ADOPTION OF INTERNET OF THINGS (IOT) AND ARTIFICIAL INTELLIGENCE (AI) FOR HOME ENERGY MANAGEMENT SYSTEM (HEMS): A CASE STUDY FOR FUTURE HOMES IN IRAQ

Alsaudi Ammar Adnan Mohammed, Assoc. Prof. Dr. Dalbir Singh

Fakulti Teknologi dan Sains Maklumat, Universiti Kebangsaan Malaysia
43600 UKM Bangi, Selangor Malaysia.

ammar.adnan79@yahoo.com, p104381@siswa.ukm.edu.my, dalbir@ukm.edu.my

ABSTRACT

The new world order prioritises energy, especially in reducing emissions to protect the environment. The energy management system is the most significant approach to reducing energy consumption through the Internet of Things (IoT) with Artificial Intelligence (AI) algorithms. Energy and cost reduction are the two most important advantages of IoT and AI in Home Energy Management Systems (HEMS). The emphasis is placed on the difficulties of implementing HEMS in Iraq. To address these issues, policymakers, energy providers, and stakeholders must work together to set standards, improve infrastructure, and ensure data privacy, awareness programs, training, and standardisation. Iraq faces many significant energy challenges due to rapid population growth, which is putting pressure on the country's energy infrastructure due to poor maintenance and low investment, thus making the energy system unstable. Sabotage and damage to equipment as well as security concerns can disrupt the energy supply on top of the reliability and safety of the system. This research proposes a framework of factors affecting the adoption of IoT and AI in the home energy management system in Iraq based on studies in other countries using new factors represented by the Technology Acceptance Model (TAM), the Unified Theory of Acceptance and Use of Technology (UTAUT), and other related factors. The methodology includes reviewing the relevant literature and comparing case studies to this literature, after which a comprehensive conceptual framework is developed based on previous research. In the final stage, the framework was validated through data collection and analysis. This research contributes to developing a framework for adopting IoT and AI technologies in HEMS tailored for Iraq. The research can help researchers, energy industry operators, and policymakers improve products and meet market opportunities that would eventually reduce energy costs and enhance efficiency.

.

Keyword: Internet of Things (IoT), Artificial intelligence (AI), Home Energy Management Systems (HEMS), Technology acceptance model (TAM), Unified Theory of Acceptance and Use of Technology

I. INTRODUCTION

The Internet of Things (IoT) is the ability to connect people and things with anyone, anywhere, and through any network or service. It is a vast and dynamic worldwide network

architecture of web-enabled, Internet-capable objects that any networked device can manage (Ghasempour, 2019). Artificial intelligence (AI) is the development of computer systems that can perform human intelligence tasks like learning, inference, problem-solving, perception, and natural language understanding by using algorithms and statistical models to process and analyze large amounts of data and learn from experience (Haenlein & Kaplan, 2019).

Artificial intelligence (AI) plays a pivotal role in this setting by sifting through mountains of data and delivering valuable information to homeowners. Artificial intelligence algorithms can use past data, weather forecasts, and other factors to project future energy consumption. This allows home energy management systems (HEMS) to make real-time adjustments to energy consumption, focusing energy delivery to individual users while reducing overall energy consumption and waste (Lu et al., 2019).

The application of AI for analysing data gathered by the network of interconnected computing, sensing, and communication nodes that make up the Internet of Things aims to determine how those nodes should be configured to maximise efficiency while minimising their impact on the planet's finite resources (Popli et al. 2019).

Using the Internet of Things (IoT) and artificial intelligence (AI), nations aspiring to make a strong entry into the field of residential energy management can do so by laying the groundwork with Internet connectivity, data collection, and processing; conversely, by making the benefits of these technologies more evident in light of the protection and convenience they offer, as well as their ability to cut costs and increase efficiency, the future is open for any nation wanting to enter the field with enthusiasm. Employing the amalgamation of the Internet of Things (IoT) and artificial intelligence (AI), countries endeavouring to establish a robust presence in residential energy management can strategically pave their way. This begins with establishing full Internet connectivity, which forms the basis for seamless data collection and processing. Notably, the symbiotic potential of IoT and AI becomes more apparent as they synergize to offer multifaceted advantages, including cost reduction and enhanced efficiency. The progressive deployment of IoT-driven sensors allows real-time data collection from interconnected devices, enabling AI algorithms to analyse and predict energy consumption patterns. This predictive capability, influenced by historical data and weather forecasts, empowers home energy management systems (HEMS)

to dynamically adjust energy usage in real time. This intelligent allocation of energy not only tailors the consumption experience for individual users but also holistically contributes to reduced waste and improved energy efficiency, addressing economic and environmental concerns. As nations embrace the potential of these technologies, they open up a promising horizon for energy management marked by resource optimisation, cost savings, and ecological sustainability (Sepasgozar et al., 2020).

