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Solar Home-Based System and Quality Management on Comprehensive User Experience among Electric Cooperatives' Member-Consumers

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ABSTRACT

Rural electrification in the Philippines still struggles with energy access, system reliability, and service quality, especially in off-grid areas served by electric cooperatives. This study assessed how the Solar Home-Based System (SHS) and Quality Management practices affect the Comprehensive User Experience of FIBECO member-consumers in Bukidnon. A quantitative descriptive-correlational design surveyed 385 active SHS households in ten municipalities using a researcher-developed, validated questionnaire. Results showed favorable perceptions of SHS implementation and Quality Management, with Comprehensive User Experience. Pearson correlation revealed strong positive relationships between SHS implementation and user experience and between quality management and user experience. Stepwise multiple regression identified environmental and economic benefits, monitoring and evaluation, support and maintenance, cost affordability, availability and reliability, and financial support as significant predictors of user experience, The findings indicate that both the technical performance of SHS units and the cooperative's quality management practices strongly shape member-consumer satisfaction, providing practical guidance for FIBECO, program implementers, and policymakers seeking to strengthen decentralized solar energy programs in rural Philippine communities.

INTRODUCTION

Access to affordable, reliable, sustainable, and modern energy for all is not merely a development goal; it is the foundation for economic growth, social equity, and environmental sustainability in the 21st century. As global communities confront the urgent challenges of climate change and energy poverty, the transition to renewable energy sources has become imperative. Solar Home Systems (SHS) stand at the forefront of this transformation, particularly for underserved rural communities where conventional grid infrastructure remains economically and geographically prohibitive.

This study directly aligns with Sustainable Development Goal 7 (SDG 7): Ensure access to affordable, reliable, sustainable and modern energy for all, and SDG 13: Take urgent action to combat climate change and its impacts. By examining the effectiveness of Solar Home Systems among electric cooperative member-consumers in Bukidnon, this research contributes evidence toward achieving universal energy access while simultaneously reducing carbon emissions and strengthening climate resilience in rural Philippine communities.

The global demand for renewable energy has increased significantly over the past decade as countries intensified efforts to reduce greenhouse gas emissions and expand access to sustainable power sources. Recent analysis highlighted rapid year-on-year global growth in PV installations, with global capacity rising by more than 23 percent between 2022 and 2023 according to International Energy Agency (Wang *et al.*, 2025). These developments emphasized SHS as viable decentralized electrification solutions for communities located far from conventional grid networks.

In Southeast Asia, national renewable energy roadmaps placed growing emphasis on solar deployment to enhance energy security and reduce dependence on imported fossil fuels. Regional studies demonstrated that PV systems performed well in tropical climates when properly maintained and monitored, although high humidity, dust accumulation, and temperature variations continued to reduce systems efficiency (Wang *et al.*, 2025). The Philippines adopted stronger renewable energy strategies under the Philippine Energy Plan to promote energy diversification and decentralized electrification.

Solar Home Systems represent a transformative technology for rural electrification, addressing multiple dimensions of energy poverty simultaneously. Unlike temporary or makeshift energy solutions, SHS provide regulated, utilitystyle services designed to ensure affordability, maintenance support, and reliable customer service. In Bukidnon, electric cooperatives such as the First Bukidnon Electric Cooperative (FIBECO) implemented Photovoltaic Mainstreaming (PVM) and Solar Home System programs specifically to address persistent rural energy poverty.

These initiatives provided households with stable electricity access, enabling extended study hours for children, improved household productivity, safer lighting

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conditions, and enhanced communication capabilities. Beyond individual household benefits, SHS programs contribute to broader community development by supporting small businesses, improving health service delivery, and strengthening social cohesion through reliable energy access.

Recent research on PV system reliability across varying climatic zones indicated that long-term performance depended heavily on system consistency and timely fault detection, especially in inverter and Maximum Power Point Tracking (MPPT) components (Fernández *et al.*, 2025). As a result, cooperatives were encouraged to adopt structured maintenance schedules to prevent energy loss and improve user satisfaction.

