

Users' understanding of smart meters in Sweden: an interpretive study

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Abstract

Smart Grid has emerged as a phenomenon in energy management by replacing traditional grids with cutting-edge technology. Central to this innovation are smart meters, which hold significant potential for transforming energy consumption, monitoring, and regulation. However, the success of smart meter implementation relies heavily on user engagement. This research delves into the perceptions, barriers, and concerns associated with smart meter usage, focusing on Sweden, where smart meter deployment is mandated by the government. Utilizing a two-step investigation comprising a literature review and interviews with new smart meter users, this study identifies key obstacles and apprehensions hindering acceptance and adoption. By employing the Social Construction of Technology (SCOT) theory as an interpretive lens, the analysis underscores the understanding of users as a relevant social group and the interpretive flexibility of a technology that, for its closure, requires further negotiation among the different relevant social groups. This approach sheds light on the challenges associated with the need for appraisal by users and the commitment to a specific technological choice by institutions. The findings offer insights for future research and practice to promote sustainable energy systems.

Keywords

Smart Grid, Smart Meter, User Perspective, SCOT Theory.

1. Introduction

In recent years, the management of energy resources has gained significant attention from both public and private organizations. This focus is driven by the goal of achieving Affordable and Clean Energy, which is one of the aims outlined in the United Nations Sustainable Development Goals (SDG). A significant development in this area is the development of the "Smart Grid." This advanced system uses cutting-edge technology to improve the way energy is distributed and consumed by addressing inefficiencies found in traditional grids. Central to the concept of the smart grid are smart meters. The whole idea with these devices (smart meters) utilize advanced technology to replace older meters,

BIR-WS 2024: BIR 2024 Workshops and Doctoral Consortium, 23rd International Conference on Perspectives in Business Informatics Research (BIR 2024), September 11-13, 2024, Prague, Czech Rep.

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which require manual readings and only provide cumulative usage data. In contrast, smart meters automatically transmit usage data to the energy provider, offering detailed, real-time insights. This automation facilitates more accurate billing, helps users identify energy-saving opportunities, and allows for more precise monitoring of electricity usage in homes and businesses. By providing real-time data on energy consumption, smart meters enable users to better understand their electricity usage patterns. This understanding helps people make more informed decisions about their energy usage, leading to more efficient and sustainable energy practices.

Unlike the traditional grid, which merely transmits or distributes electric power, the smart grid is designed to store, communicate, and make decisions, as highlighted by Tuballa and Abundo [3]. This intelligent communication feature of the smart grid brings smart meters into focus, making them one of its most important components. Smart meters facilitate two-way communication between energy suppliers and users, measuring and reporting energy consumption to enhance energy efficiency and saving. As advanced metering devices, smart meters promise to transform how we consume, monitor, and regulate energy, holding immense potential for shaping a sustainable energy future [4-6]. However, the successful implementation of smart meters for exploiting all the potential advantages of the technology and increasing their impact on the quality of the environment seems still far from being fully reached.

In the case of Sweden, considered in this paper, the successful implementation of smart meters is not merely a matter of factors like users' acceptance and engagement. In fact, it is mandated by the government, and households have no choice since smart meters are implemented as part of the energy management infrastructure [7]. It is within this context that understanding user perspectives, awareness, and attitudes toward smart meters becomes crucial, even when user choice is limited. According to the engagement-oriented perspective that guides our study, we define household electricity users in Sweden, who have undergone the mandatory implementation of smart meters, as users.

Despite the promising potential of smart meters, a notable gap exists between the technology and its full exploitation, even in mandated adoption scenarios. Many users lack knowledge and understanding of smart meters, hindering their willingness to fully embrace this innovation. Bridging this gap requires investigating how users with limited knowledge and understanding perceive smart meters, as well as identifying the barriers and concerns that influence their willingness to adopt and utilize this technology.

Therefore, the primary objective of this interpretive study conducted in Sweden is to address the following research question:

How do household electricity users understand smart meter technology when adoption is compulsory by government mandate?

The subsequent sections of this paper will first present an analysis of the state-of-the-art literature on smart meters. Then, we provide a detailed account of the study's methodology, findings from interviews, and finally implications of the research.

