An-Najah National University

Faculty of Graduate Studies

THE SMART ENERGY CONSUMPTION MANAGEMENT IN BUILDINGS

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Dedication

I am infinitely grateful and extend my heartfelt thanks to all those who wished me success and provided their unwavering support.

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Declaration

I, the undersigned, declare that I submitted the thesis entitled:

THE SMART ENERGY CONSUMPTION MANAGEMENT IN BUILDINGS

I declare that the work provided in this thesis, unless otherwise referenced, is the researcher's own work, and has not been submitted elsewhere for any other degree or qualification.

Student's Name: Baraa Hakawati

Signature:

Date: 10-10-2023

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Abstract

Smart energy consumption management, a novel technology that increases energy efficiency and lowers energy use in buildings, operates on IoT principles. The purpose of this study is to comprehend how household awareness of smart energy consumption management affects smart energy consumption management and its effects on user behavior, expenses, and environmental impact. A survey with 100 valid replies was used in the research model to assess the knowledge and consumption habits of building tenants in Palestine. However, Partial Least Squares-Structural Equation Modeling (PLS-SEM) and Smart-PLS software were used to assess the research model. The study results clearly indicate that installing intelligent energy consumption management systems in residential buildings can lead to significant improvements in energy efficiency. Implementing these advanced energy management systems holds great promise for enhancing sustainability, particularly by reducing environmental impact. The critical revelation from this research is the necessity for initiatives focused on enhancing residents' familiarity with these systems. Education and awareness campaigns are essential to encourage energy conservation and the responsible use of energy-efficient equipment. In conclusion, this study underscores the transformative potential of smart energy consumption management in contributing to a more sustainable and energy-efficient future for residential buildings, but it emphasizes that knowledge dissemination and awareness-raising efforts are integral to realizing these benefits.

Keyword: Environmental Impact; Smart Energy Consumption Management; User Behavior.

Chapter One
Introduction and Literature Review

1.1 Chapter Overview

This chapter provides an overview of the topic of the study and the underlying theory. The elements that are divided under this part include the overall context, problem statement, research questions, significance of the study, research goals, research hypotheses, and dissertation structure. A survey of the literature on the subject of the thesis is also provided in this chapter. This aims to provide a comprehensive understanding of energy efficiency and cost concepts with reference to smart energy consumption management and environmental impact. The chapter also tries to determine the inhabitants' awareness of smart energy consumption management in buildings and their patterns of energy consumption inside the building. It also examines the links between these variables and how they are evaluated in the context of the housing market in the West Bank. The proposed hypotheses were developed in order to investigate and confirm the projected correlations between the study variables based on the most recent research on these topics.

1.2 General Background

The acceleration of countries' industrial, economic and population growth is considered the most critical factors in increasing energy consumption. There should be more efforts to generate energy to comply with this growth. Consequently, we need to search for alternative sources of energy. Unfortunately, in addition to the high costs it causes, excessive power generation is also a negative factor in air quality. It is also possible, in many cases, that environmental and political problems may arise due to resource depletion, global warming, and acid rain Juaidi et al., (2016). In accordance with the elucidation provided earlier, it is reasonable to assert that we need to manage energy consumption more rationally, using modern methods that do not waste energy and make better use of it.

Nowadays, smart techniques and technologies are enhanced to be adopted in our daily life. One of these technologies is the Internet of Things (IoT), sometimes called the internet of everything or the industrial internet. IoT is an emerging technology paradigm that can be considered a global network of machines and devices that can interact through the internet Lee & Lee, (2020). As for Shrouf & Miragliotta, (2015), the paper suggested an interesting research methodology as it designed a public opinion survey that includes the technologies and benefits that the IoT offers in the factory sector.

In this study, the Palestine market is considered to be the target for us, especially in West Bank, with no smart electric meters such as those covered in Shrouf & Miragliotta, (2015) According to the statistics provided by the Palestinian Energy Authority (PEA) in West Bank, the energy consumption in the construction and buildings sector adds up to about 60 % of the total consumption of energy, which is much larger percentage than that of the industrial sector (no more than 7%).

