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Factors Influencing Smart Meter Acceptance in India: A Systematic Review

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Abstract : Rapid urbanization and expansion of the residential sector in India necessitate an energy revolution, central to which smart meters are deployed. This study presents an exhaustive review of the factors influencing the consumer acceptance of smart meters in Indian homes. It delves into socioeconomic and demographic influences, perceived benefits, obstacles to adoption, the impact of information dissemination, and trust in utility providers. The research uncovered that consumers who possess a higher level of education and financial stability exhibit a greater propensity to accept smart meters, recognizing their significance in promoting energy efficiency and realizing cost reductions. However, significant barriers persist, including initial costs, privacy concerns, and cultural resistance to technological changes. Effective informational campaigns and strong regulatory frameworks are pivotal in enhancing consumer trust and willingness to adopt smart technology. This synthesis underscores the critical role of integrating consumer education and robust policy support to facilitate smart meter integration in India's evolving energy landscape.

Keywords: Smart Meters, Consumer Adoption, Energy Efficiency, Indian Residential Sector, Information Dissemination, Regulatory Frameworks, Privacy Concerns, Technological Acceptance.

1. Introduction

Smart meter technology is the latest innovative step in energy storage and supply systems. These digital tools present the feel and flow of time by tracking the energy usage on a minute-by-minute basis, thereby paving the way for an energetic engagement between consumers and energy service providers (Verma, et al., 2020). The residential buildings in India have employed conventional meters for a long time, therefore transition to smart meters holds significant value. It is the key step for the modernization of the national grid (Kumar, 2019) This is important especially since the country continues to urbanize at a very high rate and aims to do this in a way where the growth is steady.

It is not an overstatement to say that smart measurements are critical and important for India in one way or another (Neffati, et al., 2021). With a large amount of real estate that is constantly growing, it is important to save energy efficiently. Smart meters offer a new option for improving efficiency, saving balance, and responding to the needs of both consumers and power utilities. In addition, they are an important part of the process of educating consumers, providing them with the knowledge to spare energy, which might end up reducing costs among greener lifestyle practices (Kumar, 2023).

Nevertheless, the introduction of smart meters is not merely a technological transformation but also depends on consumers' willingness to recognize and participate in the technology (Sentamilselvan et al., 2020). Consumer experience also matters, because it influences the speed and efficiency of how technology is accepted and adopted. Digesting information on the processes that affect residents' attitudes toward smart meters — for instance, perceived advantages, data security concerns, and energy providers' trustworthiness — is a key task for policymakers, manufacturers, and energy companies that are goal-oriented about implementing this technology in residential areas (Ahuja and Khosla, 2018).

The aim of this literature review is to comprehensively evaluate the plethora of issues associated with the adoption of smart meters among Indian residential buildings, and in a broader context, consumers' perspectives. The undertaking of this study will be to find the main reasons and benefits reported by consumers as per existing research. The key aim of this report is to highlight the strategies required to ease the adoption and acceptance of smart meters.

The central research question guiding this investigation is: What are some factors that influence the acceptance of smart meters by consumers in Indian homes?

1. How do socioeconomic and demographic variables affect consumers' attitudes towards smart meters in India?
2. What are the perceived benefits and barriers to smart meter adoption among Indian residents?
3. How does the dissemination of information and consumer education affect the willingness to adopt smart meters?
4. What role does trust in utility providers and regulatory frameworks play in consumers' acceptance of smart meters?

The paper's main aim is to address the above-mentioned questions in order to build a fundamental picture that can be used by stakeholders and, consequently, to facilitate the provision of mandates to promote smart meter adoption in India's residential sector.

2. Research Methodology

The PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) checklist was employed to assist researchers in the selection of articles from digital library databases. This tool, established by Liberati, Moher, Tetzlaff, Altman, and the PRISMA Group in 2009, provides a structured approach to identifying relevant literature.

2.1. Database

For this study, research articles were culled from five research journal databases: Taylor and Francis Online, Sage Publications Inc., Inderscience Publishers, and Emerald Insight.

2.2. Data Collection

In this study, a comprehensive search was conducted across multiple academic databases to gather relevant literature pertaining to the research topic. An array of carefully selected keywords was used to ensure the retrieval of pertinent articles. These keywords are central to the themes of smart meter technology adoption in the Indian residential sector and consumer behavior.