2. Literature Review

This literature review aims to examine the relevance of user involvement within the field of smart meters in the context of information systems. Employing a systematic approach, the review focuses on publications from the AIS Electronic Library spanning a 12-year period from 2010 to 2022; to ensure access to the latest insights on smart meters, reflecting recent technological advancements, evolving adoption rates, updated policies, increased research interest, and emerging trends within the field. We focus on the context of information systems since we would like to have a clear focus on the combination of people, organization and technology as the subject information systems has. The decision was then to focus exclusively on publications from the AIS Electronic Library is justified by several factors. Firstly, the AIS Electronic Library is a renowned repository specializing in information systems research, ensuring that the selected literature directly addresses the intersection of smart meters and information systems. Secondly, this approach ensures consistency and reliability in the review process, as all included articles undergo a similar level of peer-review and quality assessment. Additionally, by limiting the search to a single database, the review can effectively manage the vast amount of literature available on the topic, enhancing efficiency and allowing for a more thorough analysis within the designated timeframe. By conducting a single keyword search for "smart meter" within the titles, the review identified 21 relevant publications. Following an analysis of abstracts, 20 articles were selected for inclusion in this review based on their explicit or implicit definition or description of smart meters. These chosen articles were thoroughly investigated to explore various dimensions of smart meters, including adoption, data analytics, interface design, privacy concerns, and more. The primary objective of this review is to ascertain how these articles define smart meters and discern whether they acknowledge the active role of users that they all mostly see as users, either explicitly or implicitly, thus underscoring the significance of user involvement within the smart meter literature. In Table 1, a summary of the main themes from the literature review is provided.

Table 1: Themes on Smart Meters Adoption Perspectives.

Themes	Key points	Citation
Exchange of information and tailored decision support	The importance of smart meters as an exchange point for information about household energy consumption, empowering users to make informed choices regarding energy efficiency.	Dalén and Krämer [11]
Bidirectional communication and new services	The smart meters bidirectional communication between users and energy suppliers facilitates the provision of new services and enhances the overall functionality of the grid.	Wunderlich, Veit and Sarker [12], [13]
Energy efficiency and renewable energy integration	The data provided by smart meters reduce energy consumption and support the integration of renewable energy sources.	Sodenkamp et al. [14]

Privacy concerns and trust-building measures	Trust seals as a mechanism to enhance trust and mitigate privacy concerns for ensuring widespread acceptance and adoption of smart meters.	Degirmenci [15]
Policy effects and economic implications	The impact of policy decisions on the successful implementation of smart meters and widespread adoption.	Morelli et al.[16]
User behavioral factors	The analysis of users' attitudes, beliefs, and concerns related to privacy, risk, and the perceived usefulness and ease of use of smart meters for the development of strategies to promote smart meters adoption.	Various studies [17-20]
Business models and customer clusters	The exchange and analysis of smart meter data as a new business model to identify detailed customer clusters using smart meter data.	Strüker, Weppner and Bieser [21], Liu, Yao, Eklund and Back [22], and Flath, Nicolay, Conte, van Dinther and Filipova-Neumann [23]
Supplier perspectives and demand side management	The smart meters and demand side management (DSM) challenges should be seen from the perspective of energy suppliers.	Johansson, Granath and Melin [24]
Goal-related design features and energy consumption:	Different design features, such as consumption display, evaluative standards, goal incentives, and reference groups, impact on energy-saving behaviors. The design of smart meter interfaces with goal-related features, can motivate and empower households to achieve energy-saving goals	Wendt and Benlian [25]

In summary, the reviewed articles not only focus on the technical aspects and potential benefits of smart meters but also acknowledge the significant role of users, whether explicitly or implicitly. This recognition highlights the importance of users' involvement, engagement, and acceptance to have a successful adoption and utilization of smart meters. By considering users' perspectives, attitudes, and behaviors, these studies contribute to a more comprehensive understanding of the smart meter landscape and emphasize the need for user-centric approaches during the design and implementation of smart meters. Given the wealth of research on users' acceptance of smart meters, it's crucial to question its relevance against other potential factors when the technology is mandatory implemented.

Thus, in what follows, we discuss a interpretive study aimed at increasing our understanding of users' views, to eventually uncover fresh perspectives.

