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Challenges Associated with Implementation of Solar Energy in Ghana

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Abstract

This study investigates the challenges hindering the adoption of solar energy in Ghana, with the aim of improving understanding of the barriers to sustainable solar energy use. Most research in this area has concentrated primarily on economic, technical, and environmental factors, neglecting the sociocultural and psychological dimensions influencing solar energy adoption. This study therefore aims to bridge this knowledge gap by examining the cultural, psychological, and behavioral challenges affecting solar energy implementation in Ghana. The study adopted a cross-sectional research design which enabled the study to provide valuable insights into the prevailing issues influencing solar energy implementation across selected cities including Accra which is the capital city of Ghana. A stratified random sampling technique and a purposive sampling technique was used to select the desired sample size of 200. Descriptive statistics such as mean, median, standard deviation, and frequency distributions were used to summarize the data. The analysis also used Statistical Package for the Social Sciences (SPSS) due to its robust statistical and visualization capabilities. The findings reveal that although the initial cost of solar installations poses a significant obstacle, long-term benefits such as lower electricity expenses and positive environmental impacts are widely recognised. The research highlights a strong link between public perception and the willingness to adopt solar energy. Favorable attitudes and greater awareness correspond to higher adoption rates, while negative perceptions discourage uptake. This demonstrates the crucial role of public education and perception management in promoting solar energy integration. Key challenges identified include high upfront costs, limited information, technological difficulties, insufficient government support, cultural resistance, and inconsistent energy supply. Addressing these barriers requires comprehensive strategies that incorporate financial incentives (such as subsidies and tax reductions), awareness campaigns, enhanced government involvement, infrastructure improvements, and community engagement initiatives. Overall, the study underscores that improving public awareness and perception, alongside targeted policy measures, can create an enabling environment for widespread solar energy adoption. These insights offer valuable guidance for policymakers and researchers aiming to advance renewable energy development in Ghana and beyond.

Keywords: *Ghana, Implementation Challenges, Solar, Solar Energy.*

Introduction

The growing global commitment to mitigating climate change has intensified the need for a transition from fossil fuel–based energy systems to renewable alternatives. In most African countries, including Ghana, electricity generation remains heavily dependent on fossil fuels, which continue to dominate national energy portfolios [1].

Ghana's energy demand has been rising at approximately 10% per annum, creating

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continuous strain on its generation infrastructure Kassian, [2]. With the discovery of oil and gas, the country has simultaneously sought to expand its renewable energy base as part of a broader strategy for sustainable growth, [2, 3]. Solar energy, which plays a critical role in lowering carbon emissions, has emerged as a promising alternative in Ghana's quest for energy diversification [27]. Beyond environmental benefits, renewable energy adoption can enhance energy efficiency, reduce operational costs, and positively influence financial stability by lowering the risk of loan defaults and non-performing loans [2, 4].

Africa's vast solar potential, attributed to its abundant sunshine, provides a strong foundation for renewable energy deployment [6]. In Ghana, the solar sector gained significant attention after the 2012–2016 power crisis [30-32]. However, several barriers continue to hinder its widespread implementation. Key among these are the absence of comprehensive legal and regulatory frameworks, limited access to finance, and the high initial capital costs associated with solar technologies [6, 17]. These factors have deterred private-sector investment and slowed the growth of renewable energy adoption.

Despite these challenges, renewable energy remains central to Ghana's long-term energy strategy, particularly as the country confronts persistent supply-demand imbalances [17, 21]. As [29] notes, integrating renewable sources into Ghana's energy mix is essential for meeting growing consumption needs sustainably. Although solar power accounts for approximately 90% of Ghana's installed renewable capacity [22], the overall share of renewables in the national energy mix remains low.

This study aims to examine the challenges affecting solar energy implementation in Ghana, focusing on policy gaps, financing difficulties, and technical constraints. Using both qualitative and quantitative methods such as stakeholder interviews, household and business surveys, and literature review the research identifies critical barriers and highlights successful case studies within Ghana's solar sector. The findings will inform policymakers, investors, and industry actors on strategies to accelerate solar energy adoption, thereby contributing to Ghana's sustainable development goals and global decarbonization efforts.

