EXTENDED ABSTRACT

An Empirical Study on Factors Influencing Adoption of Renewable Energy in India

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Considering the 2050 net-zero emission commitments, substantial efforts have been dedicated to reducing dependence on fossil fuels and advancing renewable energy sources. For example, the European Union aims to raise the proportion of renewable energy production to a minimum of 42.5% by 2030, while the US government has established a goal of achieving 80% renewable energy generation by 2030. Uruguay already started producing renewable electricity up to 98%. Although renewable energy tends to entail higher expenses, greater risks, and prolonged return periods compared to fossil fuels, these challenges could potentially hinder the role of renewables in fostering sustainable economic growth, leading to unforeseen negative consequences. Nevertheless, innovation in renewable energy has the potential to mitigate production risks, lower investment costs, and expand market share. The trajectory of innovation in renewable energy has, therefore, become a crucial consideration for nations across the globe.

Understanding consumer motivation for residential adoption of renewable energy technology is essential to meeting our study objectives. This research aims to examine a range of factors that influence the adoption of renewable energy (RE) systems in households. We seek to determine whether these decisions are predominantly driven by knowledge and beliefs about renewable energy, specific household energy requirements, socio-economic benefits of the investment, or policy incentives. This exploration aligns with our broader goal of identifying enabling factors for RE adoption at the domestic level in India, thereby contributing to sustainable development goals and energy policy effectiveness. For policymakers focused on effectively guiding the adoption of renewable technology in the residential sector, understanding, and addressing this issue is crucial.

This study is designed to:

(1) investigate key influential factors for the adoption of residential renewable energy.

(2) examine the role of Sustainable Development Goals (SDGs) in renewable energy adoption; and

(3) suggest policies and strategies for faster adoption of renewable energy.

The primary objective of this research is to identify and analyze the factors influencing the adoption of renewable energy in Indian households. This involves evaluating the impact of consumer awareness and knowledge about renewable energy technologies, the role of policy incentives, and the perceived socio-economic benefits. To effectively address these challenges through well-crafted policy measures, this innovative research marks the first of its kind by conducting a real-time survey of the households and subsequently undertaking comprehensive data analysis.

Given India's vast size of approximately 1.4 billion people, representative sampling was employed in this study. A database of 1,400 individuals involved in renewable energy-related jobs and studies was compiled. This approach ensured that participants possessed sufficient knowledge and awareness of the latest developments in renewable energy in the country. The second criterion involved including individuals from different regions, representing diverse demographics, to ensure a varied and representative sample population for the study. The third criterion was to include participants who intended to adopt renewable-based equipment and technologies in the near future.

Using the email addresses of these 1,400 individuals, we sent them a self-administered Google questionnaire link for data collection. The questionnaire link was made available from December 2022 to February 2023. A total of 676 responses were received, and eight participants did not consent to participate in the study. Adhering to ethical research guidelines, 668 responses were used for further analysis. According to the G Power test, the minimum sample size required for this research is 146. The actual sample size in this study, which is 668,

significantly exceeds the minimum required by the G Power test. This substantial sample size reinforces the validity and reliability of the study's findings.

A five-point Likert scale, varying from Strongly disagree (coded as 1 for analysis) to Strongly agree (coded as 5 for analysis) was used to capture the responses against the items asked in the survey. A total of 34 questions or survey items were included in the survey construct. The constructs included variables like knowledge of new technology (four items), environmental concern (three items), socio-economic benefit of renewables (ten items), sustainable development goals (five items), policy incentives (four items), risk perception (four items) and adoption intention of RE (four items). Smart PLS 3.0 software was employed for the partial least squares (PLS) data analysis in this study. The data analysis process consisted of three steps. Firstly, an estimated model fit was determined using a model fit test. Secondly, the measurement model underwent evaluation to ensure that the constructs exhibited sufficient reliability and validity. This was followed by an assessment of the structural model for hypothesis testing. Additionally, a bootstrap resampling technique was utilized to estimate the coefficients.

In terms of gender distribution, 82% of the respondents identified as male, and most responses, 82.3%, came from an urban background. Regarding educational attainment, the majority, 62.7%, held postgraduate degrees, followed by 34% with undergraduate degrees, and 2.1% possessing trade certificates/diplomas.

The findings of the study reveal a positive association between knowledge and the adoption of renewables, indicating that consumers are more inclined to adopt renewable energy when they have a comprehensive understanding of its functionalities. This aligns with previous research in the field. The study suggests a significant relationship between knowledge and the perceived ease of utilizing renewable energy technologies. In essence, a deeper understanding of

renewable energy technology increases the likelihood of perceiving it as easy to use, thereby enhancing its perceived benefits.

Additionally, the research affirms that socio-economic benefits positively influence renewable energy adoption, consistent with prior studies. The results suggest that an individual's knowledge about renewable energy significantly impacts socio-economic benefits. Social factors such as reducing energy poverty, addressing energy inequality, improving livelihoods through clean energy, and contributing to a cleaner and greener society play a crucial role in individual decision-making. Similarly, economic factors like job creation through the establishment of local renewable energy component industries, service providers, and installers strongly influence people's decision-making processes.

A noteworthy socio-economic finding is that respondents believe adopting renewable energy will not only make India self-energy-reliant but also reduce the country's trade deficit, thereby decreasing import dependency. Moreover, the findings highlight the significant role of Sustainable Development Goals (SDGs) in adopting renewable energy by Indian households. Key SDGs such as Goal - 13, which emphasizes increased use of renewable energy for positive climate action; Goal - 7, which aims to provide affordable and clean energy solutions to every household; and Goal -11, focusing on the creation of sustainable cities and communities, exert a positive influence on the adoption of renewable energy. Respondents expressed a shared consensus regarding the greater use of renewable energy to achieve carbon neutrality and promote sustainable energy transition. The findings confirm that Indian households show a strong inclination for renewable energy adoption.

The research also underscores the importance of designing and successfully implementing suitable policy frameworks for enhanced renewable energy adoption. The current energy system and existing policy structures were originally developed for India's fossil fuel-dominated energy market, indicating the need for adaptive policies to facilitate the transition to renewable energy. This research also reveals that risk perception is linked significantly to adopting RE, and the relationship is positive. Regarding demographics, the hypothesis testing findings show that age substantially influences the adoption of RE technologies. Also, environmental concern suggests the function of perceived risk as a mediator between these factors and the intention to adopt RE.

Drawing on the responses from the participants in this study, we put forth several policy recommendations that are vital for all stakeholders involved. The study reveals that the key factors for boosting renewable energy (RE) penetration in India include knowledge enrichment and the development of appropriate policies conducive to both manufacturers and the public in fostering a renewable market. The primary objective of these policies should extend beyond merely creating a favourable market for RE-based goods and products. It should also aim to promote sustainable consumer and industrial practices.

In a nation as diverse as India, a one-size-fits-all solution is impractical. Targeted and tailored solutions are essential, such as improved solar cookers designed for the economically disadvantaged in remote areas and solar PV cells optimized for urban settings. Programs promoting biogas should be expanded and customized to suit specific populations, accompanied by innovative funding approaches and local capacity-building initiatives for maintenance.

Relying solely on consumer feedback for understanding adoption intentions may provide limited insights, as consumers might express enthusiasm without clear adoption intent due to

cost competition. Additionally, the study lacks perspectives from key stakeholders like distributors and regulatory agencies, which is essential for forming comprehensive policy recommendations. Future research could broaden the scope to include more countries, offering a diverse understanding of adoption patterns. Further exploration of the relationship between adoption intent and recommendations, considering moderating variables like demographics, would enhance the depth of understanding across various populations.