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Household Perspectives on Solar Energy Adoption: Economic, Social, and Institutional Dimensions

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Abstract: *This study examines household perspectives on adopting renewable energy technologies, with particular emphasis on solar energy, by analyzing the economic, social, and institutional factors that influence adoption decisions. A descriptive research design was used to collect data from 150 households in the study area. The findings indicate that awareness and knowledge of solar energy technologies are relatively high, and solar panels have emerged as the most widely adopted renewable energy technology. High initial installation costs, limited access to financing, and uncertainty regarding long-term savings are major barriers to adoption. Social and psychological factors, such as positive environmental attitudes, peer influence, and trust in service providers, also influence household decisions. The study further revealed significant relationships between income level, education level, awareness of government subsidies, and renewable energy adoption. Higher-income and better-educated households, as well as those aware of government incentives, are more likely to adopt renewable energy technology. The findings suggest that financial capacity, educational attainment, and policy awareness are critical determinants of household adoption. The study concludes that strengthening subsidy awareness, improving access to financing, and enhancing public education programs can accelerate the transition toward sustainable household energy use and promote the wider adoption of renewable energy technologies.*

Keywords: *Renewable energy adoption, Solar energy, Household perceptions, Government subsidies, Income level, Education level, and Sustainable energy.*

1. INTRODUCTION

Renewable energy has emerged as a crucial solution to environmental challenges and the rising demand for sustainable power sources. Many countries are transitioning toward solar, biogas, and other decentralized energy options to reduce dependence on conventional fuels (1). Despite these efforts, household-level adoption remains uneven. Studies show that cost, awareness, perceived usefulness, and social norms significantly shape adoption behaviour (2). In developing economies, such as India, where government incentives aim to increase renewable energy penetration, adoption barriers continue due to financial constraints, limited technical support, and lack of trust in service providers (3). Understanding household perceptions is essential to bridge the gap between policy intentions and real-world outcomes. The theory of planned behaviour (4) and diffusion of innovations theory (5) also highlight that attitudes, subjective norms, and perceived control strongly influence such decisions. This study uses a qualitative approach to explore household attitudes toward adoptable energy, offering a deeper understanding of the behavioural and contextual factors that influence decision-making. This study is important because household perceptions and behaviour directly influence the success of renewable energy programs. Numerous researchers have highlighted that public acceptance is as critical as technological advancements for the effective implementation of renewable energy systems (Sardinia, 2008; Rai & Robinson, 2013). By understanding household attitudes, policymakers can better design subsidy schemes, awareness campaigns, and service delivery strategies. Households are among the largest segments of energy consumers, and their choices significantly affect national energy demand and environmental sustainability. Identifying the key motivators and barriers to adoption provides policymakers, local authorities, and energy providers with valuable insights. The findings can enhance the design of renewable energy initiatives by aligning them with households' behavioural and socioeconomic realities, thereby reducing reliance on fossil fuels, lowering energy costs, and improving environmental outcomes. This study contributes to academic literature by employing qualitative methods in a field often dominated by quantitative research, emphasizing the role of perceptions, cultural influences, and

lived experiences in household decision-making. Behavioural and social factors, such as peer influence, environmental concern, and trust, have been shown to significantly affect energy choices (Ajzen, 1991; Rogers, 2003). By focusing on these elements, this research offers actionable insights to improve adoption rates. It also addresses gaps in qualitative research on renewable energy adoption, providing nuanced findings consistent with the behavioral theories proposed by Ajzen (1991) and Rogers (2003).