Aside from technical considerations, non-technical factors were also found to influence the adoption and continued use of renewable energy systems. Studies published from 2015 onward identified user awareness, training, financial mechanisms, and perceived benefits as major elements affecting SHS acceptance and long-term utilization in rural electrification settings. Recent reviews emphasized the importance of consumer education to ensure proper system use, reduce misuse, and prolong equipment lifespan (Bakhshi *et al.*, 2023).

Quality management practices also played a crucial role in improving PV system performance and fostering user trust. Contemporary reviews from the International Energy Agency's PVPS Task 13 highlighted the importance of structured maintenance, regular monitoring, and systematic evaluation to mitigate system degradation and prevent prolonged
downtime (IEA-PVPS, 2025). These practices were especially important in tropical regions where environmental stressors accelerated PV deterioration.

Given these considerations, this study examined the effectiveness of Solar Home Systems and quality management practices among electric cooperative member-consumers in Bukidnon. Specifically, it assessed user awareness, system availability and reliability, financial support mechanisms, and environmental and economic benefits associated with SHS adoption. It also evaluated the implementation of support services, maintenance procedures, monitoring strategies, and evaluation practices within the cooperative. Additionally, the study sought to determine how these technical and managerial factors shaped comprehensive user experience in remote communities.

Since limited local research has explored SHS user satisfaction within cooperative-managed settings, this study addressed a significant knowledge gap in the context of Philippine decentralized electrification. Through its findings, the research aimed to contribute evidence-based insights for improving SHS implementation and strengthening user engagement. Specifically, this study aimed to: (1) describe the demographic profile of the respondents; (2) determine the level of effectiveness of the Solar Home-Based System; (3) examine the degree of Quality Management implementation; (4) assess the level of Comprehensive User Experience; and (5) determine the relationship among Solar Home-Based System, Quality Management, and Comprehensive User Experience.

LITERATURE REVIEW

Theoretical Framework

This study was grounded in established theoretical frameworks linking photovoltaic mainstreaming, quality management practices, and comprehensive user experience within electric cooperative contexts. Input-output theories (Bhattacharyya, 2013) and SERVQUAL service quality models (Ismail *et al.*, 2016; Ong *et al.*, 2023) provided the conceptual framework, demonstrating how technical inputs (awareness, reliability, financial support) and managerial processes (maintenance, monitoring, cost affordability) generated measurable user outcomes (accessibility, satisfaction, benefits, awareness).

Photovoltaic Mainstreaming / Solar Home-Based System

Photovoltaic Mainstreaming (PVM) in the Philippines emerged as a national initiative to accelerate rural electrification through standardized Solar Home-Based Systems (SHS). Under the supervision of the National Electrification Administration (NEA) and the Department of Energy (DOE), PVM aims to deliver sustainable and utility-managed solar services to off-grid communities. This nationwide effort received support from international partners such as the World Bank and the European Union, which contributed both funding and technical guidance for cooperative-led SHS deployment (DOE, 2024).

In Bukidnon, FIBECO actively participated by installing SHS units equipped with photovoltaic panels, batteries, charge controllers, and energy-efficient lighting. Consistent with global findings, the standardized SHS configurations adopted by FIBECO ensured long-term durability and ease of maintenance (Ulsrud *et al.*, 2022). Global evidence supports the positive impact of SHS adoption on rural households. Studies from South Asia and Sub-Saharan Africa showed that SHS improved productivity, enhanced educational activities, and extended business operations during evenings (Brossmann *et al.*, 2021).

Awareness and Training

Awareness and training have consistently been identified as major contributors to the successful adoption and longterm use of SHS in rural communities. Research demonstrated that households exposed to awareness campaigns and training sessions gain essential knowledge about system benefits, limitations, and maintenance (Kayode *et al.*, 2023). Moreover, users who undergo training tend to operate their systems correctly, resulting in fewer technical issues and prolonged equipment lifespan (Sarkar & Singh, 2022).

