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EXPANDING ENERGY ACCESS IN RURAL OFF-GRID COMMUNITIES: A STUDY ON HOUSEHOLD ADOPTION AND AFFORDABILITY OF SOLAR HOME SYSTEMS IN KWARA STATE, NIGERIA

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Abstract

This investigation scrutinizes the adoption dynamics and willingness to pay (WTP) for Solar Home Systems (SHS) within the context of rural off-grid communities in Kwara State, Nigeria. A comprehensive survey was administered to 400 households to explore their perspectives towards SHS and to ascertain their valuation of these systems. The results reveal a favourable disposition towards SHS, with a notable proportion of participants favouring personal ownership of SHS even in the event of future grid electricity availability in their localities. The consensus among respondents was that SHS provide sufficient energy to cater to their needs and could potentially act as an income source. The Payment Card (PC) method within the Contingent Valuation (CV) framework was utilized to determine WTP, eliciting precise values from the surveyed households. The derived average monthly WTP for SHS fluctuated between 72% and 75% of the current market rates, exposing an affordability challenge as the WTP falls short of the prevailing market prices. In light of fostering wider adoption, it is imperative for policymakers and SHS providers to consider market price reductions and the initiation of innovative pricing mechanisms that align with household financial capacities. Further research is encouraged on alternative financing strategies and potential subsidy programs to bridge the affordability gap and bolster SHS accessibility in off-grid rural areas. Understanding the household adoption dynamics and WTP for SHS is instrumental in driving sustainable energy transitions and enhancing the living standards of rural dwellers.

Keywords: *Willingness to Pay, Solar Home Systems, Off-grid, Contingent Valuation.*

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1. Introduction

1.1 Context of the Study

As the world forges ahead in its quest for universal energy access and sustainable development, remote off-grid rural communities continue to grapple with considerable hurdles in obtaining reliable and affordable electricity services (Ritchie & Roser, 2019). With an increasing acknowledgement of renewable energy sources as sustainable solutions, Solar Home Systems (SHS) have surfaced as practical and economical alternatives to address the energy requirements of these marginalized communities (Power Africa, 2019).

The effective dissemination and application of SHS in these off-grid areas hinge on a multitude of factors, among which household acceptance and willingness to pay (WTP) for these systems are central. Deciphering the dynamics of WTP is crucial to formulate efficacious electrification strategies, confirming affordability, and augmenting energy access (Blimpo & Cosgrove-Davies, 2019).

In the Nigerian context, where energy access constitutes a significant impediment, particularly within off-grid rural communities, the acceptance and WTP for SHS become instrumental in realizing sustainable energy alternatives (Sambo, 2018). Distributed Energy Service Companies (DESCOs) have emerged as vital contributors in the provision and maintenance of SHS in these regions (Javadi et al., 2013; Palit, 2013). Through inventive business models and alliances with governmental bodies and financial institutions, DESCOs aim to bridge the energy access divide and facilitate the adoption of SHS amongst rural households (Baurzhan & Jenkins, 2016).

This research concentrates on the adoption and WTP for SHS within the rural off-grid communities of Kwara State, Nigeria. The study's objective is to investigate the elements influencing household acceptance of SHS and to ascertain the proportion of the market price that households are prepared to expend on these systems. By understanding these factors, policy designers, energy suppliers, and other stakeholders can devise strategies to encourage the adoption of SHS and enhance energy access in these underprivileged regions.

The outcomes of this research will contribute to the overarching goal of achieving sustainable and inclusive energy systems by providing insights into the acceptance and WTP for SHS within off-grid rural communities. These insights can guide the development of targeted interventions, financial strategies, and policy frameworks to boost affordability, escalate adoption rates, and expedite the shift towards sustainable energy alternatives.

To summarize, this research aims to explore the acceptance and WTP for SHS within rural off-grid communities of Kwara State, Nigeria. By probing the factors influencing household acceptance and determining the proportion of the market price households are prepared to pay, this research seeks to inform strategies that promote the adoption of SHS, enhance energy access, and contribute to the achievement of sustainable and inclusive energy systems within Nigeria's off-grid rural communities.

