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# Lived Experiences and Meaning-Making of IoT-Based Smart Energy Management in Households

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**ABSTRACT**

The rapid advancement of IoT-based smart energy management systems has reshaped household energy practices, yet little is known about the subjective experiences and meanings users construct around these technologies. While prior studies emphasize technical efficiency and adoption models, the emotional, cultural, and relational dimensions remain underexplored. This study employs an interpretative phenomenological approach (IPA) with 15 participants to examine how individuals perceive, interpret, and emotionally respond to IoT-based energy management in daily life. Thematic analysis reveals four key themes: empowerment, privacy concerns, emotional ambivalence, and negotiation of human–technology relationships. By uncovering these lived experiences, the study extends beyond technical outcomes, offering novel insights into user-centered system design and highlighting directions for future research on digital well-being.



## INTRODUCTION

In recent years, the rapid advancement of science and technology has profoundly reshaped the ways individuals interact with their environment, manage resources, and construct meaning from daily experiences (Chamola et al., 2020; Shinde et al., 2024). One of the most transformative developments is the emergence of Internet of Things (IoT)-based smart energy management systems, which enable users to monitor, control, and optimize their household energy consumption in real time. This integration of connected technologies within domestic spaces reflects broader societal trends toward digital transformation and the pursuit of sustainability-driven lifestyles.

Despite its widespread adoption, the phenomenon of technology-mediated energy management extends beyond technical and operational efficiency; it touches deeply on the subjective dimensions of human experience (Ahmed & Gopi, 2024; Sowjanya et al., 2021). Individuals do not merely use IoT systems as functional tools but also construct personal meanings, perceptions, and emotional responses in relation to these technologies. For some, IoT devices represent empowerment, autonomy, and environmental responsibility; for others, they evoke uncertainty, dependency, or privacy-related anxieties (Mukhlis, 2025a; Mukhlis & Saidah, 2025). These diverse interpretations are shaped by broader social and cultural contexts, such as household dynamics, environmental awareness, and shifting values around technology use in everyday life.

Given this complexity, understanding how individuals experience and interpret their interactions with IoT-based energy systems requires moving beyond technical assessments toward lived experience exploration. A phenomenological approach offers a suitable framework for this endeavor, as it prioritizes participants' subjective perceptions and seeks to uncover the essence of meaning embedded in their narratives (Ed-daoudy & Maalmi, 2019; Zhang & Lee, 2023). By focusing on how individuals make sense of technology within their unique contexts, this study aims to

illuminate the intricate relationships between technological innovation, personal agency, and social adaptation.

Through this perspective, the research acknowledges that technological phenomena are not isolated from the human, social, and cultural dimensions in which they are situated. Instead, they represent evolving processes where individuals negotiate identities, routines, and relationships within increasingly digitalized environments. Exploring these lived experiences is essential for building a deeper understanding of how technology transforms personal and collective realities.

Building upon the broader context of digital transformation and technological integration, research on individuals' lived experiences with IoT-based smart energy management systems has become an increasingly important field of inquiry. Scholars have recognized that technological adoption is not only a matter of usability or efficiency but also involves complex personal, emotional, and social dynamics that shape how individuals perceive, engage with, and integrate these systems into their everyday lives. As IoT technologies continue to evolve, understanding these experiential dimensions has become central to advancing both theoretical insights and practical applications.

However, significant methodological challenges remain in exploring these subjective experiences. Much of the existing literature relies on quantitative approaches that prioritize measurable outcomes, such as energy savings or adoption rates, while overlooking the interpretive processes through which individuals make sense of their interactions with technology (Elechi et al., 2025a; Mortazavi & Gutierrez-Osuna, 2023). These studies often fail to capture the nuanced emotional, cultural, and contextual factors that shape participants' perceptions, leading to a partial and sometimes fragmented understanding of the phenomenon.

This limitation underscores the need for qualitative approaches, particularly phenomenological inquiry, which allows for a more holistic and in-depth exploration of participants' narratives. By focusing on the meanings embedded within personal experiences, phenomenology provides the methodological tools necessary to uncover the essence of the phenomenon as it is lived and interpreted by individuals. Through this perspective, the study moves beyond surface-level observations and seeks to illuminate the interconnected layers of perception, agency, and adaptation within the context of IoT-driven energy management.

