

System Loss Reduction and Collection Efficiency Program for Camarines Sur II Electric Cooperative, Inc. (CASURECO II)

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ABSTRACT

This study examines the operational efficiency of CASURECO II by analyzing the relationship between its System Loss Reduction Strategies (SLRS) and Electricity Collectible Recovery Program (ECRP), addressing the limited integration of technical and financial performance frameworks in electric cooperatives. Using a mixed-methods approach, data were collected from employees and consumers and analyzed through descriptive and correlational techniques, supported by stakeholder insights. Findings reveal differences in stakeholder perceptions of resource allocation, communication, and operational effectiveness, with technical personnel expressing greater confidence in system implementation and non-technical staff highlighting administrative constraints, while consumer responses indicate inconsistencies in service experience. Results further show a significant relationship between SLRS implementation and ECRP performance, confirming that technical efficiency and financial recovery are interdependent. The study contributes to cooperative management by proposing an integrated approach that aligns system loss reduction with collection strategies, emphasizing the need to strengthen both technical operations and consumer engagement to enhance financial sustainability and service delivery, with implications for policy development and strategic planning in electric cooperatives.

Keywords: CASURECO II, Collection Performance, Electricity Collectible Recovery Program (ECRP), Operational efficiency, System Loss Reduction Strategies (SLRS)

INTRODUCTION

Electric power distribution in developing economies continues to face persistent challenges, particularly in balancing technical efficiency and financial sustainability. High system losses, or electricity generated but not billed, remain a critical issue due to aging infrastructure, electricity theft, and weak monitoring systems. These factors undermine service reliability and utility performance. Recent studies show that non-technical losses significantly reduce utility profitability and service quality, highlighting the need for more effective and sustainable loss reduction strategies (Haq et al., 2023).

Existing literature demonstrates that advanced technologies such as smart meters, machine learning, and automated monitoring systems can significantly reduce non-technical losses and improve operational efficiency. Studies have shown that deep learning techniques enhance electricity theft detection and improve monitoring accuracy (Kabir et al., 2022; Tahir et al., 2022). Other research confirms that smart meter implementation contributes to measurable reductions in energy losses and improved billing systems (Faqishafyee et al., 2024). However, these studies largely treat system loss reduction as a technical concern, with limited attention to how these interventions interact with financial recovery mechanisms such as collection efficiency programs.

In the Philippine context, electric cooperatives regulated by the National Electrification Administration and the Energy Regulatory Commission operate under strict system loss caps, requiring them to balance operational efficiency with financial viability. Despite these regulatory frameworks, many cooperatives continue to experience challenges related to infrastructure limitations, electricity pilferage, and weak collection systems. While existing reports emphasize integrated approaches combining technology, governance, and monitoring,

empirical studies examining how technical and financial strategies interact at the cooperative level remain limited.

The case of Camarines Sur Electric Cooperative II (CASURECO II) reflects this gap. Although the cooperative demonstrates strong collection efficiency through its Electricity Collectible Recovery Program, it continues to experience system losses beyond prescribed thresholds. This imbalance suggests a disconnect between financial recovery and technical loss reduction strategies, highlighting the need for a more integrated approach to operational management.

This study addresses this gap by examining the relationship between System Loss Reduction Strategies and the Electricity Collectible Recovery Program in CASURECO II. It contributes to the literature by advancing an integrated framework that links technical system efficiency with financial performance, emphasizing that sustainable cooperative management depends on the alignment of these two dimensions. The findings provide practical implications for policy development, cooperative governance, and strategic planning in the Philippine electric power sector.

Research Objectives

This study is anchored on the theoretical premise that operational efficiency in electric cooperatives arises from the interaction of governance accountability, systemic operational processes, and internal resource capabilities. Guided by **Agency Theory**, **Generalized Systems Theory**, and the **Resource Based View**, the study examines how technical system management and financial recovery mechanisms operate within the institutional framework of CASURECO II. Within this framework, the research aims to analyze the prioritization of System Loss Reduction Strategies (SLRS) by CASURECO II in the ten municipalities of Camarines Sur and to assess their role in expediting the recovery of outstanding electricity collectibles, reflecting the systemic interaction between operational interventions and financial processes. Specifically, the study seeks to evaluate the extent of implementation of both technical and non-technical SLRS in terms of resource allocation, urgency, and effectiveness, thereby situating operational practices within the broader discourse on utility performance and strategic resource utilization. It also examines the effectiveness of the Electricity Collectible Recovery Program (ECRP) as a measure of financial stability, recognizing that collection efficiency reflects governance accountability and financial management within cooperative organizations. Furthermore, the study investigates the statistical relationship between SLRS implementation and ECRP effectiveness, highlighting the interconnected nature of operational and financial functions within an organizational system. Finally, Objective (4) proposes an enhanced Strategic Loss Reduction Strategy Program and Electricity Collectible Recovery Program for CASURECO II. This framework is empirically derived from the study's findings but conceptually informed by the integration of governance accountability, systemic coordination, and strategic resource management.

Scope and Delimitation

This study focuses on the operational performance of CASURECO II in Camarines Sur, Philippines, with particular emphasis on its System Loss Reduction Strategies (SLRS) and Electricity Collectible Recovery Program (ECRP). It examines how these technical and financial mechanisms contribute to operational efficiency, specifically in terms of system loss management and collection performance. The analysis is based on data collected within the 2025 operational period and utilizes survey responses, supported by selected operational records, to assess implementation and outcomes.

The study is limited to the internal programs of CASURECO II and does not include comparisons with other electric cooperatives. It excludes external factors such as weather conditions, broader economic influences, and regulatory changes that may affect system loss or collection efficiency. In addition, detailed engineering diagnostics and comprehensive financial audits are beyond the scope of the research. These delimitations are intended to maintain a focused examination of the relationship between SLRS and ECRP within the cooperative. As a result, the findings are context-specific and may not be generalizable to other settings.