Statement of the Problem

Energy plays a vital role in human existence and economic development, with electricity serving as an essential resource for modern living. Solar energy, as the foundation of most renewable resources, offers vast potential to meet rising global energy demands sustainably. However, increasing population growth and rapid economic expansion have resulted in escalating energy needs worldwide [25, 26]. At the same time, concerns about greenhouse gas emissions and climate change have intensified efforts to transition toward renewable and sustainable energy sources [25].

Innovative advancements in solar power technology have been identified as a key approach to addressing the growing global demand for energy [7, 13, 16, 33, 34]. Likewise, [23] asserts that solar power development is an effective strategy to reduce dependence on fossil fuels and mitigate climate change through the reduction of carbon emissions. Despite these clear environmental and economic benefits, the adoption and implementation of solar energy technologies remain limited, particularly in developing economies such as Ghana.

Purpose/ Rational of the Study

Several studies have examined the barriers hindering solar energy adoption in Ghana and across Africa. [6] identified financial, technological, human resource, and environmental challenges as key obstacles. Similarly, [29] highlighted investment-related challenges, including high interest rates, limited

access to credit, lack of incentives, and inadequate technical expertise for solar system operation and maintenance. [40] also pointed out that restricted access to finance, insufficient local technicians, and unavailability of spare parts continue to impede the growth of the solar market in rural Ghana.

While these studies have provided valuable insights, most have concentrated primarily on economic, technical, and environmental factors, neglecting the sociocultural and psychological dimensions influencing solar energy adoption. Factors such as cultural beliefs, stakeholder attitudes, individual perceptions, and moral considerations toward solar technology remain underexplored. This study therefore aims to bridge this knowledge gap by examining the cultural, psychological, and behavioral challenges affecting solar energy implementation in Ghana. The insights derived will help inform policy and practice toward achieving a sustainable transition from non-renewable to renewable energy sources.

Literature Review

Public Behavior and Perception of Solar Energy Adoption

Public perception and behavioral attitudes toward solar energy adoption differ widely across regions and cultural contexts. Understanding these behavioral dynamics is essential to designing effective policies that encourage the transition to renewable energy. For instance, [35] emphasized the importance of studying behavioral factors affecting household adoption of solar photovoltaic (PV) systems in Texas, identifying information gaps that could help overcome adoption barriers. In Pakistan, public opinion significantly influences the acceptance of renewable energy technologies such as solar panels, suggesting that insight into public perceptions can inform effective policymaking [35-39]. Similarly, research in Germany revealed that attitudes toward solar radiation management (SRM) are shaped by perceptions of climate change severity, trust in scientific institutions, and ethical concerns about human interference with nature [40].

The findings of a study indicated that limited awareness and knowledge of solar energy, coupled with high installation costs, remain major barriers to adoption. The researchers recommended targeted awareness campaigns and international collaborations to improve public understanding and acceptance of solar energy [40].

In South Odisha, [9] investigated consumer attitudes toward solar-powered lighting systems. Using structured questionnaires and interviews, the study found that solar products can significantly improve rural livelihoods by reducing household expenses, enhancing health conditions, and creating new income opportunities. The authors emphasized that greater awareness and access to clean energy technologies could drive both social and economic benefits in rural communities [9-11].

Cultural and Physiological Challenges to the Adoption of Solar Energy

Cultural and social factors also play a decisive role in shaping renewable energy adoption patterns. In Nepal, the influence of ethnic and caste systems has been identified as a significant determinant in solar technology uptake [19, 21]. The Energy Cultures Framework (ECF) further explains that cultural norms and material practices can either promote or hinder the adoption of solar home systems [18]. It is observed that intersecting social variables such as gender, age, class, and ethnicity influence energy-related decision-making in South Asian contexts, affecting both household-level and community-level adoption rates [5].

[24] demonstrated in their study of Iran's Kerman Desert that solar energy initiatives can significantly contribute to sustainable rural development when communities receive proper training and support. The research established a direct link between local participation in solar

projects and improvements in sustainability indicators such as employment, awareness, and investment. Similarly, [37] found that in Finland, the effectiveness of solar energy adoption is shaped not only by technological and economic factors but also by marketing strategies, public engagement, and consumer trust. By strengthening communication, addressing consumer concerns, and clearly defining value propositions, solar companies can influence public attitudes and accelerate market acceptance.

Policymakers must account for sociocultural realities and prioritize marginalized groups when formulating renewable energy policies [28]. Without such inclusion, efforts to promote solar adoption risk reinforcing existing inequalities and missing critical behavioral barriers. Thus, understanding the cultural, psychological, and social dynamics surrounding renewable energy adoption is essential for ensuring equitable and effective energy transitions [27, 28].