The following keywords were employed in the search:

"Smart Meters"
"Indian Residential Buildings"
"Consumer Adoption"
"Energy Management"
"Technology Acceptance Model"
"User Behavior"

Several search strings were crafted to effectively navigate the databases by incorporating Boolean operators. The constructed search strings included combinations such as

("Smart Meters" AND "Indian Residential Buildings" AND "Consumer Perspectives")
("Energy Management" AND "Smart Meters" AND "User Behavior" AND India)
(Technology Acceptance Model "Technology Acceptance Model" AND "Smart Meters" AND "India")
("Consumer Adoption" AND "Energy Monitoring" AND "Smart Technology" AND "Residential Energy Consumption")

These search strings facilitated a focused and exhaustive search, enabling the identification and selection of articles that provided valuable insights into the factors influencing the adoption of smart meters by Indian households. The search strategy was designed to be as inclusive as possible while maintaining a high level of relevance to the research questions posed in this study.

2.3 Inclusion Criteria

Following article were included in the research:

1. Original Research and Research Articles
2. Research that involved participants from different countries
3. Published between 2015- 2023.
4. Available in Full-text
5. English-written articles.

It should be noted that the Zotero 5.0. was used to avoid identical metadata in RIS (Research Information Systems) format. The data were then analyzed to identify research variables and trends that have not been extensively studied in the smart meters' field.

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2.4. Critical Appraisal Tools (CAT)

The researchers used two distinct evaluation forms for their critical assessments. Qualitative-based articles apply the CAT created by the Joanna Briggs Institute, specifically the qualitative assessment, review, and appraisal instruments (JBI-QARI). On the other hand, articles based on quantitative methods or case studies were assessed using the CAT formulated by the Public Health Agency of Canada (PHAC).

2.5. Meta-Synthesis Analysis

The research team appraised the credibility of each finding using criteria defined by the Joanna Briggs Institute. The credibility levels were assigned as follows:
Unequivocal (U) = the evidence is clear and indubitable.
Credible (C): the interpretation of the finding is plausible and grounded in the data.
Unsupported (Un) = the data does not back up the finding.

After determining the credibility level, the findings were categorized into clusters that accurately reflected their conceptual congruence. The literature search resulted in 12 publications organized into five thematic groups. These groupings underwent a meta-synthesis process, yielding consolidated findings that provided a basis for recommendations for both practitioners and scholars. For the analysis and synthesis of the extracted data, the research employed meta-synthesis techniques utilizing the NVivo 12 software in its trial version. The data were further analyzed to identify publication trends from 2014 to 2023 using VOSviewer software for visual representation.