3. Research Method

In this section, we present a qualitative interpretive study [28] conducted to uncover the perceptions of the users of smart meters and identify the barriers and concerns influencing their willingness to adopt and utilize this technology. This qualitative study was conducted in Sweden, where implementation of smart meters is mandated by the government. The study's involved conducting interviews with twelve participants, representing Swedish smart meter users. They were interviewed after recently undergoing the mandatory implementation of smart meters. The analysis of the interview data yielded valuable insights into the experiences and perspectives of these users, shedding light on the factors that may hinder acceptance and utilization of smart meters among this specific group. To further scrutinize the findings, this study employs the Social Construction of Technology (SCOT) theory advanced around Science and Technology Studies (STS) by Trevor Pinch and Wiebe Bijker [8, 9]. By applying this theoretical framework to the qualitative data, this study aims to gain a deeper understanding of how user perspectives and societal factors contribute to the adoption of smart meters in the mandated context of Sweden.

3.1. Using SCOT Theory as an Interpretive Lens

We chose the Social Construction of Technology (SCOT) theory as an interpretive lens for our study because it provides us with a robust framework for understanding the complex interactions between technology and society in our study of users' perspectives on smart meters [8, 9]. SCOT suggests that technology does not determine human action; instead, human action shapes technology. It emphasizes that the working of technology is socially constructed and influenced by the values, beliefs, and interests of society [10]. In the context of smart meters, SCOT theory explores the interpretive flexibility, relevant social groups, negotiation processes, and potential for closure. By focusing on SCOT, we can explore three key concepts that are particularly relevant to our study:

Relevant Social Groups: SCOT emphasizes the importance of understanding the diverse perspectives and priorities of different social groups involved in the development and use of technology. In our study on smart meters, we recognize that stakeholders such as designers, engineers, policymakers, regulators, and users all play a role in shaping how smart meters are perceived and utilized.

Interpretive Flexibility: SCOT acknowledges that technologies can be interpreted in different ways by different social groups, depending on their context and values. In the context of smart meters, users may have varying interpretations of the technology based on factors such as their knowledge, experiences, and concerns about privacy and data security.

Negotiation and Closure: SCOT recognizes that over time, debates and negotiations among social groups may lead to the negotiation of a particular interpretation or design of technology. In our study, we are interested in exploring how user perceptions of smart meters may evolve over time as debates about their functionality, benefits, and drawbacks continue.

Using SCOT as a theoretical lens allows us to decode empirical data by analyzing how these concepts manifest in the perspectives and experiences of users with smart meters. Through structured analysis, we aim to uncover codes related to how social dynamics shape the adoption, usage, and meaning of smart meters in specific contexts.

3.2. The Case of Sweden

Since 2003, Sweden has been an early adopter of smart meters in Europe, aiming to reduce electricity consumption and achieve energy savings of 3-4% by providing real-time feedback to users on their energy usage [26]. The introduction of smart meters has evolved their functionality from mandated monthly billing to more frequent measurements. However, concerns have been raised about the varying functionalities introduced by different distribution system operators, leading to questions about the equal treatment of users [27]. In response to this, the Swedish Energy Markets Inspectorate (EI) established a regulation in 2017 that sets seven minimum functional requirements for all electricity meters in the low voltage network. These requirements aim to enable extended measurement, improve customer interface, facilitate remote measuring and data collection, ensure hourly or fifteen-minute registration of active energy, enable remote software updates and control, and provide remote access for turning power on and off through the meter [7].

The government's legislation has influenced the replacement of numerous electricity meters in Sweden, marking the second-generation rollout of smart meters in the country. However, it remains uncertain whether the newly replaced smart meters align with the minimum functional requirements set by the EI. Furthermore, it is also unclear how users with limited knowledge and understanding of smart meters perceive this technology, which is what we have collected data about, and the aim of the research presented in this paper.

3.3. Data Collection Methodology

To gather insights into user perspectives on smart meters, twelve semi-structured interviews were conducted in Sweden, both online and in-person. The interviews followed an interpretive approach and consisted of five structured questions with open-ended follow-up questions. The initial questions focused on participants' experiences with smart meters, including whether and when their electricity meter was replaced with a smart meter, their opinions on the functionality of the new meter, their awareness of its features and benefits, and their overall experience interacting with the meter, including any challenges or advantages they encountered. Follow-up questions were tailored based on participants' initial responses to delve deeper into specific areas of interest. Each interview session lasted approximately 45 minutes.

Participants for the study were selected based on their willingness to participate, communicated through an open invitation posted in a community social media group in an area where electricity meters had recently been replaced. Five participants were from this targeted area, while seven additional participants from other cities in Sweden, who also had access to the social media group, volunteered due to their similar novice experiences with

replaced electricity meters. This approach ensured a diverse representation of participants from different energy supply companies, enhancing the study's strength and validity.

The data analysis procedure involved applying the Social Construction of Technology (SCOT) theory as a lens, focusing on themes such as interpretation, social construction, negotiation, and closure.

4. Empirical Data and Findings

The perspectives shared by participants offer valuable insights into their experiences with smart meters. Participant #1, who recently had their electricity meter replaced voiced concerns:

"I'm puzzled by the lack of information about the replacement and the purpose of the small white box on the wall, which I assume is a thermostat. However, a bit more clarity, especially from the national government, would be beneficial!"

Participants #2 and #8 echoed similar sentiments, expressing confusion about the new electricity meter and its functionalities:

"I have a white box next to my meter cabinet. I presume it's for digital readings... My electricity meter was recently replaced, but I lack detailed information." (#2)

"About 18 months ago, I heard about electricity meters being replaced with smarter ones. Now that my meter has been changed, I'm unsure about the alterations." (#8)

Concerns regarding meter readings and electricity contracts were also raised by participants #4 and #5:

"I'm uncertain if the new electricity meter alters my electricity contract." (#4)

"...they replaced the electricity meter at my place. I'm concerned if our previous agreement remains valid. I hope everything will be fine." (#5)

Some participants, like Participant #6, had specific expectations or prior knowledge, such as anticipating a Home Area Network (HAN) port, only to discover otherwise:

"My electricity provider applied for hourly readings in mid-September, which hasn't been activated yet. I expected my new electricity meter to have a HAN (Home Area Network) port. Initially, I thought it should have one, but it's beneath the sealed cover at the bottom. I learned from the distributor that this meter lacks a HAN port."

Participant #3 also expressed awareness of smart meter functionalities but voiced disappointment and confusion about the information provided with the new meter:

"...They mentioned 'Track your electricity use in real time (if you connect an app to the meter)'...but after some research, I couldn't find any external meter to plug into the HAN port. I'm confused; are they referring to an app for real-time consumption?"

In contrast, Participant #7 displayed a higher level of awareness about smart meters. However, they encountered issues such as the inability to monitor solar energy input and incorrect consumption data, highlighting unresolved issues with the new meter:

"After the meter replacement, I can no longer track the electricity input from solar cells, and the consumption data displayed on my pages is incorrect. Upon contacting the distributor, I was informed it's a known issue, but they couldn't provide a timeline for resolution. Despite this, the new meter isn't particularly 'smart!'"

Participant #9 provided intriguing perspectives during the interview, despite having limited knowledge about smart meters. Demonstrating a keen interest in understanding their functionality, viewing smart meters as a digital evolution from traditional analog counterparts. Notably, Participant #9 emphasized the potential for smart meters to empower users with greater awareness and control over their energy consumption:

"If I could monitor my electricity consumption and observe daily increases, I'd be more proactive in making adjustments."

Their neutral stance on government-mandated installations, coupled with emphasis on affordability, underscores the multifaceted nature of adoption:

"I inherently trust the government's judgment... My perception is neutral; it's acceptable... In fact, I lean towards feeling more positive than negative about it."

Participant #9's insights underscored the importance of user engagement, government communication, and affordability in driving widespread smart meter utilization. Furthermore, they provided insights into potential enhancements in smart meter functionality, emphasizing the need for user-friendly interfaces and real-time feedback mechanisms. They envisioned centralized platforms or simplified displays for seamless monitoring and proposed integrating reminders and usage limits to encourage energy conservation.

In discussing the future of smart meters, Participant #9 emphasized the significance of cost-effectiveness, highlighting the impact of electricity prices on user motivation:

"My primary incentive to alter behavior would hinge on electricity prices... If electricity remains affordable, my level of engagement may diminish."

Participant #10 shared insights regarding the recent installation of smart meters in their apartment approximately six months ago. They highlighted the social and regulatory dimensions surrounding smart meter deployment, acknowledging potential benefits such as increased awareness of energy consumption and the convenience of monitoring usage through mobile apps. However, they also expressed concerns about the lack of guidance from energy providers on effectively setting up and utilizing smart meters, emphasizing the importance of comprehensive user education and support. The interview further explored the potential impact of smart meters on energy management, with Participant #10 speculating on future advancements in functionality, such as remote control of electricity consumption via mobile apps. They envisioned easier control of electricity usage from a distance. Moreover, Participant #10 discussed how access to real-time data from smart meters could influence energy consumption behavior, expressing expectations for user-friendly interfaces to visualize usage patterns over time. The participant expected clear options for filtering and summarizing usage over weeks or months.

Two residents of a century-old house discussed their experience with smart meters. Participant #11 shared that they had assumed they always had a smart meter since moving in 13 years ago. Reflecting on their awareness, Participant #12 expressed surprise at the mandated implementation of smart meters in Sweden. Despite this, they recognized the practicality of remote monitoring and precise billing facilitated by smart meters. Discussing their energy consumption behaviors, Participant #12 noted adjustments made in response to real-time pricing data provided by their smart meter, such as scheduling washing at night. The couple emphasized the importance of user-friendly interfaces and comprehensive support from energy providers, suggesting it would be useful to know which circuits use the most electricity. Envisioning the future of smart meters, Participant #11 proposed advanced functionalities that can dynamically adjust energy usage based on household activities. Overall, their insights underscored the importance of awareness, user engagement, and support. The interviews offer valuable insights into how users perceive smart meters. Many participants had limited knowledge about smart meters and joined the study to learn more. This highlights the importance of educating and engaging users in smart meter adoption, as emphasized in existing literature.

Participants also showed confusion about their new electricity meters, with some unaware of additional features. Clear communication between energy companies and customers is crucial to address this confusion. Concerns about electricity contracts indicate the need for clearer explanations about how the new meters affect energy usage and billing. Additionally, some participants had certain expectations or prior knowledge about smart meters, highlighting the importance of considering customers' varying expectations during the design and implementation of smart meter programs by energy supply companies.

These interviews reflect the Social Construction of Technology (SCOT) theory, showing how participants interpret smart meters differently based on their experiences and knowledge. Negotiations between participants and energy providers regarding smart meter functionalities and contracts were observed, highlighting the dynamic nature of user-provider interactions. While some participants expressed dissatisfaction or confusion, others showed acceptance and awareness of the benefits of smart meters. These insights underscore the complexity of smart meter adoption and the importance of social factors in designing and implementing smart meter programs. Effective communication, user engagement, and affordability are critical for successful adoption, aligning with SCOT principles. Addressing these concerns and expectations is vital for successful adoption from a user's perspective after the mandated implementation by energy companies.

5. Discussion

The interpretive investigation offered insights into users' understanding of smart meters, shedding light on their experiences, knowledge levels, expectations, and concerns. Through a thorough analysis, the study uncovered significant findings by suggesting propositions (shown in table 2) that not only contribute to ongoing discussions on smart meter adoption and usage but also introduce novel implications for both academia and industry. Furthermore, the participants' experiences resonate with various aspects of the

SCOT theory, providing additional insights into the socio-technical dynamics underpinning smart meter adoption and utilization, as outlined in Table 2.

Table 2. Applying SCOT theory.

SCOT Concepts	Building propositions based on SCOT Theory
Interpretive flexibility	Users with limited knowledge and understanding of smart meters may interpret the technology differently. Their interpretation is influenced by their interests, values, and beliefs. The lack of awareness and understanding may lead to misconceptions and concerns about the technology's functionality and potential benefits.
Relevant social groups	The relevant social groups involved in the development and use of smart meters include designers, energy suppliers, policymakers, regulators, and users. Each group has different interests, priorities, and perspectives regarding smart meters. Their engagement and collaboration are crucial for the successful integration and adoption of smart meters.
Negotiation	The development and adoption of smart meters involve negotiation among the relevant social groups. Users' concerns and preferences need to be taken into account during the design and implementation processes. Effective communication and engagement strategies are required to address users' barriers and build trust.
Closure	The closure of smart meters refers to its widespread acceptance and dominance in society. While smart meters have been increasingly adopted, the interpretation and use of the technology can continue to evolve over time. Ongoing research, policy adjustments, and technological advancements may lead to further iterations and improvements in smart meter functionality and user engagement.

A significant finding from the study is the pervasive lack of knowledge among participants regarding smart meters and their functionalities, enforcing *interpretive flexibility* among the different *relevant social groups* (see Table 2). This finding resonates strongly with prior literature, emphasizing the critical necessity for comprehensive user education and engagement strategies to facilitate widespread adoption. It underscores the imperative for energy providers and stakeholders to invest in educational initiatives aimed at enhancing awareness and understanding among users. Clear, accessible information elucidating the benefits and mechanics of smart meters is essential to bridge these knowledge gaps effectively. For instance, Participant #1's expression of uncertainty regarding replacements signals a need for broader governmental dissemination of information. Similarly, the confusion demonstrated by Participants #2, #6, #8, and #12 underscores the urgency for enhanced user education initiatives to address knowledge deficiencies. Furthermore, participant interviews unveiled widespread confusion regarding the functionality of the new electricity meters. Effective communication channels between energy providers and consumers are pivotal in resolving this issue. Providing clear and

comprehensive information regarding replacement procedures, functionalities, and benefits is crucial to alleviate confusion and foster user acceptance.

While the Swedish government has promoted the benefits of smart meters through various campaigns, many participants indicated that they did not receive detailed instructions on how to use the new technology or fully understand its benefits. This suggests an instrumental orientation toward appraisal through informing the users “to “close down” the range of possible technological commitments” [29, p.264]. This also suggests a gap in the practical information provided to users at the time of installation. Common issues reported by participants included a lack of guidance on using the meters, concerns about changes to their electricity contracts, and technical problems such as incorrect consumption data. Specifically, four participants mentioned difficulty in accessing real-time data, and two reported problems with their solar energy inputs not being accurately tracked.

Another noticeable theme that emerged is the diversity in expectations and prior knowledge among participants regarding smart meters, points out the relevance of *negotiation* among the *relevant social groups* (see Table 2). Accordingly, this underscores the importance of tailoring initiatives to accommodate existing user knowledge, manage expectations, and furnish accurate information. Aligning customer expectations with reality is crucial, as highlighted by Participant #6's anticipation of a Home Area Network (HAN) port, Participant #3's disappointment with information provision, and Participant #9's neutral stance on government-mandated installations.

Moreover, concerns were raised regarding the contractual implications of new electricity meters on existing agreements and billing. Improved communication and transparency from energy providers concerning contractual nuances are imperative to address these concerns and enhance customer trust in the technology. Technical issues encountered by participants with the new meters further underscore the importance of prompt resolution and effective customer support from energy providers. Addressing technical challenges enhances the reliability and perceived "smartness" of the meters, contributing to further appraisal [29] by the users as a *relevant social group* (see again Table 2), and opening up the closure of the smart meter.

In general, the interviews revealed that a major part of the participants had limited knowledge about smart meters and participated in the study to learn more about the technology. This emphasizes the significance of user education and engagement in the adoption of smart meters. Energy supply companies should invest in educational initiatives to increase awareness and understanding among users, addressing the gaps in knowledge identified through the interviews.

5.1. Implications for practice

The findings of this study also have implications for practice, and several recommendations can be made to enhance users' full adoption and engagement in smart meter programs. Firstly, there is a need to develop comprehensive and accessible user education initiatives that increase awareness and understanding of smart meters. These initiatives should provide clear and accurate information about the functionalities, benefits, and replacement process of smart meters. Secondly, communication strategies should be improved to ensure effective dissemination of information. Clear and accurate communication about features

and functionalities of smart meters, as well as the benefits and the replacement process, can help alleviate confusion and enhance users' understanding and awareness, increasing potential benefits of adopted smart meters. Additionally, communication and support should be tailored to address the varying expectations and concerns of different user groups. This personalized approach can help manage customer expectations and ensure a smoother transition to the new technology.

Transparency is also crucial in addressing users' concerns about the contractual aspects of smart meters. Energy supply companies should enhance transparency by clarifying any changes in contracts, billing procedures, and how the technology affects energy usage. By providing clear information, companies can alleviate customers' concerns and enhance their trust in the technology. Furthermore, addressing technical issues promptly and providing efficient and effective support to customers is essential to ensure reliable and functional smart meters. By resolving technical challenges, energy supply companies can enhance the reliability and perceived "smartness" of the meters, leading to greater user satisfaction and further way of exploiting them.

Another recommendation is to leverage relevant social groups as channels for disseminating accurate information and building trust in smart meters. Friends, family, and neighbors play an influential role in shaping users' expectations and concerns. By engaging these social groups and providing accurate information, energy supply companies can address misconceptions and build trust in smart meters.

To further contribute to understanding of smart meter adoption and full utilization, future research can explore several areas. Firstly, investigating the long-term impacts of smart meter adoption on energy consumption behavior and cost savings can provide insights into the effectiveness of the technology in promoting energy efficiency. Secondly, comparing user perspectives and experiences across different countries and contexts can help identify cultural and contextual factors influencing smart meter adoption. This can inform the development of tailored strategies for different regions. Thirdly, exploring the role of innovative communication strategies, such as social media or gamification, in increasing user engagement with smart meters can provide insights into effective communication approaches. Finally, examining the potential for smart meters to promote sustainable energy practices and behaviors can contribute to the broader goals of energy conservation and environmental sustainability.

By incorporating these improvements and conducting further research in these areas, policymakers, energy supply companies, and other stakeholders can enhance user engagement in smart meter programs. Understanding users' perspectives and addressing their needs and expectations is crucial for the successful development, implementation, and adoption of smart meters.

6. Conclusion and Future Work

In conclusion, this study contributes to understanding user engagement and obstacles to adopting smart meters, particularly within the context of mandated implementation in Sweden. Aligned with our research objectives, qualitative interviews with Swedish users provided valuable insights into their perceptions of smart meter adoption. The findings,

building on twelve interviews, underscored the significance of users' interpretive flexibility in shaping their perception of smart meters, especially considering the government-mandated nature of implementation/adoption in Sweden. It became evident that various social groups, including designers, energy suppliers, policymakers, regulators, and users, hold distinct interests and perspectives that influence smart meter development and utilization. Effective negotiation and collaboration among these groups are imperative to address users' concerns and preferences and ensure successful integration into their lives within the context of the government mandate.

The study findings highlight the importance of user awareness and understanding in widespread smart meter adoption, even in a mandated context. To promote effective adoption and engagement, providing accurate information, dispelling misconceptions, and emphasizing benefits and functionalities are crucial. Additionally, employing effective communication strategies and engagement initiatives involving relevant social groups are essential to build trust and overcome potential barriers to adoption.

The practical implications of this study are significant for policymakers, energy suppliers, and designers in Sweden. Based on the findings, policymakers should focus on strategies that provide accurate and accessible information to users, address concerns, and involve them in decision-making processes. Energy suppliers and designers should consider diverse user perspectives and interests in smart meter development and implementation, ensuring that user needs are met within the government-mandated framework. Engaging in collaborative efforts and effective communication strategies with stakeholders remain essential to enhance user engagement and promote successful integration.

Focused on the Swedish context, where smart meter adoption is government-mandated, presented findings may not fully capture experiences and perspectives in other settings. Future research should conduct comparative studies to understand the impact of government mandates on user attitudes and behaviors toward smart meter adoption. Exploring long-term effects on energy consumption patterns and assessing effectiveness of communication and engagement initiatives are crucial. Additionally, investigating experiences of Swedish users who have adopted smart meters can offer insights into factors influencing usage behavior, contributing to continuous improvement within the government-mandated framework.

Acknowledgements

This work has been conducted within the program “Resistance and Effect – on the smart grid for the many people” funded by the Kamprad Family Foundation.

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