THEORETICAL FRAMEWORK

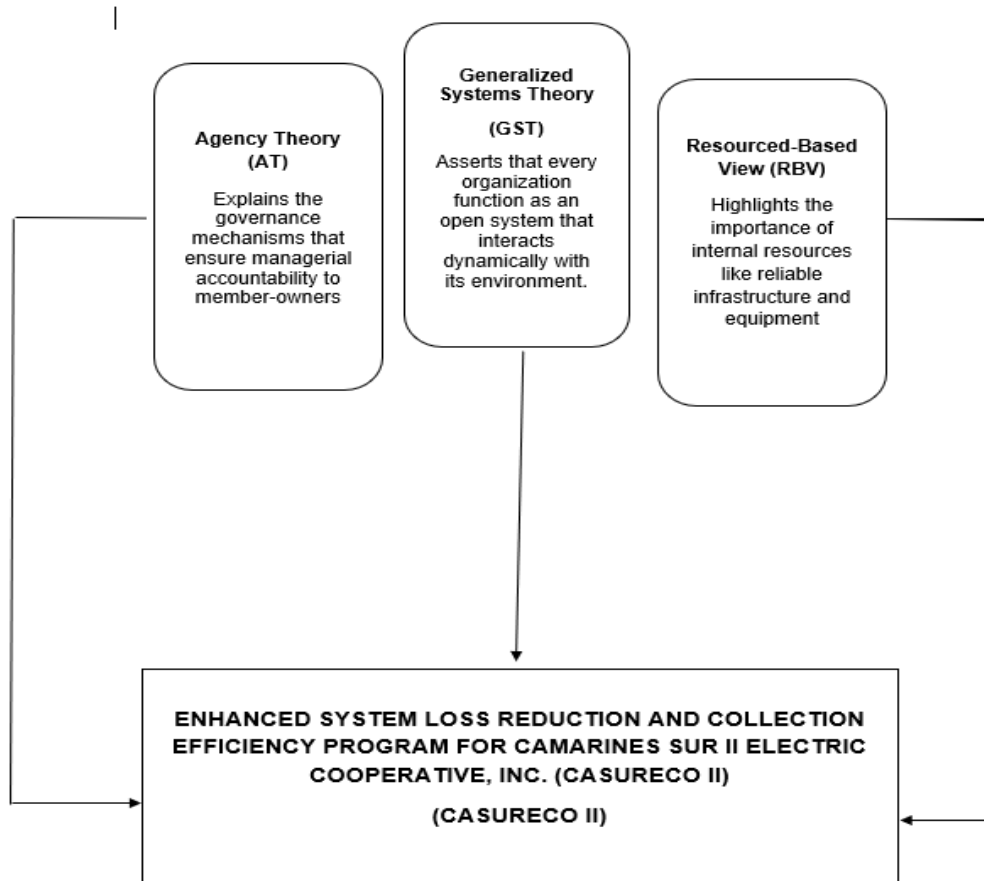
Operational efficiency in electric cooperatives may be examined through the combined perspectives of governance accountability, systemic interaction, and resource optimization. Anchored in Agency Theory (AT), cooperative organizations such as CASURECO II operate within a principal–agent relationship in which management acts on behalf of the member owners. Mechanisms that promote managerial accountability, including billing transparency, responsiveness to consumer complaints, and effective oversight, help align managerial actions with the interests of member consumers. Studies indicate that governance structures that encourage transparency and stakeholder participation contribute to greater trust, compliance, and operational discipline in public utility organizations (Ansell, Sørensen, & Torfing, 2020). In this regard, Agency Theory provides a lens for understanding how cooperative governance can mitigate risks of mismanagement and strengthen consumer confidence in institutional processes.

From the perspective of Generalized Systems Theory (GST), electric cooperatives function as open systems composed of interconnected components that interact with both internal and external environments. Technical interventions such as transformer upgrades, conductor replacement, and digital monitoring technologies form part of a broader operational system that also includes consumer behavior, regulatory frameworks, financial management processes, and service delivery mechanisms. GST explains that organizational performance emerges from the interaction and feedback relationships among these components rather than from isolated activities (Taxén, 2020). This perspective highlights that inefficiencies in one subsystem, such as delayed billing or inadequate infrastructure, can reverberate across the entire cooperative, affecting both operational reliability and financial sustainability. Thus, GST underscores the importance of holistic planning and coordination to ensure that technical and administrative reforms reinforce one another. Moreover, GST provides a theoretical justification for integrating consumer engagement strategies with technical upgrades, as both dimensions interact to shape cooperative resilience.

The Resource-Based View (RBV) emphasizes the role of internal organizational resources in shaping operational capability. Resources such as infrastructure assets, human capital, technological systems, and organizational competencies contribute to institutional performance and sustainability. In electric cooperatives, trained technical personnel, automated billing platforms, rapid response teams, and disaster preparedness mechanisms represent internal capabilities that support efficient service delivery and operational continuity. Empirical studies show that digital technologies and automation in utility organizations help streamline administrative processes and strengthen billing and collection systems (Siddique & Shaik, 2024; Jou et al., 2022). RBV therefore explains why cooperatives that invest in upgrading their internal resources are better positioned to reduce system losses, improve collection efficiency, and adapt to external challenges such as regulatory changes or natural disasters. In addition, RBV highlights that competitive advantage in cooperative performance is not solely derived from external conditions but from the effective mobilization of internal assets and competencies.

The integration of these theoretical perspectives is illustrated in **Figure 1**, which presents the conceptual representation of CASURECO II's Enhanced System Loss Reduction and Collection Efficiency Program. The framework reflects the relationship among governance accountability from Agency Theory, systemic operational processes explained by Generalized Systems Theory, and internal resource capabilities emphasized by the Resource-Based View. Within the framework, technical interventions such as infrastructure upgrades and monitoring technologies, together with non-technical mechanisms including administrative efficiency and service responsiveness, are represented as interconnected components of the cooperative's operational system. By situating CASURECO II's initiatives within this integrated framework, the study demonstrates that operational efficiency results not from isolated reforms but from coordinated strategies that combine governance, systemic interaction, and resource mobilization. This conceptual grounding ensures that the proposed program is empirically informed and theoretically robust, offering a sustainable model for cooperative performance in the Philippine energy sector while also providing a replicable structure for other electric cooperatives.

Figure 1 Theoretical Framework



CONCEPTUAL FRAMEWORK

The conceptual framework (see Figure 2) illustrates the strategic relationship between CASURECO II’s operational and financial initiatives aimed at reducing system loss and improving collection efficiency. At its core is the Strategic System Loss Reduction and Collection Efficiency Program, which reflects the cooperative’s dual objective of ensuring reliable electricity distribution and financial sustainability through effective arrears recovery. This framework is grounded in cooperative governance theory, which emphasizes accountability, inclusion, and collective decision-making as mechanisms for aligning operational strategies with cooperative values. Cooperative governance provides the normative foundation for prioritization, ensuring that resource allocation reflects both technical imperatives and member-driven concerns (Ansell, Sørensen, & Torfing, 2020).