Availability and Reliability
Availability and reliability are crucial indicators of SHS effectiveness because households depend heavily on consistent electricity access for daily activities. Research over the past decade indicated that systems with stable energy availability promoted higher user trust and long-term engagement (Alfaro *et al.*, 2023). Environmental conditions such as heat, humidity, and airborne dust commonly affected system performance in tropical regions, requiring frequent maintenance (Sari *et al.*, 2024).

Financial Support
Financial support remains one of the strongest determinants of SHS adoption, especially among low-income households. Numerous studies reported that pay-as-you-go financing models greatly reduced financial barriers by allowing users to make small, flexible payments over time (Ilskog & Kjellström, 2021). Additionally, programs offering subsidies, concessional loans, and output-based grants were found to increase SHS accessibility, particularly in rural regions with limited purchasing power (Chakraborty *et al.*, 2024).

Environmental and Economic Benefits
Environmental and economic benefits serve as important motivations for SHS adoption due to their influence on both sustainability goals and household welfare. Studies widely agree that SHS reduce dependence on kerosene lamps, diesel generators, and fuelwood, thereby lowering emissions and improving indoor air quality (Miccio *et al.*, 2024; Haque *et al.*, 2023). Additionally, SHS reduce household expenses on traditional fuels, enabling families to allocate more resources toward food, education, and livelihood activities.

Quality Management
Quality Management (QM) plays a critical role in maintaining user satisfaction and operational reliability within cooperative-led SHS programs. Structured support services and regular maintenance schedules help reduce system downtime and ensure equipment longevity (Cooperative Development Authority, 2023). Technological advancements such as real-time monitoring systems support early fault detection, optimize performance, and reduce long-term system degradation (Alcañiz *et al.*, 2022).

Support and Maintenance
Support and maintenance are widely recognized as essential components of quality management in SHS operations. Several studies confirmed that structured maintenance routines prevent system degradation and decrease the likelihood of major failures (Baral *et al.*, 2024). Research from East Africa and South Asia further showed that access to maintenance support reduced system interruptions and improved user satisfaction (Mwanga & Urpelainen, 2021).

Monitoring and Evaluation
Monitoring and evaluation (M&E) are critical in ensuring that SHS programs perform efficiently and reliably. Technological advancements have made it possible to integrate remote monitoring systems capable of detecting issues before they escalate (Ngo *et al.*, 2020). Studies consistently reported that SHS programs with structured M&E systems showed higher uptime and reduced operational failures compared to programs without M&E components (Baral *et al.*, 2024).

Cost Affordability
Cost affordability emerged as a significant dimension of SHS quality management because it shaped perceptions of fairness, accessibility, and long-term willingness to engage in solar programs. Researchers emphasized that affordability must be evaluated not only in terms of initial installation costs but also regarding recurring fees, maintenance charges, and replacement expenses for key components (Garside *et al.*, 2022).

Comprehensive User Experience
Comprehensive User Experience (CUE), operationalized through accessibility, satisfaction, user benefits, and environmental awareness, was an increasingly critical determinant of cooperative success and member-consumer loyalty. The digital transformation sweeping across the energy sector created unprecedented opportunities for improving accessibility by enabling member-consumers to engage with services via user-friendly digital platforms (Libo-on, 2021).

Accessibility
Accessibility encompassed physical and digital dimensions of service availability, which were critical to the empowerment and convenience of cooperative member-consumers. Digital platforms revolutionized how users interacted with electric cooperatives, enabling activities such as account management, outage reporting, payment processing, and information access (NRECA, 2021).

Satisfaction
Satisfaction among electric cooperative member-consumers was predominantly shaped by service quality, responsiveness, and transparency. Significant correlations existed between reliable service delivery, clear and accurate billing practices, and high-caliber technical support on one hand, and increased consumer satisfaction on the other (Ong *et al.*, 2023).