1.2 Problem Statement

In spite of Nigeria's expanding population and economy, approximately 45% of its inhabitants, equating to 81 million individuals, lack access to an electric grid, and those connections often face unreliable service (World Bank, 2020). The existing grid infrastructure fails to meet the escalating demand, resulting in an electricity access deficit that hampers economic growth and societal development. Off-grid solutions such as Solar Home Systems (SHS) are emerging as potential solutions. However, the acceptance of SHS amongst off-grid communities and the households' willingness to pay (WTP) for such systems, which is a crucial determinant of viability, warrants further exploration.

1.3 Research Objective

The primary objective of this article is to examine the household demand for off-grid solar electricity in off-grid communities within Kwara State, Nigeria, with a focus on:

i. Evaluating the acceptance and attitude of households towards SHS.

ii. Estimating the willingness to pay for SHS among these households.

1.4 Research Questions

i. How do households in off-grid communities within Kwara State, Nigeria, perceive Solar Home Systems (SHS)?

ii. What is the extent of willingness to pay for Solar Home Systems among these households?

1.5 Research Hypotheses

H_1: Households in off-grid communities within Kwara State, Nigeria, hold generally positive perceptions towards Solar Home Systems (SHS).
H_2: Households in off-grid communities within Kwara State, Nigeria, exhibit a substantial willingness to pay for Solar Home Systems.

The forthcoming empirical investigation seeks to validate these hypotheses using rich survey data from off-grid communities in Kwara State, Nigeria. The findings are anticipated to enrich the understanding of solar energy demand dynamics in rural, off-grid settings and offer actionable insights for policy and decision-makers in Nigeria's renewable energy sector.

1.6 Significance of the Study

Access to electricity remains a pressing concern in Nigeria's off-grid regions, with significant implications for socio-economic development. Solar Home Systems (SHS) present a potential solution, yet the comprehensive understanding of household demand and willingness to pay (WTP) for such systems is integral to their successful deployment. Existing research in this domain is limited, particularly concerning Nigeria's off-grid communities and their acceptance of SHS.

This article aims to address these research gaps by exploring WTP for SHS in the off-grid territories of Nigeria, offering insights into households' predilections and acceptance of this technology. This can equip stakeholders with the necessary knowledge to formulate and execute effective, bespoke strategies for promoting SHS, thereby aiding the broader goal of sustainable and affordable energy access.

In essence, this article intends to illuminate the demand for SHS in Nigeria's off-grid communities, delivering crucial information for stakeholders involved in rural electrification, and augmenting the existing body of knowledge on off-grid electrification demand dynamics.

2. Literature Review

2.1 Conceptual Review

The current investigation builds upon the existing body of literature that explores solar home system (SHS) demand and households' willingness to pay (WTP) (Marschak, 1959; McFadden, 1980; Thurstone, 1927). Notably, decision-making process, influenced by factors such as rationality, the availability of information, cognitive biases, and external variables (Bazerman & Moore, 2009; Simon, 1955; Gilovich et al., 2002), plays a significant role. Particularly, the behavioural concept of sunk costs may crucially impact WTP (Arkes & Blumer, 1985; Just & Wansink, 2011; Ho et al., 2013).

Furthermore, consumer perception and expectations feature prominently in decision-making (Kahneman & Tversky, 1979; Baddeley, 2013). Theories in behavioural economics, like the nudge theory, demonstrate how decision-making can be subtly directed towards more sustainable choices. Additionally, societal norms, peer effects, and environmental consciousness can shape consumer behaviour (Kollmuss & Agyeman, 2002). However, gaps persist in understanding the impact of sunk costs on WTP, and the correlation between perception, expectation, and WTP. This research seeks to fill these gaps by providing comprehensive insights into consumer behaviour concerning off-grid solar systems.

2.2 Theoretical Framework

The objectives of this research are grounded in the theory of demand and utility functions, which underpin the understanding of consumer behaviour in contingent valuation studies (Pearce et al., 2002). This study employs the theories of utility and demand to explain individual appraisals of an asset (Carson & Hanemann, 2005).

Given 'q' as an asset and 'x' as other market goods, utility can be defined as u = (x,q). The indirect utility function is denoted as v(p,q,y), where 'p' represents the price vector for other market goods and 'y' denotes the individual's income (Haymond, 1996). Utility is compared across two scenarios: "with q" (q1) and "without q" (q0), with the difference between these situations determining the Hicksian measures, Compensating Variation (C), and Equivalent Variation (E) (Carson & Hanemann, 2005). These measures serve as value indicators for the change in 'q'.