Accordingly, our study aims to examine the readiness of the residential buildings sector of the West Bank to adopt smart energy consumption management systems in buildings to manage energy consumption and how can smart energy consumption management be effectively applied in residential buildings to reduce energy waste and improve energy efficiency, taking into account factors such as residents' behavior and knowledge of smart energy consumption management by collecting a number of residents' opinions to study their general knowledge of the smart systems used in buildings to verify that there is sufficient residential awareness of these systems, which may help reduce environmental damage and reduce rising costs in energy consumption.

1.2.1 Problem Statement

The main problem that this study aimed to solve is the need for smart energy consumption control in residential sector in order to increase energy efficiency and decrease waste. The study identifies several facets of smart energy consumption management, taking into account energy use, using energy-efficient equipment, automating energy management, and changing resident behavior. The study also emphasizes the importance of educating residents about smart energy consumption management and its potential benefits for reducing energy consumption, costs, and environmental impact. Therefore, the research problem can be summarized as follows: How can the adoption of smart energy consumption management systems in residential buildings be promoted to increase energy efficiency, reduce energy waste, save costs, and contribute to environmental sustainability, particularly in the context of the West Bank?

1.2.2 Research Questions

First Question: How can education and awareness efforts be effectively implemented to promote the adoption of smart energy consumption management systems in residential buildings, particularly in the West Bank, and what impact does this have on residents' energy-saving behaviors and environmental sustainability?

Second Question: What are the key factors influencing the successful implementation of smart energy consumption management systems in residential sector, and how can these systems be optimized to achieve reduced energy consumption and cost savings?

Third Question: To what extent do smart energy consumption management systems contribute to increased energy efficiency, reduced energy waste, and improved sustainability in the residential sector, and what are the specific benefits and challenges associated with the adoption of these systems, especially in the context of the West Bank?

The findings of this research will provide policymakers and stakeholders with valuable insights into developing effective strategies to enhance energy efficiency and reduce the environmental impact of energy consumption in the residential sector in Palestine.

Furthermore, through this research, it is possible to come up with many results, the most important of which is knowing the extent to which the resident's knowledge of smart energy consumption management systems inside homes and their general behavior inside it affects the smart energy consumption management costs and the environment as well. Moreover, studying the growth and spread of homes that use smart energy consumption management systems in the region over the past years. In addition to knowing the most used technology in the construction sector in the Palestinian market at West Bank. In conclusion, concern with this point of view alone, in isolation from the other dimensions of this topic, is wrong and will lead to completely inaccurate results.

1.2.3 The Significant of The Study

The study of smart energy consumption management in buildings in the Palestinian residential sector is significant for several reasons. Firstly, it promotes environmental sustainability by reducing greenhouse gas emissions and energy consumption, contributing to a more sustainable future. Secondly, implementing smart energy consumption management systems can lead to economic benefits, such as cost savings for residents and building owners through reduced energy consumption and lower utility bills. Thirdly, the study can have a positive social impact by providing residents with a comfortable and sustainable living environment. Fourthly, through developing and implementing smart energy consumption management technologies and systems in the Palestinian residential sector, the study can help progress green technology. Finally, the study can provide insights and recommendations for policymakers and government officials, potentially leading to the development of more effective and sustainable energy policies.

1.2.4 Research Objectives

Research goals are mentioned below based on the importance of the study:

- The study aims to explore and demonstrate the advantages of smart energy consumption management systems, particularly in residential buildings. It focuses on the potential benefits, such as reduced energy use, cost savings, and improved sustainability.
- The study seeks to examine the impact of education and awareness efforts on residents' knowledge and behavior regarding smart energy consumption management. It aims to understand how knowledge dissemination can lead to more responsible energy use.
- The study aims to identify and analyze the key factors influencing the successful implementation of smart energy management systems, including IoT technology, energy-efficient equipment, and resident behavior. It intends to explore the challenges and opportunities associated with these factors.
- The study is conducted with a specific focus on the West Bank, and one of its objectives is to assess the feasibility and relevance of smart energy consumption management systems in this particular context. It aims to determine the potential for these systems to be adopted and effective in the region.
- To provide building owners and decision-makers suggestions and guidance on how to support the adoption of intelligent energy consumption management systems in the Palestinian residential sector, which might ultimately lead to the development of more effective and sustainable energy policies.

These objectives collectively aim to contribute to the understanding of how smart energy consumption management systems can be beneficial, and the factors that influence their adoption and effectiveness, with a specific emphasis on the West Bank.