3. Analysis and Results

3.1 Search Results

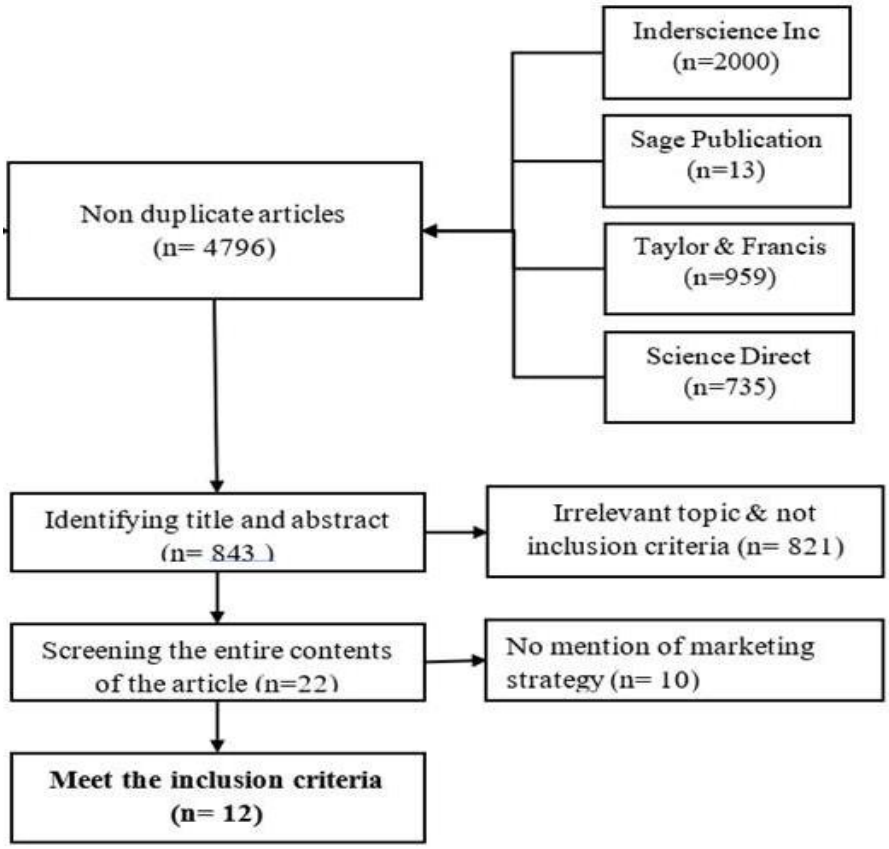

Figure 1. PRISMA Flowchart
Source: The authors' elaboration

The initial phase of the analysis involved sifting through 4,797 articles to identify any duplicates or those that were closely related, which led to the identification of one such article. The process then advanced to a review of titles and abstracts, narrowing the field to 843 articles. Subsequent detailed screening further reduced the number to 22 articles, as 821 articles were deemed irrelevant to the study topic. Upon a thorough review of the full texts, the researchers concluded that 12 of these articles satisfied the inclusion criteria.

3.2. CAT Results

In the search phase, five out of the 12 identified articles were qualitative in nature and were therefore evaluated using the JBI-QARI (CAT). As shown in Table 1, each of these qualitative studies received a score of 7 out of possible 10. This indicates a consistent scoring trend across the five articles in response to the ten evaluative questions, with the exception of questions 1, 6, and 7, where they differed.

Table 1: Qualitative CAT JBI-QARI

References	Screening Questions							
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8
Ahammed, M. T., & Khan (2022)	N	Y	N	U	N	U	U	N
Asaad et al. (2021)	Y	N	N	U	N	U	U	N
Bhalshankar, S. S., & Thorat (2016)	Y	Y	U	U	Y	U	U	N
Preethi, V., & Harish, G. (2016)	U	U	N	Y	N	U	Y	N
Mehdipour Pirbazari, A., et al. (2020)	N	Y	N	U	N	Y	U	N

N denotes = No
Y denotes = Yes
U denotes = Unclear

1. Does the research methodology align with the philosophical stance articulated in the study?
2. Are the research methodology and posed research questions or objectives consistent with each other?
3. Does the chosen methodology match the data collection methods that were employed?
4. Is there consistency between the methodology and the way data are presented and analyzed?
5. How well does the research methodology correlate with the interpretation of the findings?
6. Has the researcher's cultural or theoretical position been acknowledged in the study?
7. Is the mutual influence of the researcher and the research process itself addressed?
8. Are the participants and their perspectives sufficiently represented in the research?
9. Is the research conducted ethically according to contemporary standards and is there evidence of ethical approval by an appropriate entity?
10. Are the research report's conclusions justifiably derived from the data analysis and interpretation.

Table 2. Quantitative Descriptive CAT PHAC

References	Screening Questions					Quality of The Study
	Q1	Q2	Q3	Q4	Q5	
Chakraborty, S., et al. (2021)	S	M	S	S	M	High
Avancini, D. B., et al. (2021)	M	M	S	S	M	High

In addition to the previously mentioned outcomes, this study discovered that 12 articles collectively contributed 28 significant insights. Of these, 21 were deemed unequivocal (U) and seven were regarded as credible (C), as outlined in Table 5. Notably, none of the findings were categorized as unsupported (Un). These insights were distilled into a singular synthesized conclusion: "Smart meters for residential buildings," which are underpinned by distinct categories: power quality management, smart city infrastructure, smart grid implementation, IoT and Smart Grids, Energy utilization,

Energy management, Distribution system management, Smart Water Systems , commercial energy, Sociotechnical System, load forecasting and Energy Meter Design. Table 5 summarizes the meta-synthesis of the study's insights, detailing the specific findings, their categories, and the resultant synthesized conclusion.