2. BACKGROUND OF STUDY

The increasing global reliance on fossil fuels has led to severe environmental challenges, such as climate change, air pollution, and resource depletion. In response, renewable energy has emerged as a sustainable alternative that addresses energy security concerns while reducing carbon emissions. Governments across the globe, including India, are promoting renewable energy technologies, such as rooftop solar systems, biogas plants, and solar water heaters, through subsidies, awareness programs, and policy incentives (1). Despite these efforts, the rate of household adoption remains uneven and often lower than expected. Households play a central role in the transition toward clean energy because they are major consumers of electricity and directly influence national energy demand patterns. However, their willingness to adopt renewable energy technologies is shaped by multiple interconnected factors. These include economic considerations, such as initial installation costs, long-term savings, and access to financing; social influences, including peer behaviour and community acceptance; and psychological factors, such as environmental concern, trust in technology, and perceived ease of use (2). In many regions, a significant gap persists between the awareness of renewable energy and its actual adoption. Some households express positive attitudes toward clean energy but fail to adopt it due to financial constraints, technological apprehensions, or a lack of institutional support. Others may be influenced by cultural norms, misinformation, or doubts about the reliability and maintenance of renewable technologies (3). This gap highlights the need for a deeper understanding beyond numerical data or statistical trends. Quantitative enquiry becomes particularly valuable in this context because it helps uncover the underlying motivations, perceptions, and experiences that shape household attitudes. Through interviews, focus group discussions, case studies, and observational methods, researchers can gain richer insights into behavioural patterns and barriers that quantitative surveys may overlook. This study explores households' attitudes, perceptions, and decision-making processes regarding renewable energy adoption. By examining the socioeconomic, cultural, and psychological factors influencing these attitudes, this research aims to provide a comprehensive understanding that can inform policy interventions, improve program design, and ultimately promote greater adoption of renewable energy technologies at the household level (4, 5).

3. OBJECTIVES OF THE STUDY

- To assess household awareness and adoption of solar energy technologies.
- To identify the economic, social, and institutional factors influencing renewable energy adoption.
- To examine the relationship between household income and renewable energy adoption
- To analyze the influence of education level on renewable energy adoption
- To evaluate the impact of government subsidy awareness on the adoption of renewable energy

Scope of the Study

This study focuses on understanding household-level attitudes toward renewable energy adoption within a specific geographical or community context. It explores households' perceptions, awareness, and behavioural intentions while analyzing socioeconomic factors, such as income, education, and household size, that influence adoption. The study examines attitudes toward various types of renewable energy technologies, including solar panels, biogas, and solar water heaters. It identifies challenges related to technology, financial constraints, cultural norms, and policy awareness. Emphasizing qualitative enquiry through interviews, focus groups, and case studies, the research aims to gain deeper insights into these behavioural and attitudinal aspects. It does not attempt to measure the technical efficiency of renewable energy systems or conduct cost-benefit analyses but rather focuses specifically on the factors influencing adoption decisions.

Research Questions

- What are the levels of awareness and knowledge of renewable energy technologies among households?
- What economic, social, and psychological factors influence household attitudes toward renewable energy adoption?
- What benefits do households perceive when adopting renewable energy technologies?
- What barriers or concerns prevent households from adopting renewable energy sources?
- How do government incentives and institutional support influence household adoption decisions?
- How do community norms and peer influences shape attitudes toward renewable energy?

4. METHODOLOGY AND DATA COLLECTION

This study employs a qualitative research approach to explore household attitudes toward renewable energy adoption, with a focus on solar energy. A descriptive, exploratory qualitative design was used to gain an in-depth understanding of the motivations, barriers, and perceptions influencing household decision-making. This approach is appropriate for capturing the nuanced behavioral, social, and contextual factors that quantitative methods may not fully reveal. Data were collected using qualitative techniques, including semi-structured interviews, focus group discussions, and case studies. These methods provided flexibility for open-ended exploration of participants' experiences, attitudes, and levels of awareness regarding renewable energy technologies such as solar panels, biogas systems, and solar water heaters. The qualitative data collection aimed to uncover rich, detailed insights into household behavioral intentions, perceived benefits, and challenges related to adoption. The sample consisted of 150 households selected from the study area, representing diverse socioeconomic backgrounds with varying income levels, educational attainment, and household sizes. Demographic and socioeconomic characteristics were documented to contextualize findings and facilitate thematic analysis. Qualitative data were analyzed thematically, identifying key themes such as financial barriers, technical knowledge deficits, social influence, and institutional support issues. This thematic coding enabled the classification and quantification of recurring patterns and factors influencing adoption decisions. While the primary focus was qualitative, the study acknowledges the potential value of integrating quantitative data, such as demographic variables and adoption rates, to complement and strengthen the interpretation of qualitative findings. This mixed-methods perspective supports a comprehensive understanding of household renewable energy adoption dynamics.