User Benefits
User benefits referred to the tangible improvements that households experienced from SHS use, such as better lighting for study, increased productivity at night, improved communication through mobile charging, and enhanced household well-being. Empirical evidence from

rural SHS users demonstrates that these systems deliver multiple household benefits (Bipasha *et al.*, 2025).

Environmental Awareness

Environmental awareness as a user experience outcome reflected a household's increased understanding of the environmental value of solar energy, including reduced pollution risks and lower dependence on fossil-based lighting sources. Research on SHS use and rural energy transitions suggested that SHS adoption was frequently accompanied by decreased kerosene consumption (Stojanovski *et al.*, 2017).

MATERIALS AND METHODS

This study employed a quantitative descriptive-correlational design to examine the influence of the SHS and quality management on the comprehensive user experience of electric cooperative member-consumers in Bukidnon, Philippines. The procedures outlined were designed to ensure the rigor, validity, and ethical integrity of the research process.

The study was conducted within the service area of the First Bukidnon Electric Cooperative, Inc. (FIBECO), the primary electric power distributor serving Region 10, Northern Mindanao, Philippines. FIBECO provides electricity to municipalities across southern Bukidnon, with its main office located at P-2 Anahawon, Maramag along Sayre Highway.

This study focused on municipalities within FIBECO's jurisdiction where SHS were deployed under the Photovoltaic Mainstreaming Program. Based on FIBECO's project enrollment records at the time of data collection, the first-batch SHS program covered 13 distinct areas. However, due to challenges in accessibility, security, or respondent availability, data gathering was conducted in 10 of these areas: Damulog, Kadingilan, Kibawe, Quezon, Kitaotao, Valencia City, Pangantucan, Don Carlos, Kalilangan, and San Fernando.

The respondents of this study were exclusively the active member-consumers of FIBECO who were enrolled in and currently utilizing the Solar Home-Based System under the cooperative's Photovoltaic Mainstreaming Program. Eligibility criteria for inclusion required respondents to be (a) a registered FIBECO member-consumer, (b) currently enrolled in and actively using the Solar Home-Based System, (c) at least 18 years of age in consistent with the provisions of the Philippine Cooperative Code of 2008 (RA 9520), and (d) with a minimum of six months of continuous system usage.

The study focused on working-aged adults, defined as individuals between 18 and 64 years of age, consistent with the operational definition used by the International Labour Organization (ILO, 2023) and applied in Philippine labor force surveys (Philippine Statistics Authority, 2022). FIBECO's enrollment records identified a total of 1000 registered SHS households across the covered municipalities. However, persistent security concerns in several barangays made household enumeration impractical or unsafe. As a result, complete enumeration was implemented only among accessible SHS-enrolled member-households in the 10 participating municipalities, yielding a total of 385 valid responses.

The research instrument used for data collection was a researcher-developed validated questionnaire designed specifically to reflect the operational context of FIBECO's SHS and the lived experiences of its rural memberconsumers. Prior to deployment, the instrument underwent a two-stage validation process. First, content validity was established through expert review by academics and practitioners with expertise in renewable energy management, cooperative studies, and survey instrument design. Second, pilot testing was conducted with a small group of SHSenrolled member-consumers from municipalities not included in the main study.

Cronbach's alpha coefficients were computed for each scale to confirm internal consistency reliability, with values 0.87, exceeding .70 which is considered acceptable and values above .90 considered excellent (Hair *et al.*, 2019). The instrument comprised three main parts: Part I assessed demographic profile; Part II examined Solar Home-Based System effectiveness, comprising awareness and training, availability and reliability, financial support, and environmental and economic benefits; Part III evaluated Quality Management implementation, comprising support and maintenance, monitoring and evaluation, and cost affordability; and Part IV measured Comprehensive User Experience across four dimensions: accessibility, satisfaction, user benefits, and environmental awareness. All substantive items used five-point Likert scales.

Data collection was conducted following a series of institutional approvals and ethical clearances. Prior to pilot testing, the study underwent formal ethics review through the Office of Research, as endorsed by the research adviser, the College Research Coordinator, and the College Dean. Ethical clearance was secured from the Institutional Ethics Review Committee (IERC) before any data collection activity commenced.