1.2.5 The Structure of The Thesis

The thesis is divided into four chapters, each of which examines a distinct aspect of the research. The introduction and background of the study, a description of the research problem, a list of research questions, a summary of the research's objectives, a discussion of the theoretical foundations, and a review of the pertinent literature on smart energy consumption management in buildings are all included in the first chapter. The chapter offers both the developed hypotheses and a conceptual framework for the inquiry.

The research methodology is summarized in Chapter and includes the types and methodologies of study taken into consideration, data collecting and sampling strategies, as well as methods for measurement development and data analysis.

The third chapter focuses on data analysis, including descriptive statistics and evaluation of the proposed model. The study hypotheses are tested and the results are categorized in the chapter sections.

The fourth chapter is dedicated to discussing the obtained results and their implications. This section also includes the conclusion, recommendations, limitations, and future research directions.

1.3 Theoretical Background

The buildings sector ranks as one of the world’s primary sources of energy consumption. Just to mentioned, Mataloto et al., (2019) emphasize that buildings consume electricity as the primary energy source to provide thermal comfort (cooling and heating systems), lighting systems, communication systems, entertainment etc. to their residents. The research of Zhao & Magoulès, (2012) pointed to the factors that give rise to energy consumption and performance in buildings by noting that there are many influencing factors such as the interior design of the building, external conditions, lighting, air conditioning switches, occupant-related activities, and other causes that lead to indiscriminate use of energy.

Nowadays, smart technologies and techniques have been promoted and supported for adoption in our daily lives. During the past few years, science, techniques, and technology have developed fast and fascinatingly. For example, mobiles with higher capacities than computers have become relatively common Mataloto et al., (2019). The technological development has also extended to the electrical installations of homes and buildings, dealing with all kinds of applications and fields, such as lighting, shutter control, heating, ventilation, and air conditioning, as well as security and energy consumption management.

According to Abdullatif, (2021), construction and building automation found itself in a swift expansion in technologies and techniques to provide a fully advanced management and monitoring of the operational edges in the buildings and develop the equipment in houses for better energy consumption.

According to Andrade et al.,(2022), energy consumption management technologies can be implemented using the IoT, thus ensuring user comfort, which is the primary goal of smart systems in leading technological features in buildings. The IoT plays a vital role in our daily tasks now and in the future, and this can be seen through the recent developments in the world of the Internet, which in turn provides efficiency and effectiveness to the system on which it is based, making these new systems a source of convenience and a standard way of living due to their time, energy and cost efficiency (Kashan Ali Shah & Mahmood, 2020).

An understanding not far off, as for Andrade et al., (2022), smart home is a residence and building equipped with smart technologies specifically designed to provide customized services to users. The technological features are represented by the ability to obtain the information from the surrounding environment and interact with it accordingly Marikyan et al., (2021). As for Andrade et al., (2022), studies conducted on smart homes recommend different types of technologies and systems to monitor energy consumption and thus reduce the cost to the consumer through a unique feature of control and monitoring or even through the use of computational intelligence solutions to help improve energy consumption.

The Energy Use Control (EUC) which is refers to the practice of managing and regulating energy consumption in order to reduce wasted energy, save costs, and reduce environmental impact, the Energy Performance Analysis (EPA) which is the assessment of the energy efficiency of the building., the Energy Consumption Monitoring (ECM) which aims to ensure and track the amount of energy that the building uses, the Energy Demand Forecasting (EDF) which is the process of predicting the amount of energy needed to meet the demand in a building, and the optimization solutions applied to a building are some of the most functions that can be performed to manage energy use from Al-Ghaili et al., (2021) point of view.

To mentioned, according to Hannan et al., (2018), Building-Energy-Management-Systems (BEMSs) is one of the tools and systems standards in smart buildings, it is a method that can control and monitor energy-related functions and tasks associated with a specific building; this method can contribute to the effective management of potential sustainable energy. The main objective of the BEMS is to balance two critical considerations which are occupants' comfort, and the Building Energy Efficiency (BEE) which pointing to the design and construction of the buildings in a way that maximizes their energy performance while minimizing their impact on the environment(Al-Ghaili et al., 2021).