In light of these methodological gaps, a phenomenological approach offers an opportunity to generate richer insights that can better inform both technological design and user-centered policies (D'Souza et al., 2022). By prioritizing subjective meanings and lived experiences, the research aligns with current scholarly efforts to bridge the divide between technological innovation and human-centered understanding, ultimately contributing to a more comprehensive view of how individuals negotiate their relationships with technology in an increasingly digitalized world.

Although research on IoT-based smart energy management systems has advanced considerably in recent years, much of the existing literature has focused predominantly on technical optimization, adoption models, and energy efficiency outcomes (Mukhlis, Janwari, et al., 2023; Mukhlis & Abdullah, 2025). These studies often employ practical frameworks grounded in engineering or behavioral economics to evaluate usability, performance, and cost-effectiveness. While these approaches have contributed valuable insights, they remain limited in capturing the complex, subjective, and contextual meanings that shape individuals' interactions with IoT technologies.

The prevailing reliance on quantitative metrics and structured behavioral models has resulted in a fragmented understanding of users' experiences (Akhmetzhanov et al., 2024; Arsene et al., 2022). For example, prior studies have measured usage frequency, system reliability, and energy savings, yet they rarely explore how individuals perceive, interpret, and emotionally respond to these technologies in their everyday lives. As a consequence, the personal, relational, and cultural dimensions of IoT adoption remain insufficiently understood, particularly regarding how users construct meaning and negotiate agency when interacting with automated systems.

To address this gap, a phenomenological approach provides an alternative framework for exploring lived experiences and uncovering the essence of meaning embedded in participants' narratives (Ahmad Tarmizi et al., 2020; Jia et al., 2019). By prioritizing subjective perspectives and

situating them within their broader social and cultural contexts, phenomenology enables a holistic and nuanced understanding of how individuals integrate IoT technologies into their daily routines. Such an approach moves beyond surface-level indicators and reveals the underlying cognitive, emotional, and ethical dimensions that shape participants' engagement with emerging technologies.

This lack of comprehensive insights into the meaning-making processes surrounding IoT-based energy management highlights the need for further inquiry. A phenomenological investigation is therefore essential to deepen understanding, generate richer interpretations, and inform user-centered technological development that aligns with the lived realities of diverse individuals.

Recent studies have explored the integration of IoT-based smart energy management systems and their influence on everyday life. Prior research has primarily examined technical efficiency, energy-saving potentials, and behavioral adoption models (Elechi et al., 2025b; Semary et al., 2024). While these findings provide valuable insights, they often neglect the subjective dimensions of users' experiences, such as emotions, perceptions, and personal meaning-making. Literature on phenomenology highlights the importance of understanding these lived experiences to gain a deeper awareness of how individuals relate to technological systems. This study positions itself within this scholarly context by focusing on the interpretive layers of human experience when adopting IoT-based energy solutions.

To address these gaps, this study adopts an interpretative phenomenological approach (IPA) to explore how individuals perceive, interpret, and make sense of their interactions with IoT-based smart energy systems (Hassija et al., 2021; Rustemli et al., 2025). Phenomenology is chosen because it emphasizes the essence of meaning embedded in personal experiences, making it suitable for answering the questions raised in the previous Knowledge Gap section. Through in-depth, semi-structured interviews, participants are encouraged to reflect on their thoughts, emotions, and actions within the context of technology adoption. This approach allows for uncovering not only practical benefits but also relational, cultural, and ethical aspects often overlooked by quantitative studies. By doing so, the research contributes to a richer and more holistic understanding of how IoT technologies are experienced in domestic contexts.

This article is organized into several sections to guide the reader through the study. The Introduction outlines the broader context, research focus, and the methodological foundation of the investigation (Mukhlis et al., 2024; Mukhlis, Maryam, et al., 2023). The Methodology section explains the phenomenological design, participant selection, and data collection procedures. The Results section presents the findings organized into key themes, supported by participants' direct narratives and experiential accounts. The Discussion section interprets these findings in light of existing literature and theoretical frameworks. Finally, the Conclusion summarizes the study's contributions, practical implications, and directions for future research.

## RESEARCH METHODS

### Study Design

This study adopted a phenomenological research design to explore participants' lived experiences and the subjective meanings associated with the integration of IoT-based smart energy management systems (Clair, 2003; Fenton & Baxter, 2016). Phenomenology was chosen because it enables a deep understanding of participants' personal perceptions and interpretations of a phenomenon, rather than focusing on generalized statistical patterns.