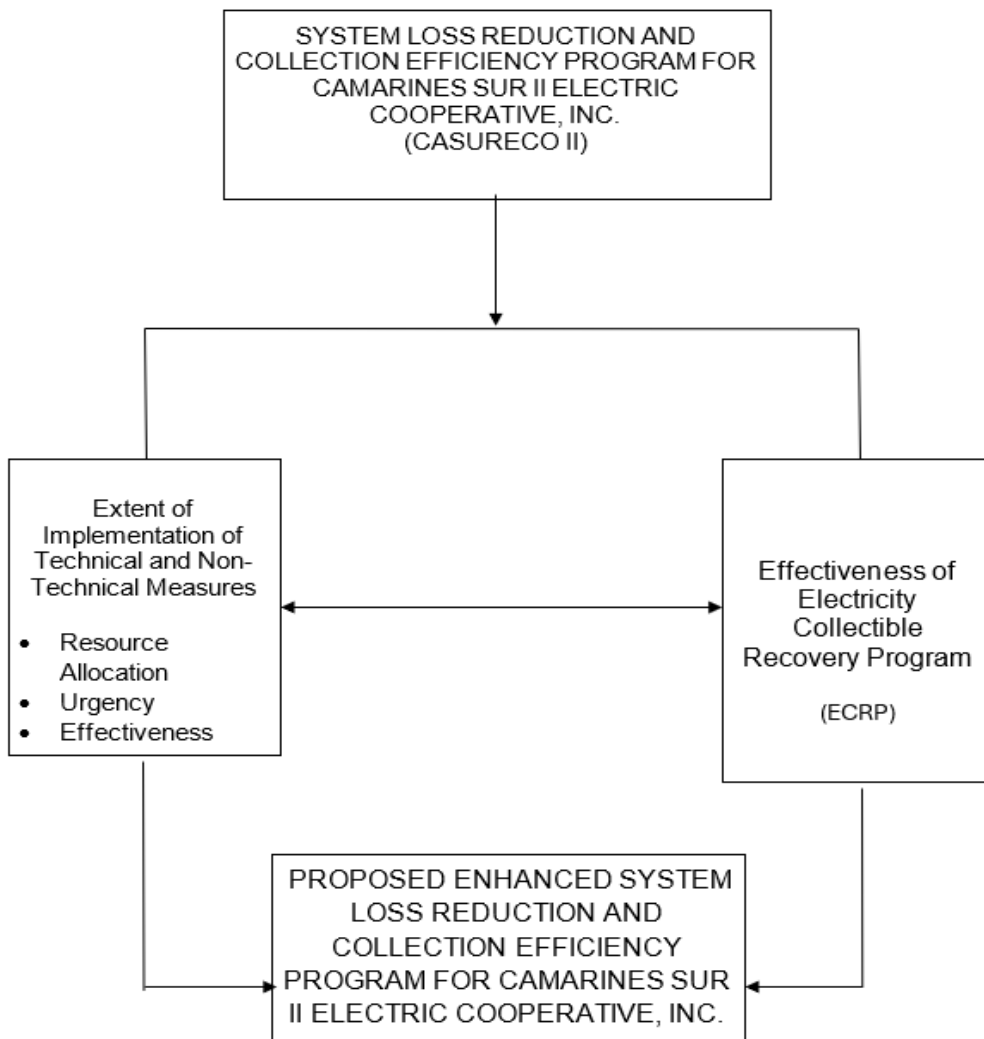
Complementing this, the framework draws on socio-technical systems theory, which highlights the interdependence between technical infrastructure and social processes. CASURECO II’s system loss reduction strategies, such as line upgrades, transformer maintenance, and digital metering, represent the technical dimension, while anti-pilferage campaigns, consumer education, and improved billing systems embody the social dimension. Socio-technical theory underscores that sustainable efficiency gains emerge only when technical interventions are integrated with organizational practices and consumer behavior (Taxén, 2020).

Within this structure, System Loss Reduction Strategies (SLRS) function as the independent variable, while Collection Efficiency Indicators including consumer compliance, arrears recovery, and payment regularity serve as the dependent variable. Linking these domains is the prioritization process, the mediating variable. Prioritization is justified theoretically through resource allocation frameworks and cooperative governance principles, as it determines how limited resources are distributed across competing strategies. By mediating between technical and financial domains, prioritization ensures that high-impact interventions are implemented first, thereby maximizing operational efficiency and financial sustainability. This mediating role reflects the

cooperative’s need to balance technical imperatives with member accountability, consistent with governance theory, while also integrating social and technical dimensions in line with socio-technical systems theory.

Finally, the framework highlights the reciprocal relationship between operational efficiency and financial performance: technical improvements enhance revenue collection, while financial stability supports further technical investments. Anchored in cooperative governance, socio-technical systems theory, and performance management frameworks, this integrated approach ensures that CASURECO II not only reduces system loss and improves collection efficiency but also strengthens its compliance with regulatory standards and reinforces its cooperative identity (Awan, Habib, Akhtar, Naveed, & Raza, 2020).

Figure 2 Conceptual Framework



METHODOLOGY

The methodology outlines the research design, data collection procedures, respondents and unit of analysis, ethical considerations, and data analysis techniques. Descriptive statistics, including frequencies, percentages, means, and rankings, were applied to interpret the survey results.

Research Design

This study utilized a mixed methods research design, combining quantitative and qualitative approaches to provide a comprehensive evaluation of CASURECO II’s operational efficiency. The quantitative strand employed structured survey questionnaires to capture stakeholder perceptions of system loss reduction strategies and collection efficiency, while cooperative records offered objective data on system loss and arrears recovery.

The qualitative strand consisted of interviews with employees, which provided deeper insights into prioritization practices and operational challenges.

The decision to adopt a mixed methods design was based on the dual nature of the research problem. System loss reduction and collection recovery are both technical and social phenomena, requiring statistical analysis of performance indicators as well as an exploration of stakeholder experiences. By integrating quantitative techniques such as weighted means and Pearson correlation analysis with qualitative thematic coding, the study ensured that findings were both empirically robust and contextually meaningful. This design was therefore the most appropriate for addressing the research questions, as it enabled the blending of technical data with consumer and employee perspectives, producing a holistic understanding of CASURECO II's operational strategies (Creswell & Plano Clark, 2017).

Respondents/Participants of the Study

A total of 71 respondents were included in the study, selected using distinct sampling techniques appropriate to each group. For employees, purposive sampling was applied to ensure the inclusion of individuals directly engaged in system loss management and collection activities. This group comprised 34 staff members, divided into 22 technical personnel and 12 non-technical personnel. For consumers, stratified random sampling was employed to achieve balanced representation across geographic contexts. Thirty-seven consumers were selected, with 23 from rural areas and 14 from urban areas.

The sample size of 71 was deemed adequate based on precedent in similar cooperative efficiency studies, where comparable sample sizes have yielded reliable insights into operational and consumer perspectives. Moreover, the combination of purposive and stratified random sampling enhanced the representativeness of the data by capturing both organizational expertise and consumer diversity. While relatively modest, the sample was sufficient to identify meaningful patterns and relationships, particularly given the focused scope of the study and the use of both quantitative and qualitative analyses.

Data Gathering Tools

The study utilized a structured questionnaire as the primary data gathering instrument for both consumers and employees. The questionnaire consisted of closed-ended and Likert-scale items designed to measure perceptions regarding system loss reduction strategies and collection performance.