4. DATA ANALYSIS

TABLE 1. Demographic and Socioeconomic Characteristics of Sampled Households

Variable	Category	Frequency (n)	Percentage (%)
Income Level	Low	55	36.7
	Medium	65	43.3
	High	30	20
Education Level	No formal education	20	13.3
	Primary	40	26.7
	Secondary	55	36.7
Household Size	Higher education	35	23.3
	1–3 members	35	23.3
	4–6 members	80	53.3

Source: Primary Survey: Table 1 presents the demographic and socioeconomic characteristics of the 150 sampled households. The income distribution shows that the majority of the sample was in the medium-income category (43.3 %), followed by the low-income (36.7 %) and high-income (20 %) categories. Education levels varied, with the largest group having completed secondary education (36.7%), followed by primary education (26.7%), higher education (23.3%), and a smaller proportion without formal education (13.3%). Household size data reveal that most households (53.3%) consist of two members, while smaller (1–3 members) and larger (members) households each constitute 23.3%. This demographic profile reflects a diverse, moderately educated, and medium-sized household population.

TABLE 2. Awareness and Knowledge Levels Regarding Renewable Energy Technologies

Technology Type	Aware (%)	Knowledgeable (%)	Adopted (%)
Solar Panels	88	72	48
Biogas Systems	70	55	30
Solar Water Heaters	76	60	35

Source: Primary Survey: Table 2 summarizes the awareness, knowledge, and adoption rates of various renewable energy technologies among households. Solar panels exhibited the highest levels of awareness (88%) and knowledge (72%), with nearly half (48%) of households adopting this technology. Solar water heaters showed moderate awareness (76%) and knowledge (60%), with a 35% adoption rate. Biogas systems had the lowest figures, with 70% awareness, 55% knowledge, and 30% adoption, suggesting relatively limited penetration compared to solar technologies.

TABLE 3. Economic Barriers to Adoption

Barrier	Frequency (n)	Percentage (%)
High initial installation cost	75	50
Limited access to financing	45	30
Uncertainty about long-term savings	30	20
Total	150	100

Source: Primary Survey: Table 3 identifies the economic barriers hindering renewable energy adoption. High initial installation costs were the most frequently cited barrier, affecting 50% of households (50%). 30% of households reported limited access to financing, while 20% expressed uncertainty about long-term savings. These findings emphasise the dominant role of financial constraints in limiting household uptake of renewable technologies.

TABLE 4. Social and Psychological Factors Influencing Adoption

Factor	Frequency (n)	Percentage (%)
Positive environmental attitude	50	33.3
Peer influence	35	23.3
Trust in service providers	40	26.7
Concerns about reliability	25	16.7
Total	150	100

Source: Primary Survey: Table 4 outlines the social and psychological factors influencing adoption decisions. Positive environmental attitudes motivate one-third of households (33.3%), peer influence affects 23.3%, and trust in service providers is noted by 26.7%. 16.7% of the report concerns the reliability of renewable energy technologies, representing a psychological barrier. Together, these factors highlight the importance of social dynamics and perceptions in shaping household willingness to adopt renewable energy solutions.

TABLE 5. Institutional Support and Policy Awareness

Aspect	Frequency (n)	Percentage (%)
Awareness of government subsidies	65	43.3
Satisfaction with policy clarity	40	26.7
Experience with the application process	45	30
Total	150	100

Source: Primary Survey: Table 5 presents data on institutional support and policy awareness among the 150 households sampled. This shows that 43.3% of households are aware of government subsidies related to renewable energy. However, only 26.7% expressed satisfaction with the clarity of these policies, indicating potential confusion or lack of transparency. Additionally, 30% of households experienced the subsidy application process, suggesting moderate engagement but also possible barriers to accessing institutional support. These findings highlight that, while there is some awareness of government incentives, overall satisfaction and active participation remain limited, underscoring the need for clearer communication and more accessible institutional mechanisms to facilitate household adoption of renewable energy.