3.3 Results of Meta-Synthesis Research Findings

Table 3: Meta Analysis

References	Findings	Categories	Synthesized Findings
Ahammed, M. T., & Khan, I. (2022)	Ensuring power quality and demand-side management through IoT-based smart meters	Power Quality Management	Improved efficiency and control in power management
Ahuja, K., & Khosla, A. (2018)	Importance of smart metering in smart cities	Smart City Infrastructure	Integration of smart meters into smart city ecosystems
Asaad, M., et al. (2021)	Smart grid and Indian experience review	Smart Grid Implementation	Adoption barriers and benefits in India
Avancini, D. B., et al. (2021)	A new IoT-based smart energy meter for smart grids	IoT and Smart Grids	The role of IoT in enhancing smart grid capabilities
Barman, B. K., et al. (2018)	IOT based smart energy meter for efficient energy utilization	Energy Utilization	Enhanced consumer energy management
Bayram, I. S., & Ustun, T. S. (2017)	A survey on energy management systems in smart grid	Energy Management	Implications for behind-the-meter energy management
Chakraborty, S., et al. (2021)	Smart meters for protection and monitoring in emerging distribution systems	Distribution System Management	Enhanced monitoring and protection through smart meters
Gupta, A., et al. (2016)	Need of smart water systems in India	Smart Water Systems	The potential of smart metering in water conservation
Karthick, T., & Chandrasekaran, K. (2021)	IoT based smart energy meter with demand side management for commercial buildings	Commercial Energy Management	Efficiency in commercial building energy usage
Kumar, A. (2023)	Promises of a truth machine: deception and power in smart grids	Sociotechnical System	Examination of smart grids beyond technical aspects
Mehdipour Pirbazari, A., et al. (2020)	Short-term load forecasting using smart meter data	Load Forecasting	Enhancing forecasting accuracy with smart meter data
Preethi, V., & Harish, G. (2016)	Design and implementation of smart energy meter	Energy Meter Design	Innovations in smart energy meter design

4. Discussion and Conclusion

4.1 Socio-Economic and Demographic Influence on Consumer Attitude

The education level and status of the economy are important factors in forming a consumer's attitude towards smart meters in India (Shahanas and Sivakumar, 2016). Highly educated clients from wealthy families are more likely to apply the advantages of smart meters, which results from the higher level of awareness due to easy access to data and better environmental protection understanding (Sreedevi, et al., 2020). Preethi and Harish (2016) and Bayram and Ustun (2017) mention that social links are the reason higher socioeconomic classes are early users of new technology because they have the authority and ability to enhance the process of innovation. Hence, Prathik et al. (2018) revealed that smart meters' education level can determine the level of individual efforts towards their acceptance. Therefore, educated people who understand the benefits to the environment and energy savings are more willing to change to smart meters (Mehdipour Pirbazari, et al., 2020). In addition, other demographic factors, such as age and working sector, have a bottom-line impact on technology diffusion. Generation Y and highly qualified workers are more prone to technology adoption, have been exposed to a constant stream of technology, and are not conservative in their outlook (Das and Saikia, 2015; Sharma and Saini, 2015).

4.2 Perceived Benefits and Obstacles

India's decision to Immigrate smart meters is connected to perceived advantages and existing barriers. As highlighted by Barman et al. (2018), the main advantages are maintaining energy consumption efficiency and proper bill generation that can help you to cash up with the principle payment. Janardhana and Shashikala (2016) are the reasons that these smart meters are being used to monitor smart meters in real-time, and consumers can take more control of their own electricity usage. Hence, this facilitates the feeling of being responsible and having control over energy conservation (Ahammed & Khan, 2022; Karthick and Chandrasekaran, 2021). However, the challenges to the already registered barriers remain crucial. Hefty costs in advance are the roadblocks for the participation of low-income people, who are meant to benefit

from energy conservation (Ramakrishnan and Gaur, 2016). Data sharing implications, along with consumer concerns about their data misuse, are of great concern, and consumers' wariness is quite palpable (Saha et al., 2018; Asaad et al., 2021). Cultural aspects play an important role in the acceptance of a new cultural system. Traditional ways and patterns of using new technologies in some regions may prevent such interventions from being accepted due to cultural conservativeness and non-readiness for change, as Asaad et al. (2021) and Gupta et al. (2016) argued.