Upon receipt of ethical clearance, the researcher coordinated formally with FIBECO management to obtain institutional permission and to access the official registry of SHS-enrolled member-consumers. The finalized survey instrument was prepared in both English and Cebuano/Bisaya to ensure linguistic accessibility. Surveys were administered through a combination of face-to-face administration conducted by trained enumerators and assisted selfadministration facilitated by FIBECO's municipal office staff.

Informed consent was obtained from all respondents prior to survey administration. Each respondent was informed of the study's purpose, the voluntary nature of participation, their right to withdraw without consequence, and the confidentiality measures governing their responses. Completed surveys were reviewed by enumerators for completeness before submission. Responses with more than 10% missing items per section

were excluded from the dataset to preserve analytical integrity.

The data gathered were analyzed using IBM SPSS Statistics, Version 28. Frequency counts and percentages were used to describe the demographic profile of respondents. Means and standard deviations were computed to determine the level of effectiveness of the Solar Home-Based System, the degree of Quality Management implementation, and the level of Comprehensive User Experience. Pearson Product-Moment Correlation analysis was applied to examine the nature and strength of the relationships between the independent variables (Solar Home-Based System and Quality Management) and the dependent variable (Comprehensive User Experience). The significance of each correlation coefficient was tested at the .05 level.

This study was conducted in strict adherence to the ethical principles governing research involving human participants, consistent with the guidelines of the Philippine Health Research Ethics Board (PHREB), the World Health Organization (2024), and the National Institutes of Health (2025). Informed consent was obtained from all participants before survey administration. Confidentiality and anonymity were strictly maintained throughout. All data were reported exclusively in aggregate form. Non-maleficence was observed through careful instrument design. All collected data were used exclusively for the academic purposes of this study and were not shared with FIBECO management or any other third party in a form that could identify individual respondents.

RESULTS AND DISCUSSION

This chapter presents the gathered data and provides a comprehensive analysis and interpretation of the findings of the study. It covers the demographic profile of the respondents, the levels of SHS implementation, quality management, and comprehensive user experience as perceived by electric cooperatives' member-consumers. Also discussed are the significant relationships between the independent variables and the dependent variable, as well as the predictors that best explain comprehensive user experience among the respondents.

The demographic profile of the respondents was examined with respect to age, gender, occupation, length of membership, location, and type of household electricity supply before installation. The largest age group comprised respondents aged 25 to 34 years, accounting for 116 individuals or 30.1% of the total sample. Those aged 35 to 44 years numbered 98, or 25.5%, while respondents aged 45 to 54 years accounted for 80 or 20.8%. Respondents aged 18 to 24 years numbered 51 or 13.2%, while those aged 55 years and above constituted the smallest group, with 40 individuals or 10.4%.

The result suggests that the SHS program has been predominantly adopted by member-consumers aged 25 to 44 who are likely heads of households and primary decision-makers regarding energy consumption. This demographic characteristic is consistent with findings from rural electrification studies, which indicate that middle-aged household members tend to be the primary beneficiaries and evaluators of off-grid energy solutions (Practical Action, 2021; World Bank, 2022).

Most respondents were male, comprising 244 individuals or 63.38% of the total sample. Female respondents numbered 141, or 36.62%. The predominance of male respondents may reflect the traditional household structure in rural Bukidnon communities, where male members more commonly serve as the registered cooperative member-consumers and primary household representatives.

The largest group comprised farmers and agricultural workers, accounting for 291 respondents or 75.6% of the sample. Private employees numbered 87, or 22.6%, while those who were self-employed accounted for only 1 respondent or 0.3%. Those belonging to other occupational categories numbered 6, or 1.6%. This occupational profile underscores the social and economic significance of the SHS program as a renewable energy solution tailored to underserved agricultural households (Department of Energy, 2022; International Renewable Energy Agency, 2023).