There are many ways in which the rapid development of technology has simplified and streamlined our daily routines. For example, cutting-edge technologies such as the IoT and AI have revolutionised our daily lives and the way we do business. There has been a rise in recent years in the usage of such technologies to better regulate domestic energy use. A home energy management system (HEMS) is an intelligent system that utilizes the Internet of Things and artificial intelligence to help homeowners save money on utility bills. Saving money on energy costs is the primary goal of (HEMS), which can be achieved through intelligent regulation of energy usage using data from various sensors, smart appliances, and weather forecasts (Rochd et al., 2021).

Concerns about environmental pollution and the depletion of natural resources have recently come to the fore, highlighting the need to combine IoT and AI to address these issues. This is especially true for home energy management, where IoT and AI can help improve efficiency and reduce waste. The trajectory of home energy management is undeniably moving toward harnessing the combined potential of IoT and AI. This convergence offers many advantages, including increased energy efficiency, cost savings, and greater sustainability. IoT facilitates real-time data collection and communication, enabling devices to gather and share information, while AI's analytical capabilities empower systems to process massive data sets and derive valuable insights from them. This partnership is transformative, enabling the optimization of energy consumption, predictive maintenance, load balancing, and even leveraging renewable energy sources like solar panels (J. Li et al., 2023).

With the massive global pollution and the need to lower operating costs, the future of home energy management is moving towards the combined usage of IoT and AI. This collaboration is particularly evident in smart home energy management systems, where IoT enabled devices such as smart thermostats and lighting controls work with AI algorithms to gather real-time consumption data and tailor energy usage to individual preferences and patterns.

This dynamic adjustment reduces energy waste and optimizes energy distribution (Sodhro et al., 2021).

In addition, smart thermostats (HEMS) can also use IoT devices like smart thermostats, plugs, and intelligent lighting to track energy consumption and advise homeowners on how to reduce costs. After learning from their actions and routines, the system can adapt the energy used to match the homeowner's habits and preferences.

IoT and AI are paving the way for homes to become more energy efficient, cost-effective and environmentally-friendly; hence, the future of HEMS is bright as they are expected to become even more sophisticated and individualized as technology develops

LITERATURE REVIEW

Based on the literature sources, the following is a critical analysis of the adoption of the IoT and AI for HEMS. IoT and AI adoption for residential energy management systems has the potential to lower energy costs, boost energy efficiency, and enable better control of energy use (Al-Fuqaha et al., 2015). IoT and AI for HEMS must successfully navigate several hurdles, such as data privacy, security, interoperability, and user acceptance. The development of an open standard platform for IoT and HEMS that supports AI, which can promote interoperability and innovation, is one possible answer to these problems (Weixian, 2019).

In order to ensure that users are prepared to adopt and use the technology, it is crucial to combine energy efficiency with user convenience and comfort when using IoT and AI for HEMS. By enabling better administration and optimisation of energy consumption, the use of IoT and AI for residential energy management systems has the potential to facilitate the switch to renewable energy sources (Kim, 2016). Lack of interoperability across systems and equipment from various manufacturers could be a barrier to the adoption of IoT and AI for HEMS, thus limiting the technology's utility and efficacy (Al-Fuqaha et al., 2015).

Another major problem in implementing IoT and AI for HEMS is guaranteeing that customers can control their data and maintain privacy (Tawalbeh et al., 2020). The creation of privacy-preserving algorithms and protocols, which enable secure and private data sharing while maintaining the efficacy of technology, is one potential answer to this problem. It is crucial to consider how the IoT and AI-based household energy management systems may affect the environment and the larger energy system, including concerns about peak demand and greenhouse gas emissions (Saha, 2019b).The

adoption of IoT and AI for residential energy management systems (HEMS) presents both opportunities and challenges. On the positive side, this adoption has the potential to reduce energy costs, improve energy efficiency, and provide better control over energy usage. However, critical issues must be addressed. These include data privacy, security, interoperability, and user acceptance. Establishing an open standard platform that integrates IoT and HEMS with AI can facilitate interoperability and innovation. Combining energy efficiency with user convenience and comfort is crucial for successful adoption, with potential benefits such as optimizing energy consumption and promoting the transition to renewable energy sources. However, barriers such as lack of interoperability across systems and equipment from different manufacturers and the need to ensure user data control and privacy remain significant challenges. Furthermore, the environmental impact of IoT and AI-based energy management systems on the broader energy system and concerns related to peak demand and greenhouse gas emissions should be considered. In conclusion, while the adoption of IoT and AI for HEMS holds promise, addressing issues related to privacy, security, interoperability, and environmental impact is essential for achieving its full potential and benefits.