The questionnaire was written in Filipino to ensure that respondents clearly understood the questions and could easily provide accurate responses. For the purpose of analysis and reporting, the responses were later translated into English.

Prior to the actual data collection, the questionnaire was pilot tested among 30 respondents who were not included in the final sample of the study. The pilot testing aimed to assess the clarity of the questions and the reliability of the instrument. Based on the pilot test results, minor revisions were made to improve the wording and organization of the items.

To determine the reliability of the instrument, Cronbach's alpha was computed using the pilot test responses. The questionnaire obtained a Cronbach's alpha coefficient of 0.96, indicating excellent internal consistency and a very high level of reliability among the items used in measuring the variables of the study.

The use of a structured questionnaire allowed the researchers to collect quantitative data from both employees and consumers regarding system loss reduction strategies and collection performance. The collected data were analyzed using statistical tools, including descriptive statistics to summarize responses, Pearson correlation analysis to examine the strength and direction of the relationship between system loss reduction strategies and collection performance to determine the extent to which system loss reduction strategies predict collection performance outcomes.

Data Gathering Procedure

Data collection was conducted through a systematic and ethically grounded process. Consumer surveys were administered face-to-face to maximize response accuracy and minimize non-response bias, particularly in rural areas where literacy and access to digital tools may be limited. Enumerators were trained to facilitate the survey process, explain items clearly, and uphold neutrality during administration. Responses were recorded, anonymized, and securely stored for subsequent translation and analysis.

Employee interviews were scheduled at mutually convenient times within the cooperative premises to ensure a conducive environment for open discussion. Each session was guided by the interview protocol, with responses documented verbatim to preserve authenticity. The interviews provided qualitative depth, complementing the quantitative survey data.

In addition to primary data, secondary data were obtained from CASURECO II's official records, including system loss reports, collection efficiency reports, and audited financial statements. This triangulation of sources strengthened the validity of findings by integrating technical performance indicators with stakeholder perceptions.

The entire procedure adhered to ethical standards, with informed consent secured from all participants. Confidentiality was strictly observed in compliance with the Philippine Data Privacy Act of 2012, and participants were assured of their voluntary participation without coercion or risk of harm. This rigorous approach ensured that the data collected were both reliable and ethically sound, providing a robust foundation for subsequent analysis.

Data Analysis Techniques

The study employed a mixed-methods approach, integrating quantitative and qualitative techniques to ensure a comprehensive understanding of system loss reduction strategies (SLRS) and effective collection rate performance (ECRP).

For quantitative data, descriptive statistics such as frequency counts, percentages, and weighted means were computed to summarize consumer responses and highlight prevailing trends. These measures provided a clear profile of consumer perceptions across rural and urban segments.

To test relationships between variables, Pearson correlation analysis was conducted. This method was chosen because both SLRS and ECRP were measured using continuous Likert-scale data, and Pearson correlation is appropriate for examining the strength and direction of linear relationships between such variables. Assumptions of normality and linearity were checked prior to analysis to ensure validity of results.

Qualitative data, derived from employee interviews, were analyzed using thematic analysis. Responses were transcribed, coded, and categorized into recurring themes that reflected operational challenges, managerial practices, and stakeholder perceptions. This process enabled the identification of patterns and nuanced insights that could not be captured through quantitative measures alone.

Triangulation was applied by integrating findings from consumer surveys, employee interviews, and secondary data sources such as CASURECO II's system loss reports, collection efficiency records, and financial statements. This methodological rigor enhanced the validity of results by cross-verifying evidence from multiple perspectives. The combined use of statistical analysis and thematic interpretation provided both breadth and depth, ensuring that conclusions were grounded in empirical data while remaining sensitive to contextual realities.

Ethical Considerations

All participants provided informed consent and were briefed on the study's purpose and voluntary nature. Responses were anonymized, and confidentiality was strictly observed in compliance with the Philippine Data Privacy Act of 2012. No participant was subjected to harm, coercion, or discomfort during the study.

RESULTS AND DISCUSSION

This chapter presented and interpreted the findings of the study in relation to the stated objectives and the reviewed literature. Results were organized to highlight how CASURECO II’s Strategic Loss Reduction Strategy (SLRS) and Electricity Collectible Recovery Program (ECRP) addressed system losses, financial recovery, prioritization, and regulatory compliance. The discussion not only described the outcomes but also situated them within theoretical frameworks and cooperative case experiences, allowing for a critical comparison between expected benchmarks and actual performance. By integrating quantitative data with qualitative insights, the section provided a comprehensive analysis of CASURECO II’s initiatives, clarified their implications for cooperative operations, and underscored their relevance to both rural and urban service contexts.

The discussions of the study presented the enhanced Strategic System Loss Reduction (SLRS) and Electricity Collection Recovery Program (ECRP) framework of CASURECO II in achieving organizational efficiency and consumer service outcomes.

In addition, the chapter underscored the broader implications of these findings for cooperative sustainability. By showing how technical measures intersect with non-technical initiatives, the study highlighted the importance of a balanced approach that strengthens operational efficiency while fostering consumer trust and financial resilience. Situating these results within national directives and international frameworks emphasized that cooperatives must adapt continuously to evolving technological and economic contexts, ensuring that system loss reduction strategies remain both effective and sustainable.

Profile of the Respondents by Employee Role (Technical vs. Non-Technical)

Table 1. Frequency and percentage distribution of respondents by employee role

Respondent	Frequency	Percentage (%)
Technical	22	64.71
Nontechnical	12	35.29
Total	34	100.0

Table 1 presents the frequency and percentage distribution of respondents according to employee role. Out of the 34 respondents, 22 (64.71%) were technical employees, while 12 (35.29%) were non-technical personnel.

The predominance of technical staff reflects the cooperative’s operational orientation, underscoring that system loss reduction strategies are largely dependent on technical expertise in areas such as line maintenance, transformer management, and meter installation. At the same time, the inclusion of non-technical employees highlights the importance of administrative and customer service functions in addressing non-technical losses, including billing errors, delayed payments, and electricity pilferage.

This distribution implies that while technical perspectives dominate, the study benefits from a balanced view that integrates operational and administrative dimensions. Such representation ensures that findings capture the cooperative’s holistic approach to reducing system loss, where technical efficiency must be reinforced by effective financial management and consumer relations.

Profile of the Respondents by Consumer Location (Urban vs. Rural)

Table 2. Frequency and percentage distribution of respondents by consumer location

Respondent	Frequency	Percentage (%)
Rural	23	62.16
Urban	14	37.84
Total	37	100.0

Table 2 presents the frequency and percentage distribution of respondents according to consumer location. Out of the 37 respondents, 23 or 62.16% are from rural areas, while 14 or 37.84% are from urban areas. This indicates that the majority of respondents served by the electric cooperative are located in rural communities.