Significance of Awareness of Solar Energy and its Operation to its Implementation

Effective implementation of solar energy systems depends on a comprehensive understanding of their operation and benefits. Educational institutions play a vital role in promoting public awareness of solar energy by disseminating knowledge about its advantages, regardless of individuals' financial capacity to invest in expensive energy technologies [39, 40]. Education and awareness initiatives are therefore fundamental to improving user acceptance and fostering long-term adoption of solar energy solutions.

In the contexts where scientific knowledge is limited, individuals often exhibit moderate awareness of solar technologies and demonstrate a strong willingness to embrace them, driven by aspirations for economic and social development [14]. In addition, technological innovation particularly in enhancing the efficiency of solar collectors and developing improved operational methods can further optimize the utilization of solar resources [20].

Overall, the successful integration of solar energy into national energy systems relies not only on technological advancements but also on public education and awareness. Increased understanding and accessibility, combined with continuous innovation, serve as key catalysts for the widespread and effective adoption of solar energy technologies.

Materials and Methods

The study adopted a cross-sectional research design to examine the challenges associated with solar energy adoption in selected urban areas of Ghana. This approach was chosen for its efficiency in capturing data within a limited timeframe and budget, allowing for an accurate assessment of current conditions and relationships among key variables. As noted by [12], cross-sectional designs are particularly effective for obtaining a snapshot of phenomena and analyzing correlations at a specific point in time. Accordingly, this design enabled the study to provide valuable insights into the prevailing issues influencing solar energy implementation across the selected cities including Accra which is the capital city of Ghana, Kumasi in the Ashanti region, Koforidua in the Eastern region, Takoradi in the Western region, Bui, Tamale and WA located in the Northern parts of Ghana.

Study Population and Sampling

The study targeted residents, solar energy specialists, legislators, residents, policy makers, government officials, satakeholders from utility companies, NGOs and local businesses. A non-probability sampling method was employed, allowing all consenting male and female among the targeted population to participate. Arrangements were made with Heads of Institutions and questionnaires were distributed. Participation was voluntary giving

participants given the option to decline without any pressure. The study targets 600 responses and careful consideration of appropriate sampling techniques was used.

Sampling

A stratified random sampling technique and a purposive sampling technique was used to select the desired sample size of 200. To achieve an even distribution of respondents among the designated cities (Kumasi, Takoradi, Accra, Bui, Lawra, and Koforidua), stratified sampling is used. I deliberately included individuals with expertise in the field, the study gains valuable insights and in-depth knowledge related to the challenges and prospects of solar energy implementation in Ghana.

Data Collection Measures

A combination of quantitative data collected and qualitative interviews were used to collect data for the study.

Quantitative Data Collection Method

A structured questionnaire were designed, including established scales and verified instruments from previous studies, to investigate variables such as awareness, affordability, infrastructure, and policy impact on solar energy uptake, comprising a goal of 200 responses, a mixed-methods approach was used, comprising online and in-person surveys, as well as interviews with experts and key informants. Residents and stakeholders participated in online surveys, while policymakers and solar energy experts chose between interviews and online surveys depending on their availability. The survey and interview questions collected demographic information, opinions, experiences, and perceived solar energy challenges. In-person surveys with closed-ended and Likert scale questions were administered to boost response rates.

Qualitative Data Collection Techniques

Semi-structured interviews with solar energy specialists, policymakers, and key stakeholders will be done using a qualitative technique to gain complete insights into the problems and potential in solar energy implementation. Purposive sampling will be used to issue invitations for interviews to persons with experience in solar energy adoption, which will be facilitated by email or other acceptable communication methods. The interviews, which will be conducted in-person or virtually depending on participant preferences, will be recorded with consent to ensure correct data collection. Transcript validation will be implemented, and differences will be resolved through follow-up talks as needed. In-depth interviews with government officials, energy experts, and consumers will provide rich subjective perspectives on the challenges of solar energy. Focus group discussions will capture stakeholders' collective views and social dynamics. Document analysis of policy reports, government documents, and industry publications will also help to provide historical and contextual context. For a robust qualitative data collection, collected audio recordings, notes, and transcripts will be subjected to rigorous analysis [5, 6, 8, 29].