Given the focus of this study on WTP rather than willingness to accept (WTA), it's worth noting the absence of individual property rights on the asset under consideration (Mitchell & Carson, 1989). This study specifically measures the Hicksian consumer surplus measure of Compensating Variation for improvements.

2.3 Empirical Review

Previous empirical research has explored households' WTP for improved electricity services and renewable energy sources in various settings.

For instance, Carlsson and Martinsson (2007) assessed households' WTP for avoiding planned and unplanned power outages in Sweden. In contrast, Abdullah and Jeanty (2011) evaluated consumers' WTP for renewable energy in Kisumu, Kenya. Also, the study conducted by Gunatilake, Maddipati, and Patail (2012) in Madhya Pradesh, India, inspected the determinants of households' WTP for enhanced electricity services. Furthermore, Khandker et al. (2014) analyzed the gender differences in WTP for solar home systems in Bangladesh.

These studies suggest various influencing factors such as outage duration, household size, income, gender, and age, that shape households' WTP. Understanding these determinants could help policymakers and stakeholders develop strategies to promote sustainable energy consumption and improve service delivery.

2.4 Literature Gap

Despite the wealth of literature, there exists a gap regarding the valuation of electricity services specifically for off-grid households in Nigeria. Prior research has primarily focused on urban populations and their willingness to pay (WTP) for solar home systems, with a significant volume of work exploring topics such as solid waste and environmental management, water services, improved healthcare services, and soil and forest resource management. While these studies have provided valuable insights into the valuation of various services in Nigeria, there is a dearth of research specifically addressing the valuation of electricity services for off-grid households.

To address this gap, the present study focuses on the dynamics of WTP, factors influencing WTP decisions, and overall valuation of electricity services in the off-grid sector of Nigeria. By concentrating on off-grid households, we hope to expand the existing knowledge base,

providing useful insights for policymakers, energy service providers, and other stakeholders to develop tailored interventions and investment strategies, enhancing electricity access and affordability for off-grid communities.

A notable study by Ugulu and Aigbavboa (2019) examined WTP for standalone solar photovoltaic systems among urban households in Lagos, Nigeria. The findings suggested a positive attitude towards photovoltaic systems among urban households, with influential factors including age, income, education, and government support impacting participation and adoption. The study also indicated household interest in participating in feed-in-tariff export schemes, reflecting a willingness to contribute to the overall energy system and benefit financially from renewable energy investments. However, these findings cannot be generalized to rural and off-grid communities, which underscores the need for additional research in these underserved areas.

In conclusion, while several studies have examined various aspects of service valuation in Nigeria, there is a distinct gap in the literature concerning the valuation of electricity services for off-grid households. This study seeks to fill this gap and offer valuable insights to help policymakers and stakeholders improve energy access and affordability for these communities.

3. Methodology

3.1 Overview of Research Design

The research study is designed to investigate the demand for solar photovoltaic systems in off-grid rural communities in Kwara state, Nigeria, with a special focus on assessing household willingness to pay (WTP) for such systems. Given the multifaceted nature of this issue, the research utilizes a mixed-methods approach, combining elements of both qualitative and quantitative research methodologies. This strategic approach allows for a broad and nuanced understanding of the research question by enabling data triangulation.

3.2 Geographical Scope and Sampling Strategy

The geographical context of this research is Kwara State in Nigeria, a region characterized by a blend of diverse ethnicities and limited access to reliable electricity. Kwara State is divided into 16 Local Government Areas (LGAs), out of which five were chosen for this study based on the proportion of households living off-grid: Asa, Baruten, Edu, Kaiama, and Patigi. The

choice of these LGAs ensures that the findings are most relevant for areas where the impact of solar photovoltaic systems can be significant.

Within these LGAs, 15 communities were chosen based on their considerable distance from the grid, indicating a high dependence on off-grid energy solutions. A cluster sampling technique was applied, wherein communities served as the clusters, allowing a manageable and comprehensive representation of the population. The final sample size was calculated using the Yamane (1967) formula, resulting in a sample of 400 households. To ensure the sample's representativeness, random sampling was implemented within each cluster.