An example of smart, innovative technologies is the Konnex Associations System (KNX). To keep things simple, KNX is defined as an open global standard for building and facility automation, both commercial and domestic Abdullatif, (2021). As in all BEMS's, the components of the KNX system are the sensors, actuators, and system devices Abdullatif, (2021). This system is recommended for many reasons, first, the system is characterized by the control of energy consumption and the programming method used in it is much easier than other systems through a program called ETS. Moreover, it is common for many large companies to manufacture spare parts for this system, which is very important in installation and maintenance operations (Abdullatif, 2021).

In addition, this system is prevalent in European and international markets and is constantly being developed. And just to mentioned, one of its interesting features is that it does not need to change parts if the various functions of the system are modified. In addition, it can easily overlap between functions and produce multiple scenarios, and the long-term system cost is lower than traditional control methods (Woo & Seung, 2009).

The residential sector has been identified as one of the most energy-demanding sectors, and as a result, there is strong interest in exploiting smart, wirelessly connected devices with the goal of improving energy efficiency, user convenience, and overall life's quality Berbakov et al., (2019). Referring to energy consumption standards in buildings, Dell'Isola et al., (2019) proposed a simplified and detailed approach to estimate the energy consumption of a specific device, which can be simply implemented in an energy monitoring IoT application but this methodology requires knowledge of the household configuration and basic information about the device.

Mataloto et al., (2019) indicates that energy management systems in buildings can operate using IoT principles, in order to provide device connectivity and automation input, thereby reducing energy costs at the building level, and improving energy efficiency through intelligent lighting control as an example as well as providing the necessary means to reduce wasted energy.

Transforming the behavior of the general society towards more efficient practices in the use of energy and reducing its waste is an appropriate option to keep pace with the advanced acceleration in technology and population growth, which in turn will require an increase in energy production, which means increasing investments in energy production and distribution infrastructure (Berbakov et al., 2019).

Marinakis & Doukas, (2018) research stated that smart energy consumption management in buildings can have a significant positive impact on the environment through the use of technology to improve energy use, reduce losses and promote sustainable practices, and then buildings can reduce carbon emissions and contribute to global efforts to combat climate change.

The research of Marinakis & Doukas, (2018) adds that one way smart energy consumption management can have a positive impact by reducing the amount of energy buildings use. By using IoT-based automated sensors and systems to monitor and control lighting, heating, and cooling systems, buildings can avoid unnecessary energy consumption and reduce carbon emissions as mentioned earlier. Overall, smart management of energy consumption in buildings can play a vital role in reducing our impact on the environment, promoting sustainable development, and mitigating the effects of climate change.

Finally, building upon the prior discourse, it becomes manifest that finding applications of smart technologies in buildings to achieve the goal of the lowest possible energy cost without any environmental impact on the life cycle of the building is the ultimate goal for all energy engineers, planners, designers and researchers (Bhutta, 2017).

1.4 Conceptual Modeling and Hypothesis Generation

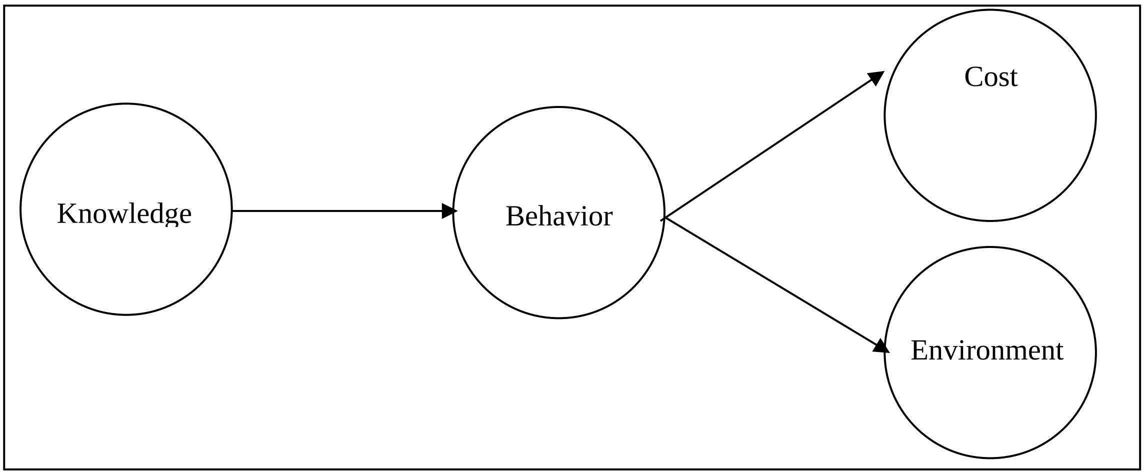
The concepts of modeling and hypothesis creation or generation are two closely related terms in the field of scientific research. Generally, the term conceptual modeling is about developing a theoretical framework or model to explain a particular phenomenon or group of phenomena, meanwhile, hypothesis generation involves creating testable specific data based on the previously mentioned model (Larry B. Christensen, 2016).