TABLE 6. Cross-tabulation: Income Level vs. Adoption Status

Income Level	Adopted Renewable Energy	Not Adopted	Total
Low	15	40	55
Medium	35	30	65
High	22	8	30
Total	72	78	150

Source: Primary Survey: Hypothesis for Chi-Square Test of Association: Income Level vs. Adoption of Renewable Energy Technologies

Statistical Form

H₀: Household income level and renewable energy adoption are independent.

H₁: Household income level and renewable energy adoption are not independent.

	Chi-Square Test Statistic	Critical Value	df	p	N	Accept/Reject
χ^2	18.07	5.99	2	0.000119	150	Reject H ₀

Interpretation of Chi-Square Test Result

The chi-square test shows a significant association between household income levels and the adoption of renewable energy technologies ($\chi^2 = 18.07$, $df = 2$, $p = 0.000119$). The calculated chi-square value is greater than the critical value ($18.07 > 5.99$), and the p-value is less than 0.05, the null hypothesis (H₀) is rejected.

This indicates that household income significantly influences the adoption of renewable energy. Higher-income households are more likely to adopt renewable energy technologies than lower-income households. Therefore, we accept our research hypothesis.

TABLE 7. Thematic Coding

Theme	Number of Mentions	Percentage (%)
Financial Barriers	60	40
Technical Knowledge Deficit	35	23.3
Social Influence	25	16.7
Institutional Support Issues	30	20
Total	150	100

Source: Primary Survey: Table 7 presents a thematic coding frequency summary derived from qualitative data, quantifying the prevalence of key themes across 150 mentions. Financial barriers were the most frequently cited themes, accounting for 40% of mentions (60 instances), underscoring the dominant role of economic constraints in hindering renewable energy adoption. Technical knowledge deficits followed, with 23.3% of mentions (35 instances), highlighting the significant impact of limited understanding and awareness on household decisions. Institutional support issues represented 20% of mentions (30 instances), reflecting concerns about policy clarity, accessibility, and the effectiveness of government programs. Social influence accounted for 16.7% of mentions (25 instances), indicating the role of peer pressure, community norms, and trust in shaping adoption attitudes. Together, these themes illustrate the multifaceted barriers and motivators identified through qualitative enquiry, reinforcing the need for integrated strategies that address the financial, informational, institutional, and social dimensions to enhance household uptake of renewable energy technologies.

TABLE 8. Education Level vs. Adoption of Renewable Energy Technologies

Education Level	Adopted	Not Adopted	Total
No Formal Education	4	16	20
Primary	12	28	40
Secondary	30	25	55
Higher Education	26	9	35
Total	72	78	150

Source: Primary Survey: Hypothesis for Chi-Square Test of Association: Education Level vs. Adoption of Renewable Energy Technologies

Statistical Form

H₀: Education level and renewable energy adoption are independent.

H₁: Education level and renewable energy adoption are not independent.

	Chi-Square Test Statistic	Critical Value	df	p	N	
χ^2	22.10706	7.8147	3	6.2	150	Reject H ₀

Interpretation of Chi-Square Test Result

The chi-square test indicates a significant association between education level and the adoption of renewable energy technologies ($\chi^2 = 22.11$, $df = 3$). Since the calculated Chi-square value is greater than the critical value ($22.11 > 7.81$), the null hypothesis (H₀) is rejected.

This finding suggests that education level significantly influences the adoption of renewable energy. Households with higher levels of education are more likely to adopt renewable energy technologies than those with lower levels. Therefore, our research hypothesis was accepted.