II. RESEARCH QUESTIONS AND RESEARCH QUESTIONS

In this study, the fundamental research question focuses on factors that play a vital role in the adoption of IoT and AI for HEMS in Iraq. The following are the specific research questions:

1. RQ1: What are the factors related to IoT and AI which determine the adoption of HEMS in Iraq?

2. RQ2: How to formulate an adoption framework for IoT and AI for HEMS in Iraq?

3. RQ3: What is the extent of the proposed usage of IoT and AI for HEMS in Iraq?

This research aims to demonstrate the adoption of IoT and AI for HEMS by answering the research questions mentioned in the previous section. Accordingly, and based on the research questions, this research tries to achieve the following objectives:

1. RO1: To investigate the factors related to IoT and AI to determine the adoption of HEMS in Iraq.

2. RO2: To formulate an adoption framework for IoT and AI for HEMS in Iraq.
3. RO3: To validate the adoption framework for IoT and AI for HEMS in Iraq.

III. METHODS: PARTICIPANTS AND DATA COLLECTION

A.METHODS

The Research Design outlines a comprehensive research design with four phases. The primary focus in phase one is an in-depth literature review on IoT and AI adoption for HEMS. Phase two involves a critical review of TAM and related frameworks, emphasizing challenges and opportunities. Phase three introduces a detailed conceptual framework combining TAM, UTAUT, and other models. Phase four validates the framework through a case study in Iraq and expert evaluations.

Phase One: Literature Review: This phase explores factors influencing IoT and AI adoption in HEMS. A systematic literature review involving 31 selected studies from various databases sheds light on key elements such as technology readiness, management support, and security concerns.

Phase Two: Critical Review: A critical review focuses on TAM and comparable frameworks, analyzing challenges and opportunities in adopting IoT and AI in HEMS in Iraq. It identifies crucial factors like data privacy, security, and interoperability, providing insights and potential solutions.

Phase Three: Framework Formulation: A conceptual framework is developed, integrating TAM, UTAUT, and additional factors specific to IoT and AI in HEMS. This comprehensive model includes perceived utility, ease of use, social impact, enabling conditions, effort, performance expectancy, hedonic motivation, price value, and habit.

Phase Four: Model Evaluation: The suggested conceptual model undergoes validation through a case study in Iraq and expert evaluations. The study involves a diverse group of users from different regions, ensuring a representative sample. Expert reviews from three specialists in HEMS further validate the proposed framework.

Summary: The chapter concludes by summarizing the key components of the suggested framework. It emphasizes the proximity of factors to users and experts, drawn from previous research on IoT and AI

in smart living settings. The study distinguishes itself by integrating IoT and AI in HEMS and conducting a case study in Iraq, providing unique insights from both user and specialist perspectives.

In essence, this research meticulously outlines the methodological approach, ensuring a thorough investigation into the adoption of IoT and AI for HEMS, particularly in the context of Iraq.

B.DATA COLLECATION

The data collection process was carried out by the participants, who were 10 individuals and three experts, and a random group was selected from several regions to ensure diversity of opinions. Since the use of the Internet of Things is new in terms of using devices, the selected category usually has different experiences in using the Internet, in addition to experts who have experience in the energy production sector or in using the Internet of Things, as shown in Table (4.1).

Table **Error! No text of specified style in document.**.1 Individuals information

No	Age	Gender	Location	Education	Work	Internet experience	Year of experience
1	27	M	Maysan	MSc.	Data Analysis	2	1
2	45	F	Baghdad	B.A.	Training Dept.	1	15
3	24	M	Baghdad	B.A.	Communication Dept.	3	2
4	33	M	Basra	B.A.	Tutor	3	7
5	40	M	Baghdad	MSc.	Power station Dept.	4	15
6	35	M	Babylon	MSc.	Accountant	4	12
7	31	F	Wasit	B.A.	Web Design	3	8
8	33	M	Diyala	B.A.	Programmer	4	12
9	42	F	NaJaf	B.A.	Manufacture Dept.	2	12
10	43	M	Baghdad	B.A.	Network & IT Manager	5	14

The decision to include 10 individuals and 3 experts in the study was guided by several considerations aimed at providing a comprehensive and diverse perspective on integrating the Internet of Things (IoT) within the energy sector. This approach was taken for several reasons. Firstly, this sample size strikes a balance between gathering a substantial range of ideas and opinions while acknowledging that statistical generalization might not be attainable. Instead, the focus is on acquiring

qualitative insights into the topic. Secondly, the inclusion of both individuals and experts ensures a diverse array of viewpoints. A wide spectrum of insights is secured by encompassing individuals with varying familiarity with IoT devices and experts immersed in energy production and IoT domains (Questionnaire Design | Methods,Aaron Moss, 2019)