Data Analysis

Data analysis is an important step in research because it converts raw data into meaningful insights and findings [8]. Data analysis for the study of challenges associated with the implementation of solar energy in Ghana's selected cities will include a combination of quantitative and qualitative analysis for survey data and interview data.

Quantitative Data Analysis Technique

The process began with data cleaning and validation to address errors, inconsistencies, and missing responses in the survey dataset. Descriptive statistics such as mean, median, standard deviation, and frequency distributions

were used to summarize the data, graphical tools including bar charts, histograms, scatterplots, and box plots were also used to illustrate emerging trends. The analysis also used Statistical Package for the Social Sciences (SPSS) due to its robust statistical and visualization capabilities.

Qualitative Data Analysis Technique

Content analysis was used to extract key themes and relevant information from documents. I efficiently organized, coded, and analyzed textual data using NVivo, a well-known qualitative analysis software, improving the management of large datasets.

Results and Discussions

Social Demographic Characteristics of Respondents

The study surveyed 200 participants and achieved a strong response rate of 75%, with 151 respondents completing the questionnaire. The combination of in-person and online survey distribution enhanced data reliability. Collected socio-demographic details including age, occupation, and location provided deeper insights into variations in perceptions and challenges among different population groups.

Table 1. Socio Demographic Characteristics of Respondents

Variable		Frequency	Percent
Sex	Female	57	37.5
	Male	95	62.5
	Total	152	100
Age Group	18-29 years	73	48
	30-49 years	71	46.7
	50-69 years	8	5.3
	Total	152	100
Respondents Educational Level	HND/ Bachelor Degree	62	40.8
	Masters/PhD	80	52.6
	No Formal Education	1	0.7
	Primary-Secondary School	9	5.9
	Total	152	100
Respondents Profession	Banker	5	3.3
	Business Man/Woman	16	10.5
	Civil Servant	12	7.9
	Electrical Engineer	42	27.6
	Health Professional	8	5.3
	Journalist	16	10.5
	Lawyer	2	1.3
	Pensioner	1	0.7
	Police Officer	2	1.3
	Procurement officer	1	0.7
	Research Officer	11	7.2
	Student	13	8.6
	Teacher	23	15.1
	Total	152	100

Source: Author Field Work (2024)

Table 1 highlights a clear gender imbalance among respondents, with males representing 62.5% and females 37.5% of the sample. This disparity is significant, as gender-based differences could influence attitudes and perceptions toward solar energy adoption.

The age distribution of participants indicates broad generational representation: 48% were aged 18–29 years, 46.7% were between 30–49 years, and 5.3% were within the 50–69 years range. Such diversity ensures that views from both younger and older groups are reflected, offering a well-rounded understanding of public engagement with solar technologies.

In terms of education, the majority of respondents held advanced qualifications—52.6% possessed master's or doctoral degrees, while 40.8% had HND or bachelor's degrees. This high educational attainment suggests that participants were relatively knowledgeable about solar energy, potentially contributing more informed opinions.

Occupationally, respondents came from varied professional backgrounds. Electrical Engineers formed the largest segment (27.6%), followed by Teachers (15.1%) and Business Professionals (10.5%). This mix of technical, educational, and commercial expertise enriches the analysis by providing both specialized and practical insights into the challenges surrounding solar energy adoption across sectors.

General perceived Challenges in Implementation of Solar Energy

The study results revealed the following are challenges in implementing solar energy in their households and businesses: high initial cost, lack of technical skills, lack of awareness, lack of government support, unreliable supply, and others as presented in table 2. The sub-section also provides some qualitative insights from the open-ended comments of the respondents.

Table 2. Challenges on the Implementation of Solar

Challenges	Sample Size	Minimum	Maximum	Mean	Standard Deviation
High Initial Costs	45	2.5	4.5	3.6	0.7
Lack of Government Support	30	2.5	4.0	3.2	0.6
Technical Complexity	22	1.8	3.5	2.8	0.7
Limited Public Awareness	35	2.0	4.0	3.5	0.8
Intermittent Energy Production	20	1.5	3.5	2.9	0.6
Regulatory Hurdles	47	3.0	4.5	3.7	0.5
Insufficient Storage Technology	25	2.0	4.0	3.2	0.8
Environmental Impact Concerns	40	3.0	4.5	3.8	0.5
Total	252	-	-	-	-

Source: Field Work Survey (2024)

Table 2 outlines respondents' views on the major obstacles to solar energy adoption. Financial constraints were identified as the most significant barrier, with "High Initial Costs" receiving the highest concern (45 respondents; mean = 3.6, SD = 0.7), indicating varied but notable apprehension about investment requirements. "Regulatory Hurdles" also ranked prominently (47 respondents; mean = 3.7), highlighting systemic and policy-related obstacles that may impede implementation.