1.4.1 Conceptualization of The Proposed Model

At this particular phase, our primary objective is to establish a comprehensive understanding of the basic research model. This entails defining the scope and criteria of the model while also delving into the fundamental concepts and their interrelationships, drawing on insights from prior studies. In Figure 1, we present the proposed model, which comprises four distinct constructs. Among these constructs, two are focused on the residents, namely knowledge and behavior. The remaining constructs pertain to the costs associated with smart energy consumption management in buildings, as well as the environmental impact of implementing such systems. It is important to note that all four constructs are presumed to possess reflective indicators, which will aid in evaluating their respective attributes and characteristics.

Figure 1

The Research Model and Proposed Hypotheses



1.4.1.1 Knowledge

As the residential sector has been identified as one of the most energy-demanding sectors, there is strong interest in exploiting smart, wirelessly connected devices with the aim of improving energy efficiency, user comfort, and overall quality of life Berbakov et al., (2019). Knowledge of smart energy consumption management systems in buildings helps to choose the appropriate system based on the characteristics of the building in which the system will be installed, and we are exploring the extent to which the Palestinian residents recognize these systems.

Residential knowledge research is crucial in the context of smart energy consumption control in buildings for a variety of reasons. To begin, the residential sector, which consumes a big quantity of energy, accounts for a sizable portion of overall energy consumed by buildings. Understanding how to manage energy consumption at home may have a significant impact on total energy use and conservation. Second, because global energy and environmental challenges persist, optimizing building energy use is more important than ever. By lowering energy waste and greenhouse gas emissions in buildings, particularly in the residential sector, smart energy management may enable a more sustainable future.

The adoption of energy-efficient techniques in the residential sector may be hampered by various obstacles and problems, which may be identified by researching residential knowledge in the context of smart energy consumption management in buildings. Policymakers and academics can create efficient policies and interventions to encourage energy-saving behavior and ease the transition to a more sustainable energy future by understanding these constraints.

1.4.1.2 Tasks

Building energy management systems (EMS) are tools for managing and keeping track of the energy-related activities and duties connected to a certain structure Al-Ghaili et al., (2021). The EUC, EPA, ECM, and EDF are some of these systems' primary responsibilities in buildings, and their overall goals are to maximize energy efficiency, cut costs, and limit environmental effect. Buildings with smart energy consumption management systems are becoming more and more crucial as the globe struggles with energy and environmental issues. The development of effective and efficient systems that may optimize energy usage in buildings depends on an understanding of the activities and functions performed by these systems. Smart energy consumption management systems can assist in lowering energy usage and expenses in households because the residential sector accounts for a significant portion of the total energy consumption in buildings Shakeri et al., (2017). By examining the functions of these systems, it is possible to spot any obstacles that can prevent their acceptance in the residential sector and to create efficient tactics to encourage adoption and assure their broad usage. Understanding how these systems work and how they affect the energy landscape is crucial for a more sustainable energy future since they have the capacity to drastically change it and make it more efficient and sustainable.

1.4.1.2.1 Effort

By maximizing energy utilization and minimizing waste, smart energy consumption management in buildings has an impact on employee productivity inside the facility. Building occupants may experience less effort and stress in an atmosphere that is more efficient and pleasant thanks to intelligent energy management technologies.

The amount of effort residents must do to regulate energy consumption inside the building can be reduced by researching their understanding about smart energy consumption management. This can be achieved by improving their awareness of energy usage patterns and habits, developing tailored solutions that align with their understanding and capacity, encouraging behavioral changes, and providing feedback mechanisms and incentives to reduce energy waste. By educating residents about the importance of energy conservation and providing them with the necessary tools and resources, they can be encouraged to adopt better energy management practices that ultimately lead to long-term behavioral changes and reduced effort in managing energy consumption.