The expertise brought in by these industry specialists allows for valuable insights and well-informed viewpoints on the challenges and opportunities entailed in IoT implementation in energy management. Participants were purposefully selected from different regions and backgrounds to enhance experimental diversity, ensuring a rich amalgamation of experiences and perspectives. (Questionnaire Design | Methods, Question Types & Examples, n.d.), This approach contributes to the depth of the collected data. Moreover, this mix of individuals and experts fosters a holistic understanding of the merits and challenges of IoT adoption. While individual perspectives reflect general sentiment and user experiences, expert insights delve into the technical and industry-specific dimensions. The selection methodology is based on random sampling to ensure impartiality and avoid bias. Additionally, purposeful sampling was employed for experts specialized in energy and related fields, further enhancing the study's depth and validity.(Focus Group: What It Is & How to Conduct It + Examples, n.d.).

Thus, the selection of 10 individuals and 3 experts in the study aims to capture a variety of opinions and insights about the use of the Internet of Things in the energy sector. Various sampling methods can be used to comprehensively represent the points of view.

IV. RESULTS & DISCUSSION

The questionnaire developed by (Holt et al. 2007) was used for gathering the required data. The table below listed the factors and the items used in this study.

1. The factor of Perceived Usefulness derived several answers from different people regarding how IoT and AI can improve energy efficiency and save money on energy bills for home energy management systems (HEMS).

Increased understanding and informed decision making

Multiple individuals discussed how IoT and AI could help homeowners understand their energy usage better, enabling them to make informed decisions on saving energy. This would be

possible by using smart devices to track energy usage, generate reports, and highlight areas for improvement.

Cost of Installation and Maintenance

One individual expressed concern about the cost of installing and maintaining IoT and AI-based systems in homes, suggesting that it may not be affordable for everyone. He noted that the initial investment may be too high, and that the maintenance costs may also be significant in the long run.

Assistance for Those Struggling with Energy Use

Seven respondents suggested that IoT and AI could be helpful for people who struggle to manage their energy use and bills. By providing real-time data and alerts, these systems could assist individuals in adjusting their energy usage habits, thereby helping them save money.

Uncertainty about Functionality

One of the responses admitted that they were not entirely sure how IoT and AI-based systems would work for HEMS, but if it helps save money on energy bills, they were open to the idea.

2. The factor of Perceived Ease of Use in adopting IoT and AI for home energy management systems (HEMS) drew in several answers and conclusions based on emerging topics.

Based on the above answers, several themes emerged. Firstly, the system's complexity is a key factor in determining how easy it would be to set up and use without technical assistance. If the system is user-friendly with clear and concise instructions, it should be easy to set up and use without technical assistance. Secondly, age and experience with technology also play a role in determining ease of use. Third, the availability of technical assistance is important for those who may struggle with setting up and using the system independently. Fourth, perceived ease of use is crucial in adopting IoT and AI for HEMS. Lastly, a user-cantered design approach can help ensure that the IoT and AI system is easy to set up and use without technical assistance.

3. The factor of Performance Expectancy in adopting IoT and AI for HEMS indicates that people generally have a positive expectation of reduced energy consumption, but are unsure about the specific impact of IoT and AI on HEMS energy efficiency.

Out of the 10 responses from citizens, three respondents expressed positive expectations of reduced energy consumption. For example, respondent 1 stated that IoT and AI could reduce energy consumption by at least 20%. Respondent 3 suggested that if the system is easy to use and understand, it could significantly reduce energy usage. The remaining respondents were uncertain or sceptical about the impact of IoT and AI on energy consumption.

However, the given answers provided limited insights into the impact of the performance expectancy factor on adopting IoT and AI for HEMS. Therefore, further research and analysis are required to examine this relationship.

4. The factor of Effort Expectancy in adopting IoT and AI for HEMS revealed the following information.

Many of the answers suggested that setting up IoT and AI for HEMS would require time and effort. However, they also agreed that the benefits, such as reducing energy consumption and costs, would be worth it in the long run. Additionally, it was emphasized that companies must make internal processes more equitable and fairer to build up their talent and attract a wider range of future hires. Inclusivity occurs when these values are implemented to help ensure that a diverse workforce feels safe, valued, and welcomed.

One of the experts defined Effort Expectancy as the level of ease or difficulty that users perceive in learning and using new technology. The expert added that for a technology to be adopted, it should be easy to learn and use, with clear benefits and low costs. Thus, it is essential to develop user-friendly systems that are easily integrated into the user’s routines.