TABLE 9: Awareness of Government Subsidies vs. Adoption Status

Awareness of Government Subsidies	Adopted	Not Adopted	Total
Aware	48	17	65
Not Aware	24	61	85
Total	72	78	150

Source: Primary Survey: Hypothesis for Chi-Square Test of Association: Awareness of Government Subsidies vs. Adoption Status

Statistical Form

H₀: Awareness of government subsidies and renewable energy adoption are independent.

H₁: Awareness of government subsidies and renewable energy adoption is not independent.

	Chi-Square Test Statistic	Critical Value	df	p	N	
χ^2	30.69962	3.841456	1	3.01	150	Reject H ₀

Interpretation of Chi-Square Test Result

The chi-square test reveals a significant association between awareness of government subsidies and the adoption of renewable energy technologies ($\chi^2 = 30.70$, $df = 1$). Because the calculated chi-square value is greater than the critical value ($30.70 > 3.84$), we reject the null hypothesis (H_0).

This result indicates that awareness of government subsidies significantly influences the adoption of renewable energy. Households aware of government subsidy programs are more likely to adopt renewable energy technologies than those unaware of them. Therefore, we accept our research hypothesis.

Statistical Evidence on Solar Energy Consumption in India

India has emerged as one of the world's fastest-growing solar energy markets. The country's solar power capacity and electricity generation have increased significantly over the past decade.

Key Statistics

Indicator	Value
Installed Solar Capacity (2014)	2.82 GW
Installed Solar Capacity (March 2026)	150.26–154.24 GW
Growth Since 2014	About 55 times increase
Global Rank in Solar Capacity	3rd largest globally
Renewable Energy Share of Total Installed Capacity (2025)	~39.7%
Renewable Share in Electricity Generation (FY, 2025)	20.20%
Non-fossil Fuel Capacity (March 2026)	283.46 GW
India's Target for 2030	non-fossil fuel capacity

India has witnessed remarkable growth in solar power capacity over the past decade, making solar energy the fastest-growing renewable energy source in the country. The installed solar capacity has expanded dramatically from a modest level in 2014 to approximately 154 GW by 2026, reflecting the country's strong commitment to clean energy development. The year 2025 marked a significant milestone, with India recording its highest-ever annual addition of solar capacity. Consequently, solar energy now accounts for more than half of India's renewable energy capacity, underscoring its central role in India's energy transition. The growth of solar power has also contributed significantly to electricity generation and consumption. Renewable electricity production has increased substantially in recent years, with non-hydro renewable sources contributing a record share of the country's total electricity generation. The share of renewable energy in electricity generation has steadily risen, with solar power emerging as the largest contributor to this increase. This expansion has helped reduce India's dependence on conventional fossil-fuel-based electricity and strengthened the country's efforts toward sustainable energy development. Trend analysis further demonstrates the rapid expansion of the renewable energy sector. The total renewable energy capacity grew considerably between 2010 and 2025, driven largely by the exceptional growth of solar energy. Among all renewable energy sources, solar power has recorded the highest growth rate, driven by continued investment, supportive government policies, technological advancements, and increasing public acceptance. These developments indicate that solar energy will continue to play a crucial role in achieving India's long-term energy security and environmental sustainability goals. Statistical evidence clearly shows that solar energy consumption and generation in India have increased dramatically over the past decade. The installed solar capacity increased from 2.82 GW in 2014 to over 150 GW by 2026, making India the third-largest solar power producer in the world. Solar power has become a key component of India's energy transition, contributing substantially to renewable electricity generation and supporting the country's goal of achieving 500 GW of non-fossil fuel capacity by 2030.