With respect to length of membership, most respondents had been program members for 6 to 11 months, accounting for 380 individuals or 98.7% of the sample. Those with 1 to 3 years of membership numbered only 5 respondents, or 1.3%. The concentration of respondents with relatively short membership duration suggests that the SHS program is still in its early implementation phase.

The largest group of respondents came from Quezon, accounting for 127 individuals or 33.0% of the sample. Damulog followed with 63 respondents or 16.4%, while Valencia City accounted for 61 respondents or 15.8%. The geographic distribution of respondents across ten municipalities reflects the broad coverage of the Solar Home-Based System program across the province (Philippine Statistics Authority, 2020).

The largest group comprised respondents who indicated other types of electricity supply, accounting for 260 individuals or 67.5% of the sample. Those with no electricity connection numbered 124 or 32.2%, while those who relied on kerosene accounted for only 1 respondent or 0.3%. The finding that nearly one-third of respondents previously had no electricity connection underscored the critical access gap that the SHS program sought to address (Department of Energy, 2022; World Bank, 2022).

The overall composite mean of 4.48 indicates that member-consumers perceived the Solar Home-Based System implementation very favorably across all dimensions. Among the sub-dimensions, Awareness and Training obtained

the highest mean (M = 4.52, Highly Effective), indicating that the cooperative provided sufficient and clear training, with regular orientations improving confidence in operating and maintaining the system.

This finding strongly aligns with the conclusions of

Table 1: Demographic Profile Analysis of Survey Respondents (N = 385)

Demographic Profile	**Category**	**Frequency (N)**	**Percentage (%)**
Age	18–24 years old	51	13.2
	25–34 years old	116	30.1
Demographic Profile	**Category**	**Frequency (N)**	**Percentage (%)**
	35–44 years old	98	25.5
	45–54 years old	80	20.8
	55 years and above	40	10.4
Total		**385**	**100**
Gender	Male	244	63.38
	Female	141	36.62
Total		**385**	**100**
Occupation	Farmer/Agricultural Worker	291	75.6
	Private Employee	87	22.6
	Self-Employed	1	0.3
	Others	6	1.6
Total		**385**	**100**
Length of Membership	6–11 months	380	98.7
	1–3 years	5	1.3
Total		**409**	**100.0**
	Damulog	63	16.4
	Kadingilan	11	2.9
	Kibawe	7	1.8
	Quezon	127	33.0
	Kitaotao	36	9.4
	Valencia City	61	15.8
	Pangantucan	16	4.2
	Don Carlos	8	2.1
	Kalilangan	13	3.4
	San Fernando	43	11.2
Total		**385**	**100**
Type of Household Electricity Supply Before Installation	No Electricity Connection	124	32.2
	Kerosene	1	0.3
	Others (battery lamps, candles, shared connections, solar lights)	260	67.5
Total		**385**	**100**

Table 2: SHS Implementation

Indicators	**Mean**	**Descriptive Rating**	**Qualitative Interpretation**
Awareness and Training	4.52	Strongly Agree	
Availability and Reliability	4.44	Agree	Effective

Financial Support	4.48	Agree	Effective
Environmental and Economic Benefit	4.48	Agree	Effective
Overall Mean	**4.48**	**Agree**	**Effective**

Kayode *et al.* (2023) and Chakraborty *et al.* (2024), who emphasized that comprehensive training programs lead to higher system usability and longer equipment lifespan. Similarly, Rahman *et al.* (2022) reported that continuous user instruction in rural electrification projects significantly reduced system misuse and maintenance costs.

Availability and Reliability recorded the lowest sub-dimension mean of 4.44 (Effective), though still favorable. This shows that the solar units provided consistent and dependable performance, though response time for repairs could be enhanced. Literature underlines reliability as a critical benchmark of SHS performance that directly affects user trust and satisfaction (Alfaro *et al.*, 2023; Haque *et al.*, 2023).

Financial Support (M = 4.48) indicates that member-consumers strongly agreed that the cooperative provided adequate financial assistance to facilitate their adoption of the Solar Home-Based System. This supports the findings of Ilskog and Kjellström (2021) and Garside *et al.* (2022), who proved that pay-as-you-go and loan-subsidy mechanisms widen SHS accessibility in rural economies.