4.3 Effect of information broadcasting and education

Smart Meters are supported by viable information transmission and effective consumer education. Such measures have stimulated demand. Metering et al. (2017) and Bhalshankar and Thorat (2016) indicated that an informational campaign, if it could successfully explain the economic and environmental benefits, would hold a high level of consumer engagement, thereby enhancing the rate of adoption. These types of campaigns should touch upon the topics of less expenditure burden, ease, and ability to detail energy consumption and also stress the importance of energy consumption by using smart meters. Local leadership is essential for the successful implementation of these campaigns, as mentioned by Chaudhari and Mulay (2019) and Sahani et al. (2017), since community members can rely on local health authorities, which in turn makes them reach out to these campaigns and accept them as helpful and necessary. Proactive government intervention in public education on smart meters, including smart meter-related information, may help bridge this information gap and ensure public trust, both of which are important factors for the successful deployment of smart meters (Bansal and Singh, 2016; Kappagantu and Daniel, 2018).

4.4 Trust between Utility Providers and Regulatory Frameworks

The emergence of a trusting relationship between power distribution utilities and robust case laws demonstrates the importance of smart grid integration. Avancini et al. (2021) and Muralidhara et al. (2020) point out the need for transparent operations within the sector and the implementation of pro-customer policies, resulting in the creation of trust. Consumers demand and expect that their data are being protected, their bills are accurate, and they are not billed or overcharged. They should receive such assurance. Chakraborty et al. (2021) and Hussain et al. (2018) have pointed out that wide-ranging regulatory systems in which consumers' interests will be safeguarded and fair trade promoted are crucial if the consumer confidence to use the space is strengthened. In addition, Kumar et al (2021) and Priyadharshini et al (2019) also brought out the need of strong regulatory frameworks which precisely defines the rights and duties of several smart grid users and providers to allay fears and resistance arising out of privacy and data security concerns.

Lastly, studies show that socioeconomic and demographic profiles, the beholder's views on costs and benefits, the extent of information dissemination, and trust in both utility service providers and the legislative framework are the key factors in smart meter adoption in India (Tripathi and De, 2018). These influences are complex and interact in many ways to determine consumer opinions and choices (Hassan, et al., 2022). In order For smart meters to gain market penetration, many of these factors need to be addressed through strong laws, targeted audiences with specific campaigns, and strong regulatory and legal mechanisms that safeguard consumer interest and data.

5. Practical Implications

Smart meter usage in Indian residential buildings will create unexplored opportunities if only careful planning and implementation exist. In practice, electricity utilities should use customer locations and socio-economic and demographic data to target different consumer segments and create effective campaigns that strike the right chord. In addressing the concerns of higher-income and well-educated individuals, it is crucial to emphasize both the environmental advantages and technological aspects of smart meters. Additionally, it is essential to highlight the cost-saving benefits of smart meters and their ability to manage brown-outs. On the other hand, service providers must also develop a highly visible communication strategy to address privacy concerns and reveal data for security purposes. Collaborations with local leaders are the key to building relationships at the grassroots level and developing communities' educated campaigns that create awareness of global issues. Similarly, regulators should have an essential function in placing into operation and enforcing standards, which are meant to defend customers` interests and promote fair practices. Consequently, people will be able to embrace smart meters with confidence.

6. Future Research Prospects

Further research should be conducted to design studies that follow consumer behaviors and attitudes longer, as smart meter technology is more pervasive. Another aspect worth considering is the psychological factors behind technology acceptance, especially connected to the feeling of control related to energy consumption and the emotional aspects connected with the introduction of new technologies. Smart meter adoption is driven by policy changes and regulatory introductions, which calls for analysis to gain insight into the role of led sociotechnical interfaces. In addition, comparative studies that engage states and cities separately in India could reveal regional deviations and ideas on how to personalize strategies for adoption. Moreover, we scrutinized the impact of smart meters on supplementing their power use by artificial intelligence and machine learning.

7. Limitations

The primary limitations of this study are the time and geographical constraints that restrict the applicability of its results to recent developments, as well as the inability to generalize the Indian residential sector as the sole representative. Furthermore, the use of only peer-reviewed literature may introduce selection bias and limit the examination of gray or unpublished literature, which could provide alternative perspectives. Additionally, the absence of an in-depth analysis of customer experiences with smart meter technology prior to this research is a notable shortcoming, as it may have yielded valuable insights. Finally, while this study incorporated diverse disciplinary approaches, its conclusions may not fully capture the intricate nature of the smart meter setup, which involves a complex interplay of technological, behavioral, and regulatory factors.

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