Findings of the Study

This study examined household perspectives on adopting renewable energy technologies, with particular emphasis on solar energy. The findings indicate that the sampled households represented diverse socioeconomic backgrounds, with a predominance of middle-income and moderately educated respondents. Household structures were generally stable, reflecting a representative community profile for examining patterns of renewable energy adoption. The analysis revealed that solar panels were the most widely recognised and adopted renewable energy technology by households. Compared with biogas systems and solar water heaters,

solar energy has demonstrated greater acceptance and diffusion, suggesting stronger public familiarity and confidence in its benefits and applications. Economic considerations are the most significant barriers to adoption. High installation costs, limited access to financial support, and uncertainty regarding long-term economic returns have discouraged many households from investing in renewable energy technologies. These findings highlight the critical role of affordability in shaping adoption decisions in developing countries. Social and psychological factors also influence household behavior. Positive environmental attitudes encourage interest in renewable energy, trust in service providers and peer influence support adoption decisions. Simultaneously, concerns about the reliability and performance of renewable energy systems act as barriers, underscoring the need for greater consumer confidence and technical assurance. The study further found that the awareness and utilization of institutional support mechanisms remained limited. Although many households were aware of government incentive programs, satisfaction with policy clarity and engagement with subsidy application procedures were relatively low. This suggests that procedural complexity and inadequate communication may reduce the effectiveness of existing support measures. Statistical analysis confirmed that household income, education level, and awareness of government subsidies significantly influenced renewable energy adoption. Households with greater financial resources, higher educational attainment, and better knowledge of government incentives were more likely to adopt renewable energy technologies. Among these factors, awareness of government support emerged as a particularly important driver of adoption. Qualitative findings reinforced these results by identifying financial constraints, limited technical knowledge, institutional challenges, and social influences as the major themes affecting household decisions. Together, these findings demonstrate that renewable energy adoption is shaped by complex interactions between economic, informational, institutional, and social factors. In conclusion, this study concludes that while awareness of solar energy is relatively widespread, actual adoption remains dependent on financial capability, educational background, and access to institutional support. Strengthening public awareness initiatives, expanding financing options, simplifying subsidy procedures, and enhancing technical support services are essential to promoting greater household adoption of renewable energy technologies.

Scope for Further Research

This study could be expanded by integrating mixed methods approaches that combine qualitative insights with quantitative data to provide a more comprehensive understanding of renewable energy adoption dynamics. Longitudinal studies tracking changes in household attitudes and behaviors over time help assess the impact of evolving policies and market conditions. Exploring regional and demographic variations in greater depth can uncover context-specific barriers and motivators, thereby enabling more targeted interventions. Future studies should investigate how emerging technologies and innovations shape perceptions and adoption rates. Research on the effectiveness of specific policy instruments, such as subsidy designs, financing models, and community engagement strategies, would provide policymakers with practical guidance. Investigating the influence of digital platforms and social media on awareness and peer influence could offer new avenues for enhancing public acceptance. Expanding qualitative enquiry to include marginalized or less-studied populations will help ensure that renewable energy programs are inclusive and equitable, addressing diverse socioeconomic and cultural contexts more effectively.

5. CONCLUSION

This study examined household perspectives on adopting renewable energy technologies, focusing on solar energy. The findings demonstrate that although awareness of renewable energy technologies is generally high, actual adoption is influenced by a combination of economic, social, educational, and institutional factors. Solar energy has emerged as the most recognized and widely adopted renewable energy option among households, reflecting its growing acceptance and perceived benefits. This study identified financial constraints, particularly installation costs and limited access to financing, as major barriers to adoption. Social and psychological factors, including environmental concern, trust in service providers, and peer influence, also play important roles in shaping household decisions. In addition, limited awareness and utilization of government support mechanisms reduce the effectiveness of existing renewable energy promotion initiatives. The analysis further revealed that household income, education level, and awareness of government subsidies significantly influenced renewable energy adoption. Households with higher incomes, more education, and greater awareness of government incentives are more likely to invest in energy technology. These findings emphasize that successful renewable energy transitions require not only technological availability but also supportive socioeconomic and institutional conditions. This study concludes that increasing household-level renewable energy adoption requires integrated policy measures that combine financial assistance, accessible financing options, effective awareness campaigns, technical guidance, and simplified subsidy procedures. Strengthening these areas can help overcome existing barriers and accelerate the transition to sustainable, environmentally responsible energy consumption.

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