In the smart energy consumption management approach, the devices are controlled remotely through a wireless controller and through an intelligent energy management system. A remote control device can control several LED lights, for example, wired or wireless, by automatic dimming, turning them on or off, changing the warmth of their glow, which reduces kinetic effort inside the building (Bhutta, 2017).

1.4.1.2.2 Time

Smart energy consumption management in buildings can reduce the time required for system installation and maintenance because intelligent energy management systems often use wireless technology and automated controls, which can simplify the installation process and reduce the need for physical wiring. Through intelligent systems, sufficient data can be obtained to identify shifts to distinguish between performance fluctuations across transitional time periods such as between day and night, working hours, etc., to report behavioral pattern changes and problems promptly and also to address inconsistencies in time series data from variation data sources to represent accurate overall energy usage pattern (Yang et al., 2017).

Studying the residents' knowledge of smart energy consumption management can reduce the system installation and maintenance time inside the building. By understanding the residents' knowledge and behaviors, installers can identify the specific needs of the building and tailor the system accordingly, which saves time and resources during installation. When residents are knowledgeable about smart energy consumption, they can participate in the installation process, help with troubleshooting and maintenance, reducing the need for professional help. Moreover, residents can maintain the system themselves, reducing the need for regular maintenance checks, and decreasing the time spent on system maintenance. Therefore, studying the residents' knowledge of smart energy consumption management can provide valuable insights that optimize the installation and maintenance processes, resulting in less time and resources needed to maintain the system.

1.4.1.2.3 IoT principals

Smart energy consumption management systems In building can be delivered using IoT principles, in order to provide device connectivity and automation inputs, thus reducing energy costs at the building level, improving energy efficiency through intelligent lighting control, as well as providing means to reduce wasted energy (Mataloto et al., 2019).

In the context of Smart energy consumption management in buildings, IoT devices can be used to collect data on energy use, occupancy levels, and other relevant factors. This data can then be analyzed to identify patterns and trends, allowing occupants within buildings to make informed decisions about how to optimize energy consumption. The importance of studying IoT principles in the context of Smart Energy Consumption Management in Residential Buildings, based on residents' knowledge and behavior, lies in enabling the development of effective strategies and technologies to optimize energy usage, promote energy conservation, and empower residents with knowledge and tools to actively participate in sustainable energy practices, ultimately leading to reduced energy costs, environmental impact, and enhanced energy efficiency in residential settings. In general, the use of IoT technology in Smart energy consumption management systems can help buildings become more efficient, sustainable and cost effective.

1.4.1.2.4 Behavior

The acceleration of technological progress and quick population growth will undoubtedly require an increase in energy production, which in turn will require significant investments in energy production and distribution infrastructure. But we have the other option which is to shift the behavior of the general community towards more energy efficient and less wasteful practices (Berbakov et al., 2019).

Understanding occupants' patterns and habits of energy consumption is critical for developing effective energy management strategies, finding possibilities for energy savings, and developing tailored solutions to encourage smart energy usage. By studying how people behave, it is possible to identify instances of energy waste, such as leaving lights on inadvertently or using energy-hungry equipment during peak hours. Addressing these concerns can help to reduce energy waste and promote more ecologically friendly energy usage. A culture of energy efficiency within the building may also be established by educating residents on the need of energy conservation and providing them with the tools and resources necessary to appropriately regulate their energy consumption. In the end, this might result in significant energy savings.

1.4.1.2.5 Lightning

Smart lighting systems are particularly interesting because they go beyond conventional lighting control and introduce autonomous lighting control based on feedback from embedded sensors, user data, cloud services, and user input. This leads to a number of advantages like increased energy savings, improved functionality, and lighting that is more user-centered (Chew et al., 2017).

Smart energy consumption management in buildings requires careful examination of resident lighting habits. By understanding residents' behavior, building managers can identify opportunities to reduce energy consumption and personalize lighting solutions to meet specific needs and preferences. Additionally, identifying areas where residents need education or incentives can lead to behavior change, resulting in significant energy savings and reduced environmental impact. Optimizing lighting systems using sensors that detect occupancy or daylight can also reduce unnecessary energy consumption. Therefore, studying residents' behavior in lighting promotes energy savings, personalization, behavior change, and system optimization, creating more sustainable and efficient buildings while also promoting resident satisfaction and comfort.