3.3 Instrumentation and Data Collection Procedures

Data for this research was collected via three primary modes: structured questionnaires, interviews, and secondary data sources. The structured questionnaires, designed in line with stated preference studies' guidelines (Johnston et al., 2017), aimed to collect quantitative data on WTP and demographic information. They included questions related to respondents' interests, acceptance, and willingness to pay for solar home systems, their knowledge, attitudes, and environmental awareness.

To supplement the questionnaire data, interviews were conducted with community leaders and Distributed Energy Service Companies (DESCOs) representatives. The interviews with community leaders helped gather information about socio-economic factors, community attitudes, and potential barriers to adopting solar energy systems. On the other hand, the DESCO interviews focused on exploring market dynamics, pricing strategies, and viable payment plans.

Moreover, secondary data was incorporated to provide a rich contextual backdrop to the study. These data were sourced from reputable organizations such as the National Bureau of Statistics, National Population Council, and Rural Electrification Commission.

To ensure an effective and efficient data collection process, trained enumerators were deployed who were fluent in both English and the local languages. Personal Administration Method was employed, fostering direct interaction between the surveyors and respondents. A total of 400 questionnaires were distributed, and a high response rate was achieved due to the competence of enumerators and the support from local government staff.

3.4 Pre-testing with Pilot Study

To ensure the quality and relevance of the survey instrument, a pilot study was conducted before the main survey. A sample of 20 households was chosen, representative of the target population, to participate in this pilot study. The feedback received from this process was instrumental in refining the questionnaire design, ensuring its validity, and improving the clarity of the questions.

3.5 Analytical Approach

The collected data underwent rigorous analysis to derive meaningful insights. Willingness to Pay (WTP), an essential economic principle, was the primary focus of the study. The WTP measures the maximum amount a consumer is willing to pay for a product or service. In this study, WTP for solar home systems was evaluated using the Contingent Valuation (CV) method, one of the stated preference techniques.

The CV method involved directly asking respondents to state their maximum WTP for the hypothetical scenario of owning a solar home system. The Payment Card (PC) approach was used in this context, where respondents were given a range of values to indicate their maximum WTP.

The selected PC method aimed to capture households' valuation of solar home systems in the most unbiased and accurate way. It provides an effective and ethical means of capturing consumers' preferences without directly asking for their absolute WTP, which may lead to bias or misunderstanding.

In addition, the use of regression analysis enabled a robust investigation of the factors influencing the WTP for solar home systems. The findings from this analysis provided vital information for understanding the nature of the demand for solar home systems and the potential for its expansion in Kwara State.

In conclusion, this study's methodology incorporated a mixed-methods design with rigorous data collection methods and analytic strategies. The process was intended to provide comprehensive insights into the demand for solar home systems in off-grid communities in Kwara State, Nigeria, thereby informing future academic discourse, policy-making, and private sector strategies for renewable energy in similar contexts.

4. Analysis and Discussion of Results

4.1 Introduction

This section unveils a comprehensive analysis and interpretation of the empirical results gathered in relation to the study's objectives. Here, the findings are examined in light of the formulated research questions and hypotheses, culminating in a deep understanding of their broader implications.

4.3 Solar Home Systems: Ownership, Usage, and Payment Plans

As shown by the data, 25% of the surveyed households owned solar home systems (SHS), primarily 80W models (91%). On average, these systems provided 15 hours of light per day, spanning from 7 to 21 hours.

The majority of SHS-owning households (21 out of 26) operated on a Pay as you Go (PAYG) plan, with an average monthly payment of NGN 4,500. The total amount paid before full ownership ranged from NGN 60,000 to NGN 250,000, averaging NGN 120,000. The remaining 5 households had fully paid for their SHS, averaging NGN 20,000 per system. Among them, two made a one-time payment, and three acquired their systems through the PAYG plan.

Regarding preferences for future payment plans over 90% favoured leasing an SHS with eventual ownership, while 4.5% leaned toward one-time payment with a service agreement. When asked about their willingness to pay for the service agreement, all respondents expressed uncertainty.