Another expert discussed the importance of cultural awareness or global/intercultural fluency, which involves understanding the differences between oneself and people from other backgrounds, especially in attitudes and values. It was identified as one of the seven competencies crucial to success in a global workforce. This competency is essential when developing IoT and AI for HEMS that can be used worldwide.

The remaining answers were more specific with respect to the time and effort required to set up IoT and AI for HEMS. One solution advised to prepare for tough questions and anticipate possible ones to ensure effective and constructive responses. Another answer provided situational interview questions and sample responses that could be used to craft effective responses.

A third answer listed different types of questions, such as closed questions, and provided examples. A fourth answer discussed the STAR format, which stands for Situation, Task, Action, and Result, as a framework for answering questions about cultural sensitivity and adapting to differences between oneself and others. A fifth answer lists powerful questions that could be used in various situations. A final solution discussed how to respond to the interview question "What would you do differently?" and advised connecting the case to a positive lesson to demonstrate solutions-focused thinking.

5. The factor of Social Influence in adopting IoT and AI for HEMS entails the usage of thematic analysis to draw a conclusion.

Based on the answers provided by respondents 1-4, the likelihood of being influenced by friends and family members to use IoT and AI for HEMS depends on the benefits of the technology. Specifically, it would be more appealing if the technology could help save energy costs. However, some individuals may not be easily swayed by their friends and family's opinions and may prefer to conduct their research to determine if the technology is right for them.

Expert opinions could provide more information on the social influence factor. Unfortunately, we do not have specific answers from experts. Therefore, we cannot apply thematic analysis on them.

6. The factor of Facilitating Conditions entails the usage of a thematic analysis approach.

Out of the responses of 10 individuals, seven said that technical support could help them get started and ensure that the system runs smoothly. Two individuals preferred to figure things out independently and did not want to rely on technical support. One individual said it depends on how complicated the system is and how much support is available.

We can identify two primary themes from the responses: the importance of technical support and individual preferences. Most respondents value technical support as an important factor in adopting this technology, as it can help them overcome potential obstacles and ensure the system runs smoothly. However, some respondents prefer to figure things out independently without relying on technical support.

Next is an examination of the expert opinions. One expert emphasized the importance of support groups for emotional and moral support for individuals with common experiences and concerns. Another expert discussed the importance of cultural awareness in working with people of

different backgrounds. The third expert provided an overview of the different types of power that influence group dynamics, including reward, coercion, and legitimate authority.

From the expert opinions, we can identify three primary themes: the importance of support groups, cultural awareness, and power dynamics. The first expert highlighted the importance of support groups in providing emotional and moral support to individuals. The second expert discussed the importance of cultural awareness in working with individuals of different backgrounds, which could be relevant in the implementation of IoT and AI in HEMS. The third expert provided insight into power dynamics, which could be relevant in facilitating the adoption and implementation of this technology.

7. For the factor of Price Value, based on the responses from the respondents and experts, there is uncertainty regarding how much money could be saved from using IoT and AI for HEMS. Although some believed that it could save a lot of money in the long run if used properly, others were more cautious and suggested that it depends on the initial investment needed to set up the system. The experts suggested that estimating potential savings without more information about the specific system is difficult. However, they also noted that IoT and AI can help optimise energy usage and reduce waste, which could lead to significant cost savings over time.

After analyzing the responses, the following themes emerged:

Initial investment: Several respondents noted that the potential savings would depend on the initial investment to set up the IoT and AI systems. This suggests that a cost-benefit analysis would be necessary to determine whether the potential savings outweigh the initial costs.

Long-term savings: Some respondents believed that IoT and AI could save many dollars in the long run if used properly. This suggests that the potential benefits of IoT and AI for HEMS may be more evident over a longer period.

Uncertainty: The respondents were uncertain about how much money could be saved using IoT and AI for HEMS. This suggests that more research is needed to determine the potential cost savings.

Optimisation: The experts suggested that IoT and AI can help optimise energy usage and reduce waste, which could lead to significant cost savings over time. This indicates that the benefits of IoT and AI for HEMS go beyond direct cost savings and may include other environmental and social benefits.

8. For the Artificial Intelligence Trust factor, several themes emerged from the responses:

Efficiency: One of the primary benefits of using artificial intelligence devices and IoT in home energy management systems is the ability to optimise energy usage and reduce waste. This indicates that there is confidence in using these technologies to manage energy consumption in homes.

Lack of familiarity: Another emerging theme is the lack of familiarity with AI and IoT devices. One of the answers suggested that even when the individual is unfamiliar with these technologies, he believes that they can be useful in managing energy consumption in homes. This indicates the need for more education and awareness of these technologies.