Environmental issues emerged as another key concern, with “Environmental Impact” recording a high mean score of 3.8 from 40 respondents, suggesting growing awareness of ecological implications. Meanwhile, “Limited Public Awareness” (35 respondents; mean = 3.5) underscores the importance of education and outreach in promoting solar adoption.

Moderate challenges included “Lack of Government Support” (mean = 3.2), “Insufficient Storage Technology” (mean = 3.2), “Intermittent Energy Production” (mean = 2.9), and “Technical Complexity” (mean = 2.8). Overall, the findings reveal a complex set of barriers dominated by financial, regulatory, and environmental factors, consistent with perspectives shared by participants during interviews.

> “*The upfront expense was a major consideration when we decided to install solar panels. The initial investment was quite substantial and caused some hesitation at first. However, after evaluating the long-term advantages and potential savings on electricity costs, we concluded that it was a worthwhile decision. Still, it’s understandable that many people might be discouraged by the high starting costs. Greater government incentives or financial support could make solar energy more affordable and appealing to a wider population*.”

Reliability of Solar Energy Systems in Ghana

This section examines the dependability of solar energy systems in Ghana, focusing on aspects such as performance, lifespan, and maintenance requirements. Both quantitative and qualitative findings from surveys, interviews, and existing literature were analyzed to evaluate the technical standards and operational effectiveness of solar installations used by households and businesses. The summary of these findings is presented in Table 3.

Table 3. The overall reliability of solar energy systems in Ghana

Variable		Frequency	Percent
Valid	Neutral	50	32.9
	Not Very Reliable	22	14.5
	Somewhat Reliable	53	34.9
	Very Reliable	27	17.8
	Total	152	100

Source: Field Work Survey (2024)

The findings presented in Table 3 offer insights into the perceived reliability of solar energy systems in Ghana. A notable portion of respondents, constituting 32.9% (50 individuals), expressed a neutral stance, indicating an ambivalent attitude toward the overall dependability of solar energy systems in the country. On the contrary, 14.5% (22 respondents) held a pessimistic view, categorizing solar energy systems as "Not Very Reliable." In contrast, a substantial majority, accounting for 34.9% (53 respondents), expressed confidence in the dependability of solar energy systems, categorizing them as "Somewhat Dependable." Additionally, a minority yet considerable 17.8% (27 responders) offered a highly positive perspective, labeling solar energy systems as "Very Dependable." This optimistic viewpoint may be attributed to favorable and consistent experiences with solar technology, showcasing

a diverse spectrum of opinions within the respondent pool.

One respondent shared,

> *"I gave a neutral rating because, honestly, my experience with solar energy has been a bit mixed. There are days when it works really well, and we have a steady supply of power. However, there are also times when it seems a bit unreliable, especially during cloudy days or when there's not enough sunlight. So, I'm kind of in the middle – it's not bad, but I wouldn't call it extremely reliable either."*

Another respondent offered a contrasting perspective, stating,

> *"I'm among those who believe solar energy systems are very reliable. I've had solar panels installed at my home for a few years now, and they consistently provide a good amount of energy. I think the key is proper maintenance and understanding the limitations. Overall, I'm quite satisfied with the reliability of solar energy in my daily life."*

The findings from Table 4 reflect the diverse perceptions regarding the reliability of solar energy systems in Ghana. While a significant number of respondents maintain a neutral stance, indicating a sense of uncertainty, there is a noteworthy segment with reservations, labeling solar systems as "Not Very Reliable." On the contrary, a substantial majority holds a positive view, categorizing solar systems as "Somewhat Dependable," showcasing a prevailing confidence in their reliability. Moreover, a minority, yet considerable proportion, expressed a highly optimistic viewpoint, deeming solar systems "Very Dependable." These varied perspectives underline the nuanced nature of opinions on the dependability of solar energy systems, with individual experiences and interactions shaping the overall perception within the respondent pool.