4.4 Public Issues

To gauge perceptions of several public issues, the survey elicited ratings on their perceived importance. As shown in Table 1, the priority was access to health facilities, with 98% of respondents regarding this as important. Close behind, 95.3% deemed extending the electricity grid to their area important. Conversely, stricter enforcement of restrictions on forest wood collection was ranked lower, with only 24% perceiving it as highly important.

Table 1. Public Issues Perception, by percentage of respondents

Public Concern	Very Important	Somewhat Important	Somewhat unimportant	Not important at all	Don't Know
Enhancement of Primary and Secondary Education	89.7	8.2	2.1		
Expanding the Electrical Grid to Your area	95.3	2.7	1	1	
Limiting Forest Access for Firewood Collection	24	33	35	2.6	5.4
Improving Access to Healthcare Facilities	98	1	1		
Reducing the Cost of Private Solar Equipment	75.4	22.6	2		
Enhancing Security Measures	85.1	13.2	1.7		

Source: Researchers' computation using Eviews

4.5 Household Energy Use

Data on the energy sources for various tasks reveal a composite picture of the households' energy consumption patterns. For lighting, solar energy was the primary source for 43% of households, while 35% relied on kerosene. Cooking was predominantly carried out using firewood (70%), with a minority using charcoal (5%) and gas (5.5%). Solar energy was the primary source for mobile phone charging for 70% of respondents, and powered TVs or radios for 45%. No specific energy sources were reported for refrigeration or cooling purposes.

Table 2 Energy sources for different tasks, by the percentage of respondents

Energy Source	Solar	Gas	Kerosine	Diesel	Charcoal	Firewood	Battery	Other	Freq.
Lighting	43		35	1			11.3	9.7	400
Cooking		5.5	19.5		5	70			400
Mobile Charging	70			12.6			14.4	3	386
Television/Radio	45			18			25	12	390

Source: Researchers'' computation using Eviews

4.6 Willingness to Pay (WTP) for Solar Home Systems

The evaluation of willingness to pay (WTP) for solar home systems (SHS) among off-grid households is a crucial objective of this research study. This measurement can provide key

insights into the perceived value of these systems, and by extension, the potential market demand. To ascertain the WTP for SHS among households in Kwara State, three analytical approaches were employed: computations based on the values from the payment card (PC), computations based on the interval midpoint values, and computations based on the censored interval.

The Payment Card (PC) values returned an average WTP of NGN 3,951 per month, with a median WTP standing at NGN 4,200. Notably, the range of WTP values was quite broad, extending from 0 to NGN 7,525. When computed based on the interval midpoint values, the mean WTP slightly increased to NGN 4,120, while the median remained stable at NGN 4,136.

For the third analytical approach, an unconditional mean WTP was calculated through interval regression without the inclusion of explanatory variables. The derived value was NGN 4,125.

The information from these analyses of mean WTP yields significant insights into the potential affordability of SHS for rural households, as well as their willingness to invest in such systems. Understanding these figures is vital for stakeholders aiming to navigate the market dynamics of solar home system distribution in off-grid rural areas.

4.7 Zero WTP

An interesting subset of the research sample consisted of respondents who reported a zero willingness to pay (WTP) for solar home systems. Delving into the reasons for this revealed important challenges to SHS adoption. Among this group, 70% stated that they simply cannot afford to pay for solar home systems, thereby highlighting the stark financial constraints faced by a significant portion of the population in off-grid rural areas of Nigeria.

Furthermore, 30% of respondents within the zero WTP group held the belief that it would be more beneficial to await the eventual expansion of the grid to their villages. This reflects a lingering perception of grid connection as a more preferable and cost-effective solution to their energy needs, despite the proven benefits and suitability of solar home systems for their context.

The identification of these reasons behind a zero WTP for SHS illuminates some of the barriers that policymakers and energy service providers must contend with. This understanding can

help in the design of effective interventions and programs to overcome these barriers, and in doing so, promote the uptake of sustainable energy solutions in rural areas.

4.8 Knowledge and Attitudes towards SHS

One of the sections of the survey was dedicated to assessing the respondents' knowledge and attitudes towards solar home systems (SHS). Interestingly, the findings from this section painted a largely positive picture. Although 56% of respondents disagreed with the prediction that the grid would reach their village within the next three years, an overwhelming 92% affirmed that they would choose to keep a private SHS even after grid electricity becomes available in their locality.