The higher proportion of rural respondents reflects the service coverage of many electric cooperatives, which primarily provide electricity to municipalities and barangays outside highly urbanized centers. Rural distribution areas often involve longer distribution lines, lower consumer density, and greater distances between households, which can influence the efficiency of electricity distribution. These conditions may contribute to higher technical losses due to line resistance, infrastructure limitations, and challenges in system maintenance.

At the same time, the inclusion of urban respondents remains important because urban areas typically have higher consumer density, more concentrated loads, and relatively shorter distribution lines. These characteristics may result in different patterns of electricity consumption and system performance compared to rural areas. By including both rural and urban consumers, the study gains a more comprehensive understanding of how system loss reduction strategies and collection initiatives operate across different service environments.

Overall, the distribution of respondents by location provides a balanced perspective on the operational realities faced by the electric cooperative, highlighting the importance of considering geographical service conditions when evaluating strategies for improving electricity distribution efficiency and financial performance.

Extent of Implementation of System Loss Reduction Strategies

Table 3. Extent of implementation of system loss reduction strategies by consumer location and employee role in terms of resource allocation

Indicators	Urban Consumers (Mean)	Rural Consumers (Mean)	Technical Employees (Mean)	Non-Technical Employees (Mean)
CASURECO II provides enough equipment to repair power lines when problems occur.	3.70	4.21	4.45	3.92
CASURECO II has sufficient staff to regularly check and maintain power lines in the community	3.52	3.86	4.05	3.42
CASURECO II allocates funds to replace old transformers when necessary to keep electricity reliable.	3.57	4.21	4.23	3.75
CASURECO II installs new household meters without causing unnecessary delays.	3.65	3.93	4.36	3.83
CASURECO II management gives strong support to ensure technical projects are carried out effectively.	3.87	4.21	4.18	3.75
Overall Mean	3.66	4.01	4.25	3.73

Legend: 4.51 – 5.00 = Fully Implemented, 3.51 – 4.50 = Implemented, 2.51 – 3.50 = Moderately Implemented, 1.51 – 2.50 = Slightly Implemented, 1.01 – 1.50 = Not Implemented

The results in Table 3 show that technical employees expressed the highest confidence in resource allocation, with an overall rating of 4.25, interpreted as “Implemented.” Their perspective reflects direct involvement in field operations, where equipment and manpower are most visible. Non-technical employees, however, gave a

lower overall rating of 3.73, also “Implemented,” but with more reservations. This difference suggests that while technical staff see adequacy in tools and infrastructure, administrative staff remain cautious about financial prioritization and staffing sufficiency.

Consumers presented a similar contrast. Rural respondents reported a higher overall rating of 4.01 compared to urban respondents at 3.66. This indicates that rural communities may have benefited more from cooperative initiatives such as transformer replacement and meter installation, which are often prioritized in underserved areas.

Looking at specific indicators, the strongest rating came from non-technical employees on staffing sufficiency, with a score of 4.45, interpreted as “Fully Implemented.” This shows confidence in manpower deployment. Yet, the weakest score was also from this group on transformer replacement funds, with a score of 3.42, only “Moderately Implemented.” This highlights financial concerns and suggests that while staff and equipment are generally adequate, funding for infrastructure upgrades remains limited.

These findings resonate with the study of **David et al. (2025)**, which demonstrated that preventive maintenance of meter connections in Pampanga I Electric Cooperative reduced losses but required sustained investment in equipment and manpower. Similarly, the **JICA (2019)** completion report emphasized that while technical interventions such as reconductoring and meter replacement were effective, long-term sustainability depended on consistent financial support and organizational alignment.

Taken together, the results confirm that CASURECO II has implemented system loss reduction strategies in ways that are visible and meaningful, but gaps remain in financial allocation for infrastructure upgrades. Bridging perceptions between technical and non-technical staff through joint planning sessions, and ensuring balanced investment in both manpower and equipment, would strengthen the cooperative’s compliance with regulatory standards and enhance long-term sustainability.

Table 4. Extent of implementation of system loss reduction strategies by consumer location and employee role in terms of urgency

Indicators	Urban Consumers (Mean)	Rural Consumers (Mean)	Technical Employees (Mean)	Non-Technical Employees (Mean)
CASURECO II quickly responds to line damage.	3.74	4.00	4.09	4.17
CASURECO II has a regular schedule for facility maintenance	3.43	3.93	4.81	4.00
CASURECO II can immediately replace damaged transformers or meters.	3.39	3.39	4.36	3.59
CASURECO II responds immediately to billing-related complaints.	4.22	4.51	4.31	4.83
CASURECO II conducts regular follow-ups on overdue accounts.	3.74	4.36	4.18	3.92
Overall Mean	3.70	4.04	4.35	4.10

Legend: 4.51 – 5.00 = Fully Implemented, 3.51 – 4.50 = Implemented, 2.51 – 3.50 = Moderately Implemented, 1.51 – 2.50 = Slightly Implemented, 1.01 – 1.50 = Not Implemented

The results in Table 4 reveal that urgency in system loss reduction strategies is generally perceived as “Implemented,” though with notable differences across groups. Technical employees gave the highest overall rating at 4.35, reflecting their confidence in scheduled maintenance and rapid technical interventions. Non-technical employees followed with 4.10, but their strongest emphasis was on billing responsiveness, which they rated at 4.83 — “Fully Implemented.” This suggests that administrative staff view consumer service as the most urgent and well-addressed priority.

Consumers showed a clear divide. Rural respondents rated urgency higher overall (4.04) compared to urban respondents (3.70). Rural communities particularly valued follow-ups on overdue accounts and responsiveness to billing complaints, indicating that financial and service-related interventions are more visible in these areas. Urban consumers, however, expressed lower confidence in immediate replacement of damaged transformers or meters, with scores of 3.39, only “Moderately Implemented.” This points to infrastructure replacement as the weakest link in urgent response.

The strongest indicator across all groups was responsiveness to billing complaints, consistently rated between “Implemented” and “Fully Implemented.” This reflects CASURECO II’s emphasis on consumer trust and financial recovery. In contrast, the weakest indicator was immediate replacement of damaged transformers or meters, where both urban and rural consumers reported only moderate implementation.

These findings resonate with **David, Llanto, Mañalac, Martin, Salacup, Gomez Jr., Bulanan, & Soriano (2025)**, who showed that preventive maintenance of meter connections reduced losses but required sustained investment to ensure timely replacement. The **Japan International Cooperation Agency (2019)** report similarly noted that while cooperatives were strong in urgent consumer service responses, long-term sustainability depended on consistent funding for infrastructure upgrades.