Trust: A critical factor that impacts the adoption of AI devices and IoT in home energy management systems is trust. One response highlighted the importance of trustworthy AI systems which are not brittle and can handle noise or imperfections in the data they collect. Reliable systems are essential for ensuring that users have confidence in the technology and its ability to manage energy consumption in the home.

Expectations: Another response suggested that individuals have high expectations of AI devices and IoT, with 60% expecting them to profoundly change their daily lives in the coming years. This suggests that there is a high degree of interest and potential for the adoption of these technologies in home energy management systems.

Given that the majority of elements have been successful by 50% or more, it can be said that the current framework is the ultimate framework. None of the factors can be dismissed as they are all advantageous and already chosen by earlier studies. In the future, expanding the survey area might produce different findings. Figure 4.1 presents the final framework.

4.3.1 The Experts Finding

Based on the information provided in the paragraphs, here are the expert findings extracted from each section:

1- Perceived Usefulness: The experts' findings suggest that IoT and AI have the potential to improve energy efficiency and save money for home energy management systems (HEMS). Individuals highlighted benefits such as increased understanding and informed decision-making

through real-time tracking and reports on energy usage. However, concerns were raised about the cost of installation and maintenance, as well as uncertainties about the functionality of IoT and AI-based systems for HEMS.

2- Perceived Ease of Use: The experts' findings indicate that ease of use is crucial in adopting IoT and AI for HEMS. A user-friendly system with clear instructions is important for independent setup and usage. Age, experience with technology, availability of technical assistance, and a user-centered design approach also play roles in determining ease of use.

3- Performance Expectancy: The experts' findings reveal mixed expectations regarding the impact of IoT and AI on energy consumption for HEMS. Some respondents expressed positive expectations of reduced energy consumption, while others were uncertain or skeptical. The need for further research and analysis to understand the relationship between performance expectancy and IoT/AI adoption was highlighted.

4- Effort Expectancy: The experts' findings emphasize that user perception of the ease or difficulty of learning and using new technology is crucial for adoption. Technical support, individual preferences, and cultural awareness play roles in shaping effort expectancy. User-friendly systems and addressing cultural differences are important for successful adoption.

5- Social Influence: The experts' findings suggest that social influence, particularly from friends and family, can impact the adoption of IoT and AI for HEMS. The appeal of these technologies is higher if they offer energy cost savings. However, some individuals may prefer to conduct their research before adopting new technologies.

6- Facilitating Conditions: The experts' findings highlight the importance of technical support and individual preferences in facilitating the adoption of IoT and AI for HEMS. Additionally, support groups, cultural awareness, and understanding power dynamics are identified as key themes in this context.

7- Price Value: The experts' findings indicate uncertainty about the potential cost savings of using IoT and AI for HEMS. Factors such as initial investment, long-term savings, and optimization of energy usage contribute to the complexity of estimating cost benefits. IoT and AI are expected to optimize energy usage and reduce waste over time.

8- Artificial Intelligence Trust: The experts' findings emphasize the benefits of using AI in home energy management, including optimizing energy usage and reducing waste. Lack of

familiarity and trust are identified as factors influencing adoption. Trustworthy AI systems are crucial for user confidence, and there are high expectations for AI's transformative impact on daily lives.

4.3.2 The Finding based on each Hypothesis

Based on the hypotheses you've presented and the findings derived from the responses and expert opinions, let's analyze how each hypothesis aligns with the results:

Hypothesis 1 - Perceived Usefulness positively impacts the intention to adopt IoT and AI for home energy management systems: The findings show that respondents recognized the potential benefits of IoT and AI in improving energy efficiency and reducing costs. The increased understanding and informed decision-making stemming from IoT and AI's ability to track energy usage and generate reports were noted. This aligns with the hypothesis, suggesting that when individuals perceive a technology as useful for achieving specific goals (such as saving energy and money), their intention to adopt it increases.

Hypothesis 2 - Perceived Ease of Use positively impacts the intention to adopt IoT and AI for home energy management systems: The responses suggest that the perceived ease of use is a crucial factor in adopting IoT and AI for home energy management systems. User-friendly interfaces, clear instructions, and technical support are mentioned as factors that can enhance ease of use. This corresponds to the hypothesis, indicating that when individuals find a technology easy to use, their intention to adopt it is more likely.

Hypothesis 3 - Performance Expectancy positively impacts the intention to adopt IoT and AI for home energy management systems: The findings indicate mixed expectations regarding the impact of IoT and AI on energy consumption. Some respondents expressed positive expectations, while others remained uncertain or skeptical about the technology's effectiveness. This provides partial support for the hypothesis, suggesting that when individuals believe adopting IoT and AI will lead to improved performance (energy efficiency), their intention to adopt it is positively affected.