There was also a high level of recognition of the adequacy and benefits of SHS among the respondents. 83% agreed that a SHS would be sufficient for their electricity needs. Moreover, 85% disagreed with the idea of leasing a SHS and ceasing the lease once the grid becomes available in their village. This demonstrates an understanding of the value in owning and continuing to use a SHS, even in the event of grid extension.

The survey also found that knowledge about SHS among respondents was relatively high. A significant 91% agreed that SHS could serve as an income-generating tool, thus demonstrating awareness of its multifaceted potential beyond domestic energy supply.

In summary, the responses in this section reflect a largely positive perception and adequate knowledge of SHS among respondents, which should serve as a positive foundation for promoting the further adoption of these systems in off-grid rural communities.

4.9 Willingness to Pay (WTP) and Market Prices

Understanding the potential disconnect between the willingness to pay (WTP) for solar home systems (SHS) and the current market prices for these systems is an important aspect of this study. A consideration of these dynamics can reveal the economic viability of SHS distribution in the target communities and inform policy or business strategy for boosting adoption.

From the market price survey conducted in conjunction with the WTP study, the average market price for a basic SHS unit (which includes a 50W solar panel, a battery, a charge controller, three LED lights, and a port for charging mobile phones) was found to be NGN 49,500. When this cost is spread over a period of 12 months, it translates to a monthly payment

of approximately NGN 4,125, assuming a zero interest rate. Broadly speaking, these findings indicate that households are ready to pay up to 72% to 75% of the prevailing market price, as established at the time of this research.

Table 3: WTP and Market Prices

PC Value (NGN)	***Interval (NGN)***	***Midpoint Value***	***Market Price (NGN)***
3950.6	*4120.49*		*5,500*

Source: Researchers 'computation using Eviews

The information in Table 3 above reveals an affordability challenge, as the WTP falls short of prevailing market prices. Hence, while there's some level of market readiness, a significant disparity exists between what households are willing and able to pay and the actual cost of SHS.

Accounting for the diverse socio-economic contexts of the respondents is crucial. Those with zero WTP underscore the presence of economic barriers that prevent them from partaking in a market-based solution. For these households, there's a clear need for interventions, such as subsidies, affordable financing arrangements, or government-led electrification initiatives.

Moreover, the widespread positive attitudes towards SHS among respondents suggest a willingness to stretch their budgets slightly above their stated WTP, provided more accessible financing solutions are available.

In conclusion, while the calculated average monthly WTP suggests some level of market readiness, it also emphasizes the need for innovative financial solutions, policy interventions, and bespoke strategies to bridge the affordability gap and ensure the broad accessibility of SHS for all households in off-grid rural communities.

4.10 Research Questions and Results

This section presents a summary of the primary research questions (RQ) and the corresponding results of the study. It elucidates the understanding of the acceptance and willingness to pay for Solar Home Systems among households in the off-grid areas of Nigeria.

RQ1: Acceptance of Solar Home Systems

The acceptance of SHS was measured by assessing the attitudes of households towards solar energy, the perceived adequacy of the electricity supplied, and the economic prospects of having SHS. The results of the study reveal an overall favorable acceptance of SHS among the respondents.

Approximately 92% of the households expressed a strong inclination to continue using privately-owned SHS, even in the event of grid electricity becoming available. In addition, 83% of the respondents agreed that the electricity provided by SHS meets their household needs. Furthermore, recognition of the income-generating potential of SHS was high at 91%, with 75.5% of households acknowledging the ability of SHS to power appliances.

These results underscore a positive disposition towards SHS among households in off-grid areas of Nigeria, which is indicative of a potentially vibrant market for SHS.

RQ2: Willingness to Pay for Solar Home Systems

The willingness to pay (WTP) for SHS was determined through an extensive economic analysis employing diverse methodological approaches. The results indicate an average monthly WTP falling between NGN 3,951-4,200. However, considering the prevailing market rates for SHS, this mean WTP represents approximately 72% to 75% of the current costs, exposing an affordability gap for households in these communities.

The revealed willingness to pay within this range indicates a potential market demand for SHS in these areas. However, the affordability challenge underscores the importance of pricing strategies and innovative financial solutions that align with the WTP of households to enhance the accessibility and adoption of SHS.