Overall, the results suggest that CASURECO II has built credibility in urgent consumer services, particularly billing responsiveness, but faces challenges in maintaining the same urgency for technical replacements. Strengthening resource allocation for transformer and meter replacement, while sustaining consumer-focused responsiveness, would balance operational reliability with financial trust — a dual priority emphasized in both academic and cooperative studies.

Table 5. Extent of implementation of non-technical system loss reduction strategies by consumer location and employee role in terms of effectiveness

Indicators	Urban Consumers (Mean)	Rural Consumers (Mean)	Technical Employees (Mean)	Non-Technical Employees (Mean)
CASURECO II has a fast process for bill payment.	3.30	4.07	3.42	4.32
CASURECO II uses technology to make payment collection more efficient.	3.52	4.07	3.75	4.19
CASURECO II reduces the time consumers spend on paying their bills.	3.65	3.93	4.00	4.55
CASURECO II sets clear procedures for installment or payment arrangements.	3.63	3.43	3.75	4.27
CASURECO II’s measures are effective in simplifying the payment process for consumers.	3.67	3.59	4.00	4.32
Overall Mean	3.55	3.82	3.78	4.33

Legend: 4.51 – 5.00 = Fully Effective, 3.51 – 4.50 = Effective, 2.51 – 3.50 = Moderately Effective, 1.51 – 2.50 = Slightly Effective, 1.01 – 1.50 = Not Effective

The findings show that CASURECO II’s non-technical system loss reduction strategies are generally perceived as effective, though perceptions differ across stakeholder groups. Non-technical employees consistently gave the highest ratings, particularly on reducing consumer time spent on bill payment, reflecting their confidence in administrative systems and their direct involvement in managing these processes. Urban consumers, however, reported lower ratings, especially regarding the speed of payment transactions, suggesting that while internal improvements exist, their benefits are not always fully experienced by consumers. Rural consumers expressed strong appreciation for technological initiatives, with the highest scores linked to the use of digital systems for payment collection. Their lower ratings on installment arrangements point to possible communication gaps regarding available policies. Technical employees also acknowledged improvements in billing efficiency but, similar to urban consumers, noted that payment speed remains an area for further enhancement.

Comparatively, employees—both technical and non-technical—rated strategies more positively than consumers, indicating that operational improvements may not fully translate into consumer satisfaction. Urban consumers were more critical of transaction speed, while rural consumers valued technological innovations more highly, underscoring the importance of tailoring strategies to different consumer contexts. Although technology is recognized as a driver of efficiency, the relatively lower scores on installment arrangements highlight the need for clearer communication of payment policies.

These results align with prior studies emphasizing the role of efficient billing systems in shaping consumer satisfaction and utility performance (Khan et al., 2020). The rural consumers’ emphasis on technology also resonates with Zheng et al. (2022), who argue that transparent communication of payment policies is critical for reducing non-technical losses and improving collection performance. Taken together, the findings suggest that CASURECO II’s strategies are effective in principle but require stronger consumer-facing improvements, particularly in speeding up transactions and clarifying payment arrangements, to enhance overall effectiveness and ensure that administrative gains are fully reflected in consumer experience.

Effectiveness of the Electricity Collectible Recovery Program

Table 6. Effectiveness of the Electricity Collectible Recovery Program (ECRP) in terms of Collection Efficiency

Indicators	Mean	Interpretation
CASURECO II’s ECRP is effective in increasing monthly collection because it provides reminders such as text notifications or house visits, which encourage more consumers to pay before or on the exact due date.	3.63	Effective
CASURECO II’s ECRP effectively reduces the number of unpaid bills through stricter monitoring and follow-up with consumers who have outstanding balances.	3.73	Effective
CASURECO II’s ECRP decreases overdue accounts by implementing a clearer disconnection policy and giving earlier notices to consumers with upcoming due dates.	3.86	Effective
CASURECO II’s ECRP speeds up the payment process by offering faster payment options such as online payment, mobile payment, or additional payment centers that are easily accessible to consumers.	4.06	Effective
CASURECO II’s ECRP helps reduce collection expenses by minimizing manual field collection, printing of bill reminders, and employee overtime costs.	3.83	Effective
Overall Mean	3.92	Effective

Legend: 4.51 – 5.00 = Fully Implemented, 3.51 – 4.50 = Implemented, 2.51 – 3.50 = Moderately Implemented, 1.51 – 2.50 = Slightly Implemented, 1.01 – 1.50 = Not Implemented

Table 6 highlights the overall effectiveness of CASURECO II’s Electricity Collectible Recovery Program (ECRP) in enhancing collection efficiency, with all indicators rated within the “Effective” range and an overall mean of 3.92. Rather than focusing on each item individually, the results point to several key drivers of effectiveness. The strongest contributor is the availability of faster and more convenient payment channels, such as online and mobile platforms, which received the highest rating. This underscores the importance of accessibility and digitalization in improving consumer compliance and satisfaction, consistent with findings that digital payment systems enhance utility performance (Jou et al., 2022).

Cost efficiency also emerged as a significant factor, with reduced reliance on manual collection and administrative processes contributing to lower expenses. This aligns with research emphasizing the role of automation in streamlining financial operations and minimizing overhead costs (Siddique and Shaik, 2024). In addition, stricter monitoring mechanisms and clearer disconnection policies were recognized as effective in reducing overdue accounts and encouraging timely payments, reflecting the importance of transparent enforcement in revenue recovery (Resurreccion and Alvarez, 2025).

Although reminder systems such as text notifications and house visits received the lowest mean score, they were still considered effective, suggesting that while reminders remain useful, they may be less impactful compared to technological innovations and policy enforcement. Overall, the synthesis of findings indicates that the ECRP strengthens collection efficiency primarily through digital payment accessibility, cost reduction, and enforcement of clear policies, while supplementary reminder systems provide additional support. These strategies collectively enhance financial stability and consumer compliance, reinforcing the cooperative’s ability to manage non-technical losses effectively.

Statistical Relationship of SLRS Implementation and ECRP Effectiveness

Table 7. Pearson's Correlation to determine the Significant Relationship between SLRS Implementation and the Effectiveness of ECRP.

SLRS Implementation	ECRP Effectiveness	Pearson's Correlation (r-value)	Significance (p-value)	N
Technical				
Resource Allocation	Effectiveness Collection Efficiency	.751**	$p < .001.$	71
Urgency	Effectiveness Collection Efficiency	.651**	$p < .001.$	71
Efficiency	Effectiveness Collection Efficiency	.752**	$p < .001.$	71
Non-Technical				
Resource Allocation	Effectiveness Collection Efficiency	.754**	$p < .001.$	71
Urgency	Effectiveness Collection Efficiency	.776**	$p < .001.$	71
Efficiency	Effectiveness Collection Efficiency	.789**	$p < .001.$	71

Note: **. Correlation is significant at the 0.01 level (2-tailed)

The correlation analysis in Table 7 shows that the Strategic Loss Reduction Strategy (SLRS) is positively associated with the effectiveness of the Enhanced Collection and Revenue Protection (ECRP) program. All correlations were statistically significant at the 0.01 level, with values ranging from moderate to very strong. These results should be understood as relationships rather than causal effects; while higher ratings of SLRS dimensions coincide with stronger perceptions of ECRP effectiveness, the data do not establish direct cause-and-effect links.