Hypothesis 4 - Effort Expectancy positively impacts the intention to adopt IoT and AI for home energy management systems: The responses highlight that while setting up IoT and AI for home energy management systems might require effort, the potential benefits, such as reduced energy consumption and costs, make the effort worthwhile. This aligns with the hypothesis, indicating that when individuals perceive the effort required as manageable and worth the benefits, their intention to adopt the technology is likely to be higher.

Hypothesis 5 - Social Influence positively impacts the intention to adopt IoT and AI for home energy management systems: The findings suggest that social influence plays a role, but it's not a dominant factor. Respondents considered the opinions of friends and family, but the decision ultimately depended on their personal assessment of the technology's benefits. This partially supports the hypothesis, indicating that social influence can impact intention to adopt, but it might not be the primary driver.

Hypothesis 6 - Facilitating Conditions positively impact the intention to adopt IoT and AI for home energy management systems: The responses emphasize the importance of technical support and external factors for the adoption of IoT and AI. The majority of respondents value technical assistance, aligning with the hypothesis that facilitating conditions, such as technical support and compatibility, positively impact intention to adopt.

Hypothesis 7 - The value of the Price positively impacts the intention to adopt IoT and AI for home energy management systems: The findings suggest uncertainty regarding potential cost savings. While some respondents believed in significant long-term savings, others were cautious about the initial investment. This aligns with the hypothesis, as perceived value in terms of cost savings can influence the intention to adopt.

Hypothesis 8 - Trust in artificial intelligence positively impacts the intention to adopt IoT and AI for home energy management systems: The responses highlight the importance of trust in AI systems and their ability to optimize energy usage. This supports the hypothesis, indicating that when individuals trust the reliability and functionality of AI, their intention to adopt IoT and AI increases.

Hypothesis 9 - Behavioral Intent and User Behavior are positively influenced by behavioral intentions: While the specific results related to behavioral intentions and user behavior aren't explicitly discussed in the provided findings, the earlier analysis of the other hypotheses indirectly suggests that when individuals perceive a technology as useful, easy to use, offering performance improvements, and supported by facilitating conditions, their behavioral intentions to adopt and use the technology are likely to be positively influenced.

In summary, the findings generally support the hypotheses, suggesting that factors like perceived usefulness, ease of use, performance expectancy, effort expectancy, social influence, facilitating conditions, price value, and trust in artificial intelligence all contribute to shaping the intention to adopt IoT and AI for home energy management systems. However, it's important to note that the impact of each factor might vary among individuals and contexts, and some factors might have a stronger influence than others based on the specific circumstances of the adopters.