Cultural or Social Factors that Hinder the Widespread Adoption of Solar Energy

This sub-section examines the cultural or social factors that hinder the widespread adoption of solar energy in the study area. The sub-section explores the attitudes, beliefs, values, norms, and behaviors of the respondents and the stakeholders towards solar energy and how they affect the acceptance and diffusion of solar energy.

The sub-section also analyzes the role of social networks, peer influence, community participation, and public awareness in promoting or discouraging solar energy adoption. The sub-section uses both quantitative and qualitative data from the survey, the interviews, and the literature review to provide a rich and nuanced understanding of the cultural or social dimensions and challenges of solar energy in the study area.

Table 4. Cultural or Social factors that hinder the Widespread Adoption of Solar Energy in Ghana

Factors	Minimum	Maximum	Mean	Standard Deviation
Attitudes towards solar energy	3.0	4.5	3.8	0.7
Beliefs about solar energy	3.0	4.0	3.5	0.6
Values and cultural norms	2.0	4.0	3.2	0.8
Social network influence	1.8	3.5	2.8	0.6
Peer influence	1.5	3.5	2.5	0.9
Community participation	2.5	4.0	3.0	0.7

Public awareness	2.0	4.0	3.5	0.8
Challenges and barriers	2.5	4.5	3.6	0.7

Source: field work (2024)

The results from Table 4 provide valuable insights into the cultural or social factors hindering the widespread adoption of solar energy in Ghana. Each factor is analyzed based on frequency, percentage, mean, standard deviation, minimum, and maximum scores. Among the respondents, 80 individuals (52.6%) expressed a relatively positive average attitude towards solar energy, with a mean rating of 3.8. The standard deviation of 0.7 indicates a moderate level of agreement, showcasing a diverse range of attitudes from generally favorable to very positive. This was also confirmed by Respondent who indicated:

> *Well, you know, I think attitudes towards solar energy play a big role. Personally, I've always had a positive view of it. It just makes sense – harnessing energy from the sun is clean and sustainable. A lot of my friends share similar views, but there are also those who aren't quite convinced. It's interesting how different people perceive it.*

Also 60 respondents (39.5%) demonstrated a moderately positive average belief level in solar energy, with a mean rating of 3.5. The standard deviation of 0.6 suggests a relatively consistent agreement, although variations exist in the strength of belief among respondents. A Respondent of an interview indicates:

> *Yeah, beliefs are crucial too. Some folks think it's not reliable, especially during cloudy days. Others, like me, believe in its potential and understand its limitations. It's about striking a balance and knowing what to expect.*

For 45 respondents (29.6%), the mean rating of 3.2 indicates a moderately positive perception of solar energy concerning cultural norms. While there is some diversity in responses, the standard deviation of 0.8 reflects a fair level of acceptance with variations in alignment with cultural norms. In support of this a Respondent indicates:

> *That's an interesting one. Our cultural norms often dictate what's acceptable or not. For some, embracing new technologies like solar might go against the grain. But I've noticed a positive shift in recent years. People are more open to sustainable living, and that's encouraging.*

Similarly, a total of 30 respondents (19.7%) demonstrated a relatively neutral influence of social networks on their perception of solar energy, as reflected in the mean rating of 2.8. The moderate standard deviation of 0.6 indicates a consistent yet diverse impact of social networks. A Respondent indicates:

> *Absolutely. I've seen cases where friends or family members who are skeptical about solar energy can influence others. On the flip side, a positive experience from someone in your social circle can make you reconsider your views. It's like a ripple effect.*

Among 25 respondents (16.4%), the mean rating of 2.5 suggests a generally neutral to slightly negative peer influence on solar energy adoption. The standard deviation of 0.9 highlights diversity in responses, indicating varying levels of negative influence. In a Respondent view:

> *Community plays a big role. If more people in the neighborhood embrace solar, others might follow suit. And awareness is key. Some folks might be hesitant because they don't fully understand how solar works. So, the more awareness there is, the more likely people are to adopt it.*

On the same wave length, the mean rating of 3.0 for 38 respondents (25.0%) indicates a moderately positive average level of community participation in solar energy adoption. With a standard deviation of 0.7, there is some consistency in positive community involvement. A total of 42 respondents (27.6%) showed a moderately positive perception of public awareness, as reflected in the mean rating of 3.5. The standard deviation of 0.8 indicates variations in the level of awareness among respondents. Among 50 respondents (32.9%), the mean rating of 3.6 indicates a moderately challenging environment for solar energy adoption. The standard deviation of 0.7 suggests some consistency in perceiving challenges, with variations in the severity of challenges among respondents. A Respondent was recalled to have said:

> *High initial costs can be a barrier, and if the government doesn't provide support, it makes it even tougher. Technical complexities and intermittent energy production are challenges too. But, you know, it's a journey. As more people overcome these hurdles, I believe we'll see even greater solar adoption.*

These results collectively illustrate the complex interplay of cultural and social factors influencing the acceptance and adoption of solar energy in Ghana. The analysis provides a nuanced understanding of respondents' attitudes, beliefs, values, and the influence of social networks, peers, community participation, public awareness, and challenges, contributing valuable insights for further investigation and policy considerations.

Perceived Challenges in Implementation of Solar Energy

The results from Table 2 provide valuable insights into the challenges hindering the implementation of solar energy in Ghana, offering a critical understanding of the obstacles faced by individuals and businesses adopting solar solutions. mong the various challenges identified, the issue of high upfront investment stands out as a major barrier, highlighted by 45 participants. With an average rating of 3.6 and a standard deviation of 0.7, the data reflects differing levels of concern across respondents. This finding is consistent with previous studies that have identified substantial initial costs as one of the primary deterrents to widespread adoption of solar energy technologies. Another noteworthy challenge is the perceived lack of government support, recognized by 30 respondents with a mean rating of 3.2. This aligns with existing literature emphasizing the crucial role of government policies and incentives in promoting renewable energy adoption [5]. Technical complexity is identified by 22 respondents as a challenge, with a mean rating of 2.8 and a moderate level of concern indicated by the standard deviation of 0.7. This underscores the importance of user-friendly technologies and adequate training to address technical complexities hindering solar adoption [15]. Additionally, limited public awareness is cited by 35 respondents, emphasizing the crucial role of awareness campaigns (mean rating of 3.5), while concerns about intermittent energy production (mean rating of 2.9) highlight the need to address intermittency issues for increased confidence in solar energy systems [22]. Regulatory hurdles, recognized by 47 respondents with a high mean rating of 3.7, pose a substantial challenge, as regulatory barriers can impede the deployment of solar energy systems. The challenge of insufficient storage technology, acknowledged by 25 respondents with a mean rating of 3.2, emphasizes the importance of efficient energy storage for overcoming intermittency in solar energy systems. Environmental impact concerns, raised by 40 respondents with a high mean rating of 3.8, underscore the importance of addressing sustainability in solar energy adoption, aligning with literature emphasizing the need for green energy solutions. These findings, echoing existing literature, highlight

the multifaceted challenges faced by adopters, with qualitative insights from respondent interviews reinforcing the impact of high initial costs and the crucial role of government support in addressing these challenges.

Turning our attention to the reliability of solar energy systems in Ghana, the insights derived from Table 3 shed light on respondents' perceptions regarding the performance, durability, and maintenance of these systems. The results unveil a spectrum of perspectives, showcasing a significant portion of respondents with varying levels of confidence in the reliability of solar energy systems. A sizable contingent, constituting 32.9% (50 individuals), adopted a neutral stance, signaling an ambivalent attitude toward the overall dependability of solar energy systems in Ghana. This neutrality reflects the diverse experiences and perceptions of respondents, illustrating the nuanced landscape surrounding the reliability of solar technologies. Conversely, a minority of respondents, comprising 14.5% (22 individuals), held a pessimistic view, categorizing solar energy systems as "Not Very Reliable." This suggests that certain respondents may have encountered issues or concerns that influenced their perception of the reliability of solar energy systems.

In contrast, a substantial majority, accounting for 34.9% (53 respondents), expressed confidence in the dependability of solar energy systems, categorizing them as "Somewhat Dependable." This positive perspective can be attributed to favorable and consistent experiences with solar technology. Furthermore, a minority, yet a considerable 17.8% (27 responders), offered a highly positive perspective, labeling solar energy systems as "Very Dependable." This group indicates a strong belief in the reliability of solar energy systems, suggesting a positive impact on their daily lives. The diversity in responses highlights the intricate nature of perceptions surrounding the reliability of solar energy systems. Individual experiences, maintenance practices, and system design play pivotal roles in shaping how users perceive the dependability of solar technologies, emphasizing the need for a nuanced understanding of these factors in assessing overall system reliability.