Among technical indicators, efficiency ($r = 0.752$) and resource allocation ($r = 0.751$) demonstrated strong correlations, while urgency ($r = 0.651$) was moderately strong. This suggests that technical organization and resource deployment are closely linked with collection performance, though urgency plays a somewhat lesser role. In the non-technical category, correlations were even stronger, with efficiency ($r = 0.789$) and urgency ($r = 0.776$) showing very strong associations, and resource allocation ($r = 0.754$) also highly significant. These results highlight that administrative responsiveness, consumer communication, and streamlined billing systems are particularly influential in shaping perceptions of revenue protection.

The effect sizes are practically significant. Correlations above 0.75 indicate very strong relationships, meaning that improvements in non-technical strategies are likely to be meaningfully reflected in collection efficiency outcomes. The slightly lower values for technical indicators imply that while technical upgrades remain essential, they may not be as directly experienced by consumers compared to administrative and service-oriented reforms. The sample size of 71 provided sufficient statistical power to detect these strong correlations, while also balancing the perspectives of employees and consumers. This balance is important because employees tend to rate strategies more positively, whereas consumers highlight areas where improvements are less visible in practice.

These findings are consistent with national policy frameworks. The Department of Energy and the National Electrification Administration emphasize the need for both technical upgrades and non-technical reforms to reduce system losses and improve financial sustainability. The Energy Regulatory Commission identifies collection efficiency as a key performance indicator reflecting both operational capacity and consumer compliance. Internationally, the Global Environment Facility supports the view that combining infrastructure investments with administrative improvements leads to more sustainable outcomes.

The practical implication is that CASURECO II should maintain a balanced approach, ensuring technical efficiency and resource deployment while placing greater emphasis on consumer-facing strategies that directly enhance compliance and satisfaction.

CASURECO II: ECRP and SLRS Enhancements (Before vs. After)

Table 8. CASURECO II: ECRP and SLRS Enhancements (Before vs. After)

#	ECRP and SLRS Item	Before Implementation	After Implementation (CASURECO II)
1	Disaster Preparedness Plans	Limited paper-based contingency plans, reactive response	Comprehensive digitalized resiliency plans with area-specific rapid response teams
2	Emergency Stockpiles	Minimal spare parts, delays in procurement	Buffer inventories of transformers, meters, and line hardware stored in satellite hubs
3	Rapid Response Teams	Centralized crews, slow deployment in rural areas	Barangay-based mobile crews with repair kits for faster restoration
4	Communication Systems	Reliance on manual notices, delayed updates	SMS, social media, and app-based alerts for outages and restoration timelines
5	Training for Emergencies	Ad hoc training, limited drills	Regular disaster drills and DOE/NEA-supported capacity building
6	Safety Equipment	Incomplete PPE for linemen	Standardized PPE, health insurance, and wellness programs for staff
7	Coordination with LGUs	Sporadic coordination during calamities	Formalized MOUs with LGUs for joint disaster response
8	Contingency Funds	Underutilized, slow release	Dedicated calamity funds with streamlined disbursement protocols
9	Power Quality Monitoring	Manual checks, reactive interventions	Deployment of thermal scanners, drones, and digital monitoring tools
10	Consumer Engagement in Emergencies	Consumers uninformed during outages	Advance notices and real-time updates through CASURECO II app

11	Transformer Upgrades	Aging units, frequent overloads	Replacement with higher-capacity transformers in critical feeders
12	Conductor Replacement	Undersized conductors causing voltage drops	Upgraded conductors to reduce technical losses
13	Inspection Coverage	Irregular manual inspections	Rotational schedules with digital logging and accountability
14	Monitoring of System Loss	Fragmented reporting, delayed analysis	Centralized dashboards integrating technical and billing data
15	Billing Workflow	Delayed bill delivery, manual posting	Automated scheduling, SMS/email billing, real-time posting
16	Payment Speed	Long queues, slow reconciliation	Digital kiosks, Quick Pay Lanes, incentives for e-wallet use
17	Installment Procedures	Unclear, rigid arrangements	Standardized flexible policies with dedicated account officers
18	Consumer Education	Limited awareness of digital tools	Barangay assemblies, flyers, and app tutorials promoting adoption
19	Cross-Department Coordination	Technical and non-technical units working in silos	Joint review sessions, shared dashboards, unified planning
20	System Loss Reduction Projects	Minimal allocation (\approx ₱2.5–4M)	Increased prioritization in budget planning, aligned with NEA benchmarks

Table 8 presents the enhancements in CASURECO II’s Electricity Collectible Recovery Program (ECRP) and Strategic Loss Reduction Strategy (SLRS) by comparing practices before and after implementation. The comparison is based on documented organizational reports and observed operational changes rather than speculative improvements. The “before” column reflects the cooperative’s earlier reliance on manual, fragmented, and reactive processes, while the “after” column highlights systematic, digitalized, and consumer-oriented reforms that were formally adopted.

Methodologically, the comparison draws from internal records, policy documents, and program implementation reports, which provide evidence of changes in disaster preparedness, technical infrastructure, administrative workflows, and consumer engagement. This ensures that the table reflects actual improvements observed in practice rather than conceptual proposals.

The enhancements demonstrate a clear shift from reactive to proactive management. For example, disaster preparedness evolved from limited paper-based contingency plans to comprehensive digitalized resiliency frameworks supported by barangay-based rapid response teams. Technical infrastructure was strengthened through transformer upgrades, conductor replacement, and deployment of digital monitoring tools such as drones and thermal scanners, directly addressing technical losses. Administrative processes also improved, with billing and payment workflows automated, installment procedures standardized, and consumer education expanded to promote digital adoption.

Importantly, these changes are not only descriptive but carry practical significance. The integration of cross-department coordination, formalized partnerships with LGUs, and increased budget allocation for system loss reduction projects reflects a strategic prioritization of both technical and non-technical reforms. These enhancements collectively improve disaster readiness, reduce technical losses, streamline billing, and foster stronger consumer engagement, thereby contributing to financial sustainability and operational efficiency.

RECOMMENDATIONS

In terms of **resource allocation**, CASURECO II should strengthen financial support for transformer replacement and infrastructure upgrades, as non-technical employees expressed reservations about funding adequacy. Balanced investment in manpower and equipment is necessary to bridge the gap between technical staff

confidence and administrative concerns, ensuring compliance with NEA benchmarks and long-term sustainability.