Table 3: Quality Management Implementation

Indicators	**Mean**	**Descriptive Rating**	**Qualitative Interpretation**
Support and Maintenance	4.42	Agree	Good Implementation
Monitoring and Evaluation	4.43	Agree	Good Implementation
Cost Affordability	4.37	Agree	Good Implementation
Overall Mean	**4.41**	**Agree**	**Good Implementation**

Environmental and Economic Benefit (M = 4.48) indicates that member-consumers strongly agreed that the Solar Home-Based System has delivered tangible benefits. Environmental benefits, such as reduced smoke exposure and forest pressure, confirm the earlier evidence from Brossmann *et al.* (2021) showing ecological co-benefits of solar expansion.

The overall composite mean of 4.41 indicates that member-consumers perceived Quality Management practices favorably. Among the sub-dimensions, Monitoring and Evaluation obtained the highest mean (M = 4.43), suggesting that the cooperative conducted meaningful program monitoring and evaluation. This supports the studies of Ngo *et al.* (2020) and Chakraborty *et al.* (2024) who found that performance monitoring and feedback loops substantially reduce operational failures.

Support and Maintenance (M = 4.42) indicates that member-consumers generally agreed that adequate support and maintenance services were provided. Member-consumers recognized the accessibility and competence of cooperative technicians, signaling that FIBECO has effectively institutionalized service protocols. This outcome aligns with Baral *et al.* (2024), who identified structured maintenance frameworks as key to minimizing downtime and improving satisfaction.

Cost Affordability recorded the lowest mean at 4.37, identifying it as the most critical quality management dimension warranting further attention. The relatively lower overall mean for cost affordability, while still favorable, highlights the financial sensitivity of the predominantly agricultural respondent population. This aligns with Ilskog and Kjellström (2021) and the World Bank (2022), who underscored that even modest recurring costs can burden agrarian households.

The overall composite mean of 4.48 indicates that member-consumers perceived a very favorable comprehensive user experience with the Solar Home-Based System. Environmental Awareness and User Benefit both obtained the highest means at 4.50 (Excellent User Experience), suggesting that perceived environmental and personal household benefits were the most positively experienced dimensions of the program.

The consistently high ratings across all User Benefit indicators affirm that the Solar Home-Based System has delivered multi-dimensional improvements to household life quality. The observed improvements in safety, study conditions,

and communication mirror the findings of Bipasha *et al.* (2025) and Stojanovski *et al.* (2017), which linked SHS adoption to household productivity gains and social inclusion.

The high overall Environmental Awareness mean reflects a meaningful shift in environmental consciousness among solar system users in Bukidnon. Respondents associated SHS with reduced emissions and improved indoor health,

Table 4: Comprehensive User Experience

Indicators	**Mean Descriptive Rating Qualitative Interpretation**	**Accessibility**	**4.44 Agree**	**Good User Experience**
Satisfaction	4.49 Agree	Good User Experience User Benefit	4.50 Strongly Agree	Excellent User Experience Environmental Awareness 4.50
Strongly Agree	Excellent User Experience	Overall Mean	4.48 Agree	Good User Experience

Table 5: Correlation between SHS, Quality Management, and Comprehensive User Experience

Variable	**Correlation Coefficient (r)**	**p-value**
Solar Home-Based System	.756	<.001
Awareness and Training	.487**	<.001
Availability and Reliability	.648**	<.001
Financial Support	.637**	<.001
Environmental and Economic Benefit	.758**	<.001
Variable	Correlation Coefficient (r)	p-value
Quality Management	.798	<.001
Support and Maintenance	.713**	<.001
Monitoring and Evaluation	.733**	<.001
Cost Affordability	.593**	<.001

*Note. **Correlation is significant at the 0.01 level (2-tailed). N = 385*

findings consistent with Miccio *et al.* (2024) and Haque *et al.* (2023).

wwSatisfaction obtained a mean of 4.49, indicating that member-consumers were highly satisfied with the Solar HomeBased System. This aligns with Ong *et al.* (2023), who found that satisfaction in electric cooperatives is driven by reliability, transparency, and empathy.