Also Examining Table 4 unveils critical insights into the cultural and social factors impeding the widespread adoption of solar energy in Ghana. The results intricately delineate the significance of attitudes, beliefs, values, social networks, peer influence, community participation, public awareness, and challenges in shaping the acceptance and diffusion of solar energy. A notable majority of respondents (52.6%) conveyed a relatively positive average attitude toward solar energy, as reflected in the mean rating of 3.8. This aligns with existing literature underscoring the pivotal role of attitudes in influencing the adoption of renewable energy technologies [4, 8]. Similarly, a substantial segment of respondents (39.5%) exhibited a moderately positive average belief level in solar energy, with a mean rating of 3.5. Studies emphasize that beliefs about the reliability and effectiveness of solar energy can wield considerable influence over adoption decisions.

In terms of cultural norms, 29.6% of respondents demonstrated a moderately positive perception of solar energy, registering a mean rating of 3.2. This underscores the crucial role of cultural factors in shaping individuals' acceptance of innovative technologies. Conversely, social networks yielded a relatively neutral influence on the perception of solar energy for 19.7% of respondents, reflected in a mean rating of 2.8. It is noteworthy that social networks possess the dual capacity to both positively and negatively impact attitudes and behaviors related to solar adoption. Further, a generally neutral to slightly negative influence of peers on solar energy adoption was expressed by 16.4% of respondents, as indicated by a mean rating of 2.5. This suggests that peer opinions and

experiences may exert varying impacts on individual decisions to embrace solar technologies. Meanwhile, a moderately positive average level of community participation in solar energy adoption was reported by 25.0% of respondents, reflected in a mean rating of 3.0. Community involvement emerges as a crucial factor for fostering the collective adoption of renewable energy.

Additionally, moderately positive perceptions of public awareness were reported by 27.6% of respondents, evidenced by a mean rating of 3.5. Recognizing the essential role of public awareness campaigns in disseminating information and dispelling myths about solar energy. Lastly, for 32.9% of respondents, the mean rating of 3.6 indicates a moderately challenging environment for solar energy adoption. Overcoming obstacles such as high initial costs and technical complexities stands out as a pivotal task for promoting widespread adoption [4, 8].

In synthesis, these results collectively unveil the intricate interplay of cultural and social factors influencing the acceptance and adoption of solar energy in Ghana. The nuanced insights into attitudes, beliefs, values, social networks, peers, community participation, public awareness, and challenges contribute invaluable information for policymakers and researchers striving to facilitate sustainable energy adoption in the region.

Conclusion

The impediments hindering the widespread adoption of solar energy in Ghana are multifaceted, encompassing economic constraints, information gaps, and concerns regarding the reliability of solar systems. A critical analysis underscores the significance of overcoming these challenges for sustainable and enduring solar adoption. Key obstacles include formidable initial costs, a dearth of information, technological complexities, inadequate government support, cultural and sociological barriers, as well as intermittent energy generation. Addressing these issues is imperative to pave the way for the comprehensive integration of solar energy solutions into the energy landscape of Ghana.

Recommendations

Based on the research findings, the following recommendations are made to promote solar energy adoption in Ghana: Develop interventions that are tailored to address the specific challenges and motivations identified within different socio-demographic groups. Implement financial incentives and support mechanisms to alleviate high initial costs, encouraging wider adoption across diverse economic backgrounds. Prioritize comprehensive education and awareness programs targeting various demographic segments, emphasizing the economic, environmental, and societal benefits of solar energy. Strengthen policy frameworks to provide a supportive environment for solar energy adoption, addressing regulatory hurdles, and promoting sustainable practices. Foster community engagement initiatives to capitalize on the positive role of social networks, peer influence, and community participation in promoting solar energy.

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Conflict of Interest

None declared.

Ethical Approval

Adhered to all ethical requirements.

Author’s Contribution

As the only Author I conceptualized the research and am fully responsible for the methodology, data curation and analysis, writing original draft and editing of the final work.

Data Availability

The Data that support the findings of this study are available on reasonable request from the corresponding Author (Abdul Samad Issahaque) at samadbigson1@gmailcom for purposes of privacy and confidentiality of participants. The data was collected through questionnaires and interviews.

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