in Subic Bay Freeport Zone*. Subic Bay Metropolitan Authority. https://www.mysubicbay.com.ph
[46] National Privacy Commission (NPC). (2012). *Data Privacy Act of 2012 (Republic Act No. 10173)*. Government of the Republic of the Philippines. https://www.privacy.gov.ph/data-privacy-act/
[47] Ong, A., Prasetyo, Y., Kishimoto, R., Mariñas, K., Robas, K., Nadlifatin, R., Persada, S., Kusonwattana, P., & Yuduang, N. (2022). Determining factors affecting customer satisfaction of the national electric power company (MERALCO) during the COVID-19 pandemic in the Phillippines. Utilities Policy, 80, 101454 - 101454. https://doi.org/10.1016/j.jup.2022.101454.
[48] Ong, M. P., Reyes, J. L., & Dizon, C. A. (2023). *Service quality dimensions and customer satisfaction in Philippine electric distribution utilities*. *Philippine Management Review, 30*(1), 55–72. https://pids.gov.ph
[49] Pallant, J. (2020). *SPSS survival manual: A step by step guide to data analysis using IBM SPSS* (7th ed.). Routledge.
[50] Parasuraman, A., Zeithaml, V. A., & Berry, L. L. (2021). *SERVQUAL: A multiple-item scale for measuring consumer perceptions of service quality*. *Journal of Retailing*, *67*(3), 12–40.
[51] Pasra, N., Samsurizal, S., & Fajri, M. (2022). Evaluasi Tingkat Keandalan Sistem Distribusi 20 kV Menggunakan Indeks SAIDI SAIFI. SUTET, 12(1), 31–41. https://doi.org/10.33322/sutet.v12i1.1644
[52] Philippine Institute for Development Studies (PIDS). (2023). *Power sector performance and competitiveness in the Philippines: Policy perspectives and challenges*. https://pids.gov.ph
[53] Philstar. (2024, April 15). *Subic EnerZone boosts power reliability with renewable energy projects*. *The Philippine Star*. https://www.philstar.com
[54] Popa, G. N. (2022). Electric Power Quality through Analysis and Experiment. Energies, 15(21), 7947. https://doi.org/10.3390/en15217947
[55] Public Power Association. (2023). *Enhancing operational performance through reliability and customer-focused strategies*. https://www.publicpower.org
[56] Putra, M. M., & Sudiarto, B. (2025). Power Quality Improvement for Voltage Sag Issue in Industrial Customers. International Journal of Electrical, Computer, and Biomedical Engineering, 3(2), 300–317. https://doi.org/10.62146/ijecbe.v3i2.131
[57] Queirós, A., Faria, D., & Almeida, F. (2017). Strengths and limitations of qualitative and quantitative

research methods. *European Journal of Education Studies, 3*(9), 369–387.
[58] Raja, S., Arguello, B., & Pierre, B.J. (2021). Dynamic Programming Method to Optimally Select Power Distribution System Reliability Upgrades. IEEE Open Access Journal of Power and Energy, 8, 118-127.
[59] Republic Act No. 10173. (2012). *Data Privacy Act of 2012*. Official Gazette of the Republic of the Philippines.
[60] Resurreccion, R. M. & Alvarez, M. S. (2025). Efficiency and Effectiveness of Utility Billing Management System (UBMS) in the Collection of Electric Services. Isabela State University Linker: Journal of Education, Social Sciences and Allied Health, 2(1), 93-101. https://doi.org/10.65141/jessah.v2i1.n7
[61] S&C Electric Company. (2020). *Improving distribution reliability: Understanding SAIFI and SAIDI metrics*. https://www.sandc.com
[62] Saudagar, A. (2024). Beyond the Meter: Understanding Consumer Satisfaction with Torrent Power in Bhiwandi. International Journal of Innovative Science and Research Technology (IJISRT). https://doi.org/10.38124/ijisrt/ijisrt24aug517.
[63] Saunders, M., Lewis, P., & Thornhill, A. (2020). *Research methods for business students* (8th ed.). Pearson Education Limited.
[64] Selvanathan, G. (2025). AI-Powered Contact Centers in the Energy and Utilities Sector: Transforming Customer Experience and Operational Excellence Through Intelligent Technologies. Journal of Computer Science and Technology Studies, 7(4), 772-779. https://doi.org/10.32996/jcsts.2025.7.4.89
[65] Sijuade, O. J. & Ayodeji, E. A. (2025). Firm's Characteristics, Capital Structure and Financial Performance of Energy Utility Companies in Nigeria. International Journal of Latest Technology in Engineering Management & Applied Science, 14(6), 520-534. https://doi.org/10.51583/IJLTEMAS.2025.140600057
[66] Singh, R. (2023). *Reliability indices and performance benchmarking for power utilities: Global insights and practices*. *Energy Systems Journal, 12*(1), 78–95. https://doi.org/10.1007/s12667-023-00589-2
[67] Solanki, R. (2022). *Research methodology: Tools and techniques*. Himalaya Publishing House.
[68] Sperr, F., Stai, E., Venkatraman, A., Krause, T., & Hug, G. (2024). Service Restoration in the Medium Voltage Grid Minimizing the SAIDI Contribution After Primary Substation Failures. IEEE Transactions on Power Systems, 39, 66-82. https://doi.org/10.1109/tpwrs.2023.3237976.
[69] Subic Bay Metropolitan Authority (SBMA). (2023). *SBMA annual report 2023: Strengthening Subic Bay's investment potential*. https://www.mysubicbay.com.ph
[70] Tabachnick, B. G., & Fidell, L. S. (2020). *Using multivariate statistics* (7th ed.). Pearson Education.
[71] Tantu, A., & Biramo, D. (2024). Power flow control and reliability improvement through adaptive PSO based network reconfiguration. Heliyon, 10. https://doi.org/10.1016/j.heliyon.2024.e36668.
[72] Tefera, B., & Kim, H. (2019). Designing effective survey questionnaires: Techniques for validity and reliability. *Journal of Social Research Methods, 15*(2), 45–58.
[73] U.S. Department of Energy (DOE). (2024). *Grid modernization strategy: Enhancing customer engagement and service responsiveness*. https://www.energy.gov
[74] U.S. Energy Information Administration (EIA). (2024). *Electric power annual 2024: Reliability metrics for U.S. electric utilities*. https://www.eia.gov
[75] Wardhani, K. A., & Otok, W. B. (2025). Analysis of the Impact of the Implementation of Priority Service Policy on Customer Satisfaction. Research Horizon, 5(2), 209–224. https://doi.org/10.54518/rh.5.2.2025.533
[76] Woldemichael, T.M. (2024). Effect of Service Quality on Customer Satisfaction: The Case of Ethiopian Electric Utility in South Western Region. Journal of Multidisciplinary Cases, 4(03), 24–30. https://doi.org/10.55529/jmc.43.24.30
[77] World Bank. (2023). *Reliable and affordable electricity for sustainable economic growth*. https://www.worldbank.org
[78] Wu, Z. (2026). Design Method for Improving Power Quality in Urban Public Spaces Using Wind Energy. Engineering Reports 8, no. 1 (2026): e70523, https://doi.org/10.1002/eng2.70523.
[79] Zhu, Hui & Yue, Heng & Xin, Cunsheng & Li, Yimeng. (2023). Research on the Application Mode of Smart Contract Technology in Targeted Payment. 1-6. 10.1109/EASCT59475.2023.10393593.