For **urgency**, the cooperative must prioritize rapid technical interventions, particularly transformer and meter replacement, which urban consumers rated only “Moderately Implemented.” Streamlining procurement processes, allocating contingency funds, and sustaining strong billing responsiveness will help balance operational reliability with consumer trust.

Regarding **effectiveness of non-technical strategies**, CASURECO II should expand digital payment channels, quick-pay lanes, and flexible installment policies to address urban consumers’ concerns about payment speed. Consumer education programs must also be intensified to promote awareness and adoption of digital tools, thereby reducing communication gaps and improving satisfaction.

On **ECRP effectiveness**, the cooperative should continue investing in automation and digitalization, as faster payment options and cost efficiency were identified as the strongest contributors. Monitoring mechanisms and clearer disconnection policies should be reinforced to reduce overdue accounts, while reminder systems should be retained as supplementary tools to encourage compliance.

The **correlation analysis** revealed that non-technical strategies such as efficiency and urgency had stronger associations with ECRP effectiveness compared to technical indicators. CASURECO II should therefore maintain technical efficiency while placing greater emphasis on consumer-facing reforms, including communication and billing responsiveness. The balanced sample of 71 respondents highlights the importance of integrating both employee and consumer perspectives in future planning.

Finally, the **union of strategies** underscores CASURECO II’s transition from fragmented, manual processes to integrated, technology-driven reforms. To sustain these gains, the cooperative should institutionalize cross-department coordination, formalize partnerships with LGUs, and integrate technical monitoring with billing data through centralized dashboards. Prioritizing system loss reduction projects in budget planning and combining infrastructure investments with administrative reforms will ensure sustainable outcomes and stronger resilience.

REFERENCES

1. Ansell, C., Sørensen, E., & Torfing, J. (2020). Understanding inclusion in collaborative governance: A conceptual framework. *Policy and Society*, 39(4), 497–512. <https://doi.org/10.1080/14494035.2020.1785726>
2. Awan, H. M., Habib, M. N., Akhtar, C. S., Naveed, M., & Raza, A. (2020). Effectiveness of performance management system for employee performance through engagement. *SAGE Open*, 10(4), 1–12. <https://doi.org/10.1177/2158244020969383>
3. Creswell, J. W., & Plano Clark, V. L. (2011). *Designing and conducting mixed methods research* (2nd ed.). Thousand Oaks, CA: SAGE Publications. <https://doi.org/10.1111/j.1753-6405.2007.00096.x>
4. David, M. D., Llanto, P. K., Mañalac, S. S., Martin, A., Salacup, A. J., Gomez Jr., R., Bulanan, E., & Soriano, M. E. (2025). Analysis of system loss reduction through recovery preventive maintenance (RPM) of kWh meter connections, PELCO I. *Asian Journal of Applied Science and Technology*, 9(2), 217. <https://doi.org/10.38177/ajast.2025.9217>
5. Department of Energy. (2024). *Missionary Electrification Development Plan 2024–2028*. Department of Energy, Republic of the Philippines. <https://tinyurl.com/DOE-MEP-2024>
6. Energy Regulatory Commission. (2018). *Rules governing the recovery of system loss costs by distribution utilities*. Energy Regulatory Commission. <https://tinyurl.com/ERC-systemloss>
7. Energy Regulatory Commission. (2019). *Guidelines on accurate metering and billing for distribution utilities*. Energy Regulatory Commission Philippines. <https://tinyurl.com/ERC-metering-guidelines>
8. Faqishafyee, M. M., et al. (2024). Mitigating non-technical losses and electricity theft through smart meters: A case study of the Akre district power distribution network. *Energy Reports*. <https://www.researchgate.net/publication/384928123>

9. Haq, I. U., et al. (2023). Electricity theft detection for smart grid security using smart meter data: A deep CNN-based approach. *Energy Informatics*, 6(1). <https://www.researchgate.net/publication/365472194>
10. Japan International Cooperation Agency. (2019). The project on system loss reduction for Philippine electric cooperatives (ECs): Completion report. Japan International Cooperation Agency. <https://tinyurl.com/JICA-loss-reduction>
11. Japan International Cooperation Agency. (2020). Distribution network improvement project reports in the Philippines. Japan International Cooperation Agency. <https://tinyurl.com/JICA-distribution-report>
12. Jou, Y. T., Saflor, C. S., Mariñas, K. A., Young, M. N., Prasetyo, Y. T., & Persada, S. F. (2022). Assessing service quality and customer satisfaction of electric utility provider online payment systems. *Electronics*, 11(22), 3646. <https://doi.org/10.3390/electronics11223646>
13. Kabir, M. A., Hossain, M. S., & Andersson, K. (2022). A survey on machine learning techniques for electricity theft detection in smart grids. *Sustainability*, 14(14), 8611. <https://doi.org/10.3390/su14148611>
14. Khan, Z. A., Adil, M., Javaid, N., Saqib, M. N., Shafiq, M., & Choi, J. G. (2020). Electricity theft detection using supervised learning techniques on smart meter data. *Sustainability*, 12(19), 8023. <https://doi.org/10.3390/su12198023>
15. Resurreccion, R. M., & Alvarez, M. T. S. (2025). Efficiency and effectiveness of utility billing management system in the collection of electric services. *Journal of Education, Social Sciences and Allied Health*, 2(1), 93–101. <https://tinyurl.com/utility-billing-efficiency>
16. Siddque, K. Q., & Shaik, M. (2024). Digital transformation in utilities and meter to cash processes. *Journal of Computer Sciences and Applications*, 12(1), 1–9. <https://tinyurl.com/digital-utilities-process>
17. Sovacool, B. K. (2014). What are we doing here? Analyzing fifteen years of energy scholarship and proposing a social science research agenda. *Renewable and Sustainable Energy Reviews*, 36, 52–60. <https://doi.org/10.1016/j.rser.2014.04.063>
18. Tahir, M., Shah, S. A. A., & Javaid, N. (2022). Electricity theft detection in smart grids using deep learning techniques. *Frontiers in Energy Research*, 10, 867991. <https://doi.org/10.3389/fenrg.2022.867991>
19. Taxén, L. (2020). Reviving the individual in socio technical systems thinking. *Complex Systems Informatics and Modeling Quarterly*, 22, 53–72. <https://doi.org/10.7250/csimq.2020-22.03>
20. World Bank. (2021). Philippines energy sector development reports. World Bank. <https://tinyurl.com/worldbank-energy-ph>
21. World Bank. (2023). Reducing transmission and distribution losses in developing countries. World Bank. <https://tinyurl.com/worldbank-loss-reduction>
22. Zheng, Y., Chen, F., Yang, H., & Su, S. (2022). Edge computing-based electricity theft detection of low voltage users. *Frontiers in Energy Research*. <https://doi.org/10.3389/fenrg.2022.892541>