Accessibility registered the lowest mean at 4.44, underscoring the need for improved service responsiveness and communication channels. These outcomes correspond to NRECA (2021) and Libo-on (2021), who reported that cooperatives leveraging digital tools and simplified enrollment processes enhance utility accessibility in remote settings.

Correlation results indicated that Solar Home-Based System ($r = .756$, $p < .001$) and its sub-components Awareness and Training ($r = .487$, $p < .001$), Availability and Reliability ($r = .648$, $p < .001$), Financial Support ($r = .637$, $p <$ .001), and Environmental and Economic Benefit ($r = .758$, $p < .001$) showed statistical significance relative to Comprehensive User Experience.

This indicates that improvements in SHS implementation across awareness, reliability, financial accessibility, and environmental benefits lead to enhanced user experience. The results strongly align with Brossmann *et al.* (2021) and Rahman *et al.* (2022), who demonstrated that households experiencing comprehensive training, reliable system performance, and clear environmental benefits report significantly higher satisfaction and sustained SHS engagement.

Equally important, correlation results revealed that Quality Management ($r = .798$, $p < .001$) and its constituent factors such as Support and Maintenance ($r = .713$, $p < .001$), Monitoring and Evaluation ($r = .733$, $p < .001$), and Cost Affordability ($r = .593$, $p < .001$) were significantly associated with Comprehensive User Experience.

The analysis indicates a strong positive relationship between quality management practices and user satisfaction, meaning that enhancing quality management within cooperative SHS programs substantially improves memberconsumer experience. This outcome is substantiated by Baral *et al.* (2024) and Patel and Pareek (2018), who established that structured maintenance programs and Total Quality Management frameworks significantly enhance consumer confidence and system reliability.

Among SHS sub-dimensions, Environmental and Economic Benefit recorded the highest correlation with

user experience (r = .758), reflecting the critical importance of tangible household improvements in shaping overall program evaluation. Within Quality Management dimensions, Monitoring and Evaluation demonstrated the strongest association with user experience (r = .733), validating Ngo *et al.* (2020) and Chakraborty *et al.* (2024), who emphasized that systematic performance monitoring and user feedback mechanisms substantially enhance program accountability and consumer trust.

The comparatively stronger correlation of Quality Management (r = .798) over Solar Home-Based System (r = .756) with Comprehensive User Experience suggests that perceived organizational care and systematic service delivery exert a slightly more powerful influence on member-consumer satisfaction than technical system performance alone. These

findings position quality management practices as the primary leverage point for retention and satisfaction in resource- constrained cooperative settings.

CONCLUSIONS

The SHS program in Bukidnon was mainly adopted by members (25–44), mostly farmers, showing its role as energy access for agrarian communities. Short-term membership and prior lack of grid connections indicate early adoption. Implementation was effective across awareness/training, reliability, finance, and environmental benefits, though responsiveness to technical issues needs improvement. Quality management was generally good—accessible maintenance, competent technicians, and meaningful monitoring—while cost affordability remained the top concern. Member-consumers reported positive outcomes: safer lighting, longer productive hours, better communication, improved education for children, increased environmental awareness, and strong willingness to recommend the program. Significant positive correlations existed between SHS implementation and user experience ($r = .756$, $p <$ .001) and between quality management and user experience ($r = .798$, $p < .001$), with quality management showing a stronger link. Recommendations: strengthen pre-installation awareness on environmental and financial benefits; establish localized technician networks with service turnaround standards; adjust payment schedules for seasonal farmer incomes; create LGU-cooperative helpdesks and mobile repair units; include SHS metrics in provincial plans; and adopt structured Quality Management in national off-grid program assessments. Future research should track long- term user experience and replicate the study elsewhere.

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