In conclusion, the findings of this research significantly enhance our understanding of SHS acceptance and WTP among households in off-grid regions of Nigeria. The manifest positive attitudes towards SHS and the demonstrated willingness to pay reveal a potential for SHS adoption in these areas, provided affordability constraints are adequately addressed. This emphasizes the need for tailored interventions and strategies to promote sustainable energy access in Nigeria.

4.11 Testing the Hypotheses

The hypotheses formulated for this study were tested using data from our survey of 400 households within off-grid communities in Kwara State, Nigeria. The econometric analysis involved assessing the attitudes of households towards solar energy, their perceived adequacy of the electricity supplied, and the economic prospects of having SHS.

H_1: The perception of Solar Home Systems (SHS) among households in off-grid communities within Kwara State, Nigeria, is generally positive.

Empirical evidence strongly supports this hypothesis. Approximately 92% of the households expressed a preference for using privately-owned SHS, even if grid electricity becomes available. In addition, 83% of respondents agreed that the electricity provided by SHS meets their household needs. Moreover, 91% recognized the income-generating potential of SHS, with 75.5% acknowledging its capacity to power appliances. These results underscore a positive disposition towards SHS, suggesting a potentially vibrant market for these systems in Nigeria's off-grid areas.

H_2: The willingness to pay for Solar Home Systems among households in off-grid communities within Kwara State, Nigeria, is substantial.

Willingness to pay for SHS was examined through an exhaustive economic analysis. The findings pointed to an average monthly willingness to pay in the range of NGN 3,951-4,200, suggesting households' readiness to allocate a minimum monthly payment within this range for SHS. However, the mean WTP represents 72% to 75% of the current market prices for SHS, unveiling an affordability issue.

While these figures do substantiate our second hypothesis, demonstrating a significant potential market demand for SHS, they also underscore an affordability challenge that needs to be tackled.

In conclusion, our results validate both hypotheses, shedding light on the dynamics of SHS adoption in rural Nigeria, and offering key insights for addressing affordability challenges and promoting sustainable energy access. The results emphasize the need for inventive pricing strategies and interventions to enhance the affordability and accessibility of SHS.

5. Summary, Conclusion, Recommendations, and Further Studies

5. Conclusion and Recommendations

These findings underscore the potential of SHS as a sustainable energy solution in off-grid regions of Nigeria. The high acceptance of SHS and an established WTP within a certain range reveal a market ready for effective interventions. However, the study also suggests that affordability remains a significant constraint that needs addressing to fully exploit the potential of SHS adoption.

Recommendations

Based on the findings, the following recommendations are proposed:

1. **Market Development**: Encourage private sector participation to foster competition, improve quality, and drive down costs, thereby aligning the price of SHS with the WTP of households.

2. **Policies and Subsidies**: Develop and implement policies that incentivize the adoption of SHS. This can include subsidies to reduce the initial high costs associated with SHS, tax incentives for SHS providers, or the creation of low-interest financing schemes for consumers.

3. **Consumer Awareness**: Intensify efforts in educating the populace about the benefits of SHS. While acceptance is high, there is a need to further enhance the understanding of the economic prospects of SHS.

Further Studies

For future research, the following topics are suggested:

1. **Exploring Factors Affecting WTP:** Conduct further studies to investigate the specific factors that influence households' willingness to pay for solar home systems, including income levels, gender dynamics, distance to the grid, and payment schemes. Analyzing these factors in detail will provide valuable insights into the decision-making process and help develop targeted strategies to enhance affordability and promote sustainable energy adoption.

2. **Differentiation of WTP**: Investigate how WTP varies with different socio-economic factors such as income, education level, and size of households.

3. **Long-Term Impact of SHS**: Conduct longitudinal studies to examine the long-term impacts of SHS on household income, quality of life, and environmental sustainability.

4. **Comparison with other Renewable Energy Systems**: Expand the scope of research to include other renewable energy systems such as wind and hydro energy. A comparative study of these systems with SHS can provide a comprehensive understanding of renewable energy potential in Nigeria.

This research sets a foundation for understanding the dynamics of SHS adoption in off-grid regions of Nigeria. However, it is only a starting point. A continued effort in research and policy-making is essential to fully unlock the potential of SHS and other renewable energy systems for Nigeria's sustainable development.

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