1.4.1.2.6 Air-conditioning

Within the scope of smart home networks, residential air conditioners should not be a major contributor to household electricity bills and loads on electrical grids. Instead, they must be energy efficient and respond to fluctuations in the grid to mitigate demand imbalances in the power supply. The existing demand response control strategies for residential air conditioners primarily target single-speed units and predominantly rely on adjusting the temperature set point in response to the electricity rates from the previous day on an hourly basis. By using the adaptability of single-speed air conditioners, these solutions seek to maximize energy usage and successfully control peak demand periods (Hu et al., 2019).

To regulate energy usage in buildings intelligently, it is essential to examine how inhabitants use air conditioning. It's because energy consumption is significantly increased by air conditioning, especially in hotter regions. Understanding resident behavior may assist find areas for energy savings and allow temperature control systems to be tailored to fit particular requirements and preferences, increasing resident comfort and satisfaction while improving energy efficiency. Buildings may be made more sustainable and effective by improving air conditioning systems with sensors that detect occupancy or alter temperature in accordance with external circumstances.

1.4.1.2.7 Electric heaters

A significant portion of home energy use goes into heating water, and several efforts have been made to integrate various domestic heating technologies to create hybrid heating systems that are more adaptable, efficient, clever, and affordable (Wang et al., 2020). Understanding how inhabitants behave might assist find areas for energy savings because electric heaters are a large energy consumer, particularly in colder locations. Greater resident comfort and satisfaction can result from adapting temperature control options to fit particular requirements and preferences via the behavior of inhabitants. This can also increase energy efficiency.

1.4.1.3 Cost

Given the recent advancements in fast internet, the Internet of Things is going to become increasingly important in our day-to-day activities. The system on which the IoT is built gains efficiency and effectiveness thanks to it. Due to their time, energy, and cost effectiveness, these modern technologies are sources of convenience and a norm for life (Mahmood & Kashan Ali Shah, 2020)

There are several reasons why it is crucial to research the expenses involved with smart energy consumption management. First off, by locating locations where energy usage may be decreased, it can result in cost savings. This is important since energy prices may account for a sizable amount of the expenses for both families and enterprises. Second, by finding opportunities to utilize energy more effectively and lower carbon emissions, an awareness of the expenses associated with controlling energy use may also aid in reducing the environmental impact of energy usage. Thirdly, by identifying possible dangers and weaknesses in the energy system, research into the costs of smart energy consumption management may enhance energy security. Lastly, it can promote innovation and economic growth by supporting the development of new technologies in this growing field. Overall, a better understanding of the costs associated with smart energy consumption management is vital for achieving a more sustainable, efficient, and secure energy system that supports economic growth and environmental sustainability.

1.4.1.3.1 Energy consumption

The IoT provides the feasibility and effectiveness of the system on which it is based so that these new technologies provide convenience and a standard way of living due to their time, energy and cost efficiency Kashan Ali Shah & Mahmood,(2020). For example, intelligent energy management systems in buildings define an energy consumption profile and predict the amount of energy consumption in the future, which can then be compared to the available energy in order to respond in a timely manner to deviations and reduce overall energy consumption (Bhutta, 2017).

Studying the costs associated with smart energy consumption management can help reduce energy consumption in several ways. Firstly, by identifying areas where energy is being used inefficiently, households and businesses can take measures to reduce energy consumption, such as replacing outdated equipment with more energy-efficient models. Second, by identifying locations where energy is being used needlessly, smart energy consumption management systems enable real-time monitoring of energy usage, which can result in behavior changes and energy reduction. Studying the costs of energy management also encourages people and companies to minimize their energy usage by highlighting the financial savings that may be realized by doing so. To achieve a more sustainable energy system by lowering energy consumption and carbon emissions, it is crucial to evaluate the costs of smart energy consumption management.

1.4.1.3.2 Installing System

The installation of energy management systems may be significantly impacted by researching the expenses related to smart energy consumption management. It tackles possible installation difficulties, aids in finding the most economical solutions, and promotes innovation