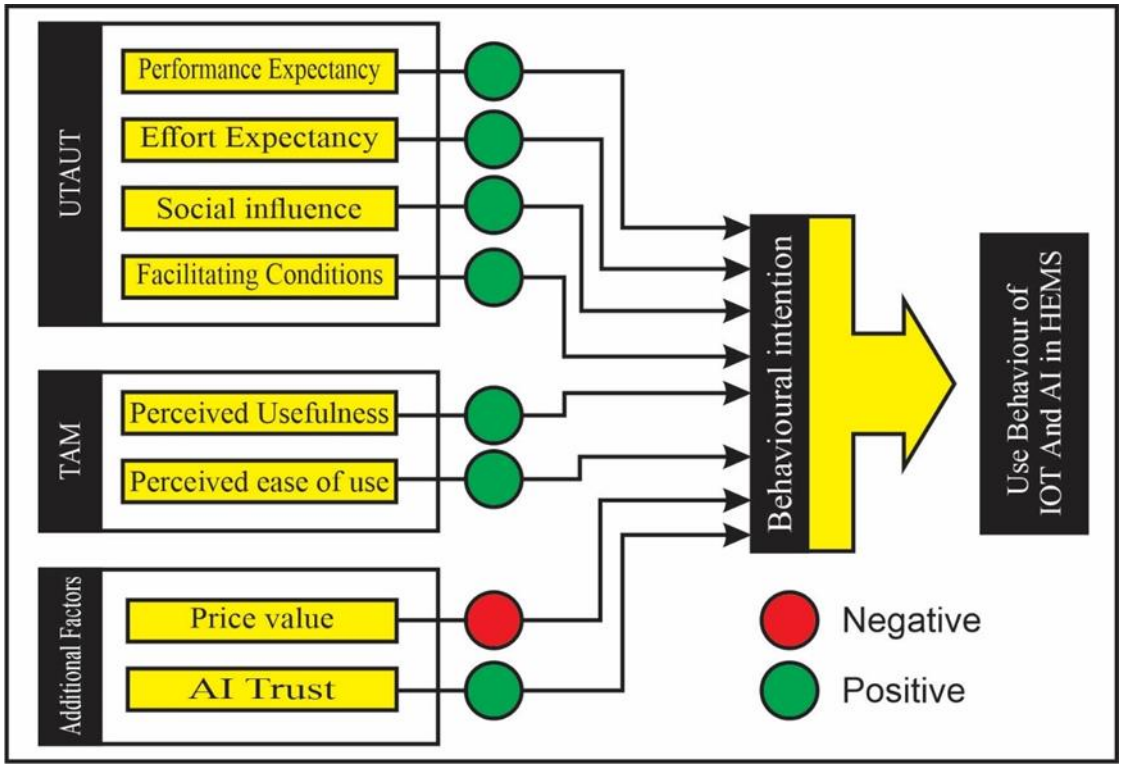

Figure 4.1 Final Framework

V. CONCLUSION

The emerging field of Home Energy Management Systems (HEMS) in Iraq leverages IoT and AI technologies to efficiently manage energy resources. A literature review was conducted to analyze factors influencing HEMS adoption, resulting in a framework encompassing technology infrastructure, user acceptance, policy and regulation, data privacy and security, and stakeholder collaboration, customized to the Iraqi context. Beneficiary and expert participation enriched the framework, enhancing its validity. This study aids researchers in understanding how these factors affect IoT and AI adoption in Iraqi HEMS, potentially impacting energy management systems globally. It offers valuable insights for industries, fostering technology adoption and sustainability, and informs government policies to promote IoT and AI integration in HEMS for energy efficiency, sustainability, and economic growth. Future work aims to implement IoT and AI in domestic energy management systems in Iraq, assess their feasibility and impact, and provide recommendations for

further enhancement, contributing to the broader understanding and implementation of these technologies in Iraqi HEMS.

ACKNOWLEDGEMENT

First I would like to express my high appreciation to my supervisor, Assoc. Prof. Dr. Dalbir Singh, his supervision, I could not have produced the thesis in this way without his guidance.

Secondly, A word of thanks is given to all my Faculty of Information Science and Technology, Universiti Kebangsaan Malaysia professors, with whom I took courses. Thank you for helping me to gain knowledge.

REFERENCE

Ghasempour, A. 2019. Internet of things in smart grid: Architecture, applications, services, key technologies, and challenges. MDPI Multidisciplinary Digital Publishing Institute.

Haenlein, M. & Kaplan, A. 2019. A brief history of artificial intelligence: On the past, present, and future of artificial intelligence. *California Management Review* 61(4): 5–14.

Holt, D.T., Armenakis, A.A., Feild, H.S. & Harris, S.G. 2007. Readiness for Organizational Change: The Systematic Development of a Scale. *The Journal of Applied Behavioral Science* 43(2): 232–255.

Li, J., Herdem, M.S., Nathwani, J. & Wen, J.Z. 2023. Methods and applications for Artificial Intelligence, Big Data, Internet of Things, and Blockchain in smart energy management. Elsevier B.V.

Lu, R., Hong, S.H. & Yu, M. 2019. Demand Response for Home Energy Management Using Reinforcement Learning and Artificial Neural Network. *IEEE Transactions on Smart Grid* 10(6): 6629–6639.

Popli, S., Jha, R.K. & Jain, S. 2019. A Survey on Energy Efficient Narrowband Internet of Things (NBIoT): Architecture, Application and Challenges. Institute of Electrical and Electronics Engineers Inc.

Rochd, A., Benazzouz, A., Ait Abdelmoula, I., Raihani, A., Ghennioui, A., Naimi, Z. & Ikken, B. 2021. Design and implementation of an AI-based & IoT-enabled Home Energy Management System: A case study in Benguerir — Morocco. *Energy Reports* 7: 699–719.

Sepasgozar, S., Karimi, R., Farahzadi, L., Moezzi, F., Shirowzhan, S., Ebrahimzadeh, S.M., Hui, F. & Aye, L. 2020. A systematic content review of artificial intelligence and the internet of things applications in smart home. *Applied Sciences (Switzerland)* 10(9).

Sodhro, A.H., Gurtov, A., Zahid, N., Pirbhulal, S., Wang, L., Rahman, M.M.U., Imran, M.A. & Abbasi, Q.H. 2021. Toward Convergence of AI and IoT for Energy-Efficient Communication in Smart Homes. *IEEE Internet of Things Journal* 8(12): 9664–9671.