An interpretative hermeneutic phenomenological approach was employed, following Heidegger's perspective, to capture the essence of participants' lived experiences while considering the contextual meanings embedded in their narratives (Daly, 2007; Murphy & Dingwall, 2017). This approach was deemed appropriate for exploring the complexity of participants' relationships with emerging technologies, allowing the study to move beyond surface-level descriptions and uncover deeper, nuanced insights.

### Participants

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A total of 15 participants were involved in the study (Iosifides, 2016; Longhofer et al., 2012). Selection was conducted using a purposive sampling strategy, ensuring that only individuals with direct and relevant experiences of using IoT-based smart energy management systems in their households were included.

Inclusion criteria consisted of:

- Adults aged between 25 and 50 years
- Active users of IoT-based energy management devices for at least six months
- Willingness to share personal experiences related to technology adoption

Exclusion criteria included individuals with:

- No prior exposure to IoT-based energy systems
- Limited ability to communicate personal experiences effectively

The participants comprised eight males and seven females, with an average age of 36.8 years. Demographic variation, including professional backgrounds and household energy usage patterns, provided a richer contextual understanding of the phenomenon under study.

**Data Collection**

Data were collected through in-depth, semi-structured interviews, supported by direct observations when necessary. An interview guide was developed to ensure consistency while allowing flexibility for participants to express their experiences freely (Carreiras & Castro, 2012; Migdal, 2018). Each interview lasted between 60 and 90 minutes and was conducted in a quiet and comfortable environment, either in participants' homes or via secure video conferencing platforms.

All interviews were audio-recorded with participants' consent and later transcribed verbatim for analysis. Field notes were also taken to capture non-verbal cues and contextual factors influencing the conversations. To ensure the authenticity and richness of the data, participants were encouraged to provide detailed descriptions of their personal experiences and emotional responses to using IoT systems.

**Data Analysis**

Data were analyzed using a thematic interpretative phenomenological analysis (IPA) approach to uncover the essential meanings underlying participants' experiences (Hillman & Radel, 2018; Lutz & Knox, 2014). The process involved the following systematic steps:

1. Immersion in Data – All transcripts were read repeatedly to gain a holistic understanding of participants' narratives.
2. Identification of Meaning Units – Significant statements and expressions related to participants' experiences were highlighted and coded.
3. Theme Development – Codes were clustered into broader categories and transformed into emerging themes that captured the essence of the phenomenon.
4. Cross-Case Comparison – Themes were compared across participants to identify shared patterns and unique variations in experiences.
5. Synthesis of Essential Meanings – Final themes were refined to represent the core structures of meaning that described participants' lived experiences.

NVivo 14 qualitative analysis software was used to assist in data management and thematic organization, without influencing the interpretative process. The use of software enhanced traceability and transparency, ensuring methodological rigor.

**Ethical Considerations**

Ethical approval for this study was obtained from the Institutional Research Ethics Committee (Approval No. XXX/2025) (Borcsa & Rober, 2015; McNabb, 2015). All participants received

detailed information about the purpose, procedures, and potential implications of the study. Written informed consent was obtained prior to participation.

Participants' identities were anonymized using pseudonyms, and all data were stored securely to maintain confidentiality and privacy. The study adhered to the principles outlined in the Declaration of Helsinki and followed internationally recognized ethical guidelines for human research.

## RESULTS

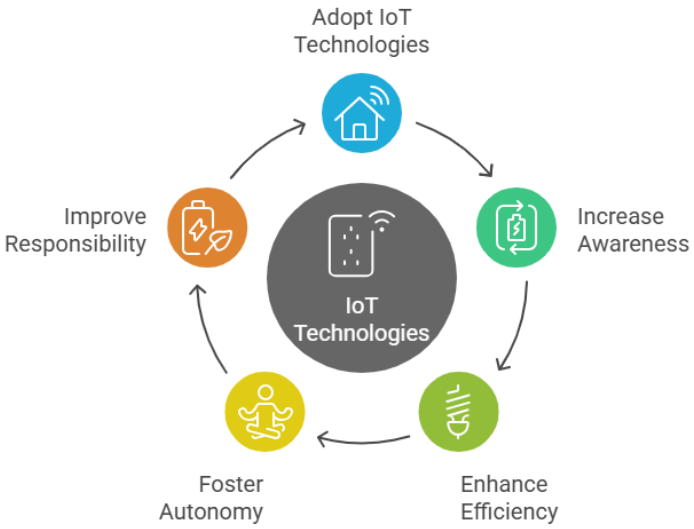
### Empowerment Through Technology

Participants described their experiences of adopting IoT technologies as a process that empowered them to take control of their energy consumption. They perceived the technology as a valuable tool for enhancing efficiency and enabling more sustainable energy use. Many reported increased awareness of their daily energy habits and a sense of autonomy in managing household resources.

"Since I started using the smart energy system, I feel like I finally understand how much energy we actually use. It gives me control and helps me make better decisions for my family." (Participant 3)

This theme highlights the transformative role of IoT technologies in shaping users' behaviors and perceptions. The participants' narratives revealed that IoT systems not only facilitated monitoring but also fostered a sense of agency, which they associated with improved environmental responsibility.

**Cycle of Empowerment through IoT**




### Data Privacy and Security Concerns

Despite recognizing the benefits of IoT systems, participants expressed deep concerns about data security and privacy. Many participants felt uneasy knowing that their energy usage patterns and household routines could potentially be accessed by third parties or misused by service providers.

"I like the convenience, but I always worry about who is watching my data. What if someone hacks into my system and knows when we are at home or not?" (Participant 5)

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This concern underscores a persistent tension between technological convenience and personal security. Participants' stories revealed an ongoing negotiation between trust and vulnerability, suggesting that greater transparency from service providers may be necessary to increase users' sense of safety.

**Emotional Ambivalence Towards Automation**

A recurring theme was the mixed emotional responses participants had toward increased automation in their homes. While many appreciated the efficiency and time-saving benefits, some expressed discomfort with delegating control to an algorithm-driven system.

"It feels strange letting the system decide when to turn on the heating or when to switch off the lights. Sometimes, I just want to make those decisions myself." (Participant 7)

This theme illustrates how automation intersects with personal autonomy and identity. Participants struggled to balance their desire for convenience with the need for human agency in household decision-making.

**Negotiating Human–Technology Relationships**

Participants frequently reflected on the evolving relationship between humans and technology. Rather than seeing IoT as a neutral tool, they perceived it as an active participant in their daily lives, shaping routines, habits, and even family dynamics.

"Sometimes, I feel like the system knows us better than we know ourselves. It learns our patterns, predicts our needs… It's like having another member in the family." (Participant 2)

This theme demonstrates how IoT adoption reshapes not only practical energy management but also participants' sense of identity and relationships within the home. For some, the technology became a collaborator, while for others, it introduced subtle feelings of dependency.

Across all themes, participants' experiences reveal the complex interplay between empowerment, security, autonomy, and technological integration. While IoT-based smart energy systems offer greater control and efficiency, they also introduce new emotional, ethical, and relational challenges. These findings contribute to a deeper understanding of users' lived experiences and highlight the subjective meanings that emerge when individuals interact with advanced technologies in domestic contexts.

## DISCUSSION

**Contribution of the Findings to the Research Question**

The findings demonstrate that the use of IoT-based energy management systems goes beyond technical adoption and involves deeper personal, emotional, and relational dimensions. The themes identified in the Results such as empowerment through technology, privacy concerns, and negotiating human–technology relationships offer new perspectives on the subjective experiences surrounding IoT adoption.

Specifically, participants described feeling empowered by gaining greater control and awareness over energy usage, yet simultaneously expressed anxieties regarding data privacy and discomfort with automation. These nuanced experiences directly address the research question by revealing that technological acceptance is not merely a rational decision, but also an emotional and contextual process shaped by personal meaning-making.

This contribution is unique because it highlights the interpretive dimension of IoT adoption, showing how individuals' subjective understandings influence their behaviors and attitudes toward technology. Unlike previous studies that focused primarily on efficiency metrics and technical usability, this research expands the discourse by providing holistic insights into users' sense-making processes and how these processes shape their interaction with emerging technologies.

**Relationship to Previous Literature and Theoretical Perspectives**

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The findings both confirm and extend existing literature on IoT adoption and user experiences. Consistent with Mukhlis et al., (2025), the results support the idea that users value IoT technologies for their practical benefits while simultaneously facing data security concerns. However, this study advances the conversation by uncovering emotional ambivalence and the redefinition of agency in human–technology interactions, dimensions that remain underexplored in prior quantitative studies.

From a theoretical standpoint, the results align with interpretative phenomenological frameworks, which emphasize understanding how individuals make sense of their lived experiences. By applying this perspective, the study highlights that IoT systems are not merely functional tools but are active participants in shaping household dynamics, decision-making processes, and perceptions of control.

Furthermore, the findings complement Mukhlis, Arifin, Ridwan, & Zulbaidah, (2025), who observed that technological adoption involves a negotiation between trust, convenience, and personal identity. By situating these experiences within a phenomenological context, the study demonstrates that meaning-making is deeply situated within social, cultural, and emotional realities, extending existing knowledge and offering richer explanatory depth.

**Implications of the Findings**

The findings of this study provide important practical and theoretical implications for understanding how individuals experience and interpret the integration of IoT-based smart energy management systems. From a social perspective, the narratives reveal that technology adoption involves more than functionality—it reshapes daily routines, household dynamics, and perceptions of personal autonomy. This suggests that successful implementation of IoT technologies requires user-centered design strategies that prioritize not only technical efficiency but also emotional engagement and trust-building mechanisms.

Culturally, the results indicate that users' experiences are shaped by their values, privacy expectations, and environmental awareness, highlighting the need for context-sensitive policies that address diverse user needs. Professionally, these insights can inform energy policymakers, developers, and service providers about the importance of aligning technological innovation with individuals' lived realities. By understanding the subjective meaning-making processes, stakeholders can design more effective interventions and support systems that enhance user satisfaction, technology acceptance, and sustainable energy practices on a broader scale.

**Limitations of the Study**

Although the study provides valuable insights, several limitations should be acknowledged to guide the interpretation and transferability of the findings. First, the research focused on a specific population of IoT users within a limited geographic and cultural context, which may restrict the applicability of the results to other settings. Second, data were collected exclusively through in-depth interviews, which rely on participants' self-reported narratives and may be subject to memory bias or social desirability effects.

Additionally, the study employed an interpretative phenomenological approach, which prioritizes depth over breadth. While this design provides rich experiential insights, it inherently limits the generalizability of the findings to larger populations. These constraints do not diminish the value of the research but rather highlight the importance of contextual interpretation when applying the results to different demographic or cultural groups.

**Directions for Future Research**

Building on these findings, future research can further explore how meaning-making processes evolve as IoT technologies continue to advance and become more deeply embedded in daily life. Expanding the scope to include diverse populations and cross-cultural contexts would enable a more comprehensive understanding of how cultural norms, values, and technological ecosystems shape user experiences.

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Moreover, integrating mixed-methods designs—combining phenomenological interviews with observational studies or behavioral data—could offer deeper insights into the interplay between perceived experiences and actual usage patterns (Mukhlis, 2025b; Mukhlis, Suradi, et al., 2023). Future studies may also investigate the role of trust, ethical considerations, and digital well-being in shaping human–technology relationships, extending beyond energy management into other domains of smart living. By deepening our understanding of these dynamics, researchers can contribute to the development of inclusive, user-centered technological frameworks that better reflect individuals' lived realities.

## CONCLUSION

This study explored individuals' lived experiences with IoT-based smart energy management systems to understand how they perceive, interpret, and make meaning of technology in managing household energy. The findings revealed four essential themes: empowerment through technology, data privacy and security concerns, emotional ambivalence toward automation, and negotiating human–technology relationships. These results extend existing knowledge by addressing the limitations of prior research, which primarily focused on technical performance and adoption rates, by providing a deeper understanding of users' subjective experiences. The study contributes to developing user-centered design strategies and policy recommendations that integrate emotional, cultural, and ethical dimensions into technological innovation. Furthermore, the findings open opportunities for future research to explore cross-cultural perspectives and the long-term impacts of IoT technologies on users' daily lives. By applying a phenomenological approach, this study offers a holistic framework for understanding the complex dynamics between individuals and emerging technologies.

## CONFLICT OF INTEREST

The authors declare that there is no conflict of interest regarding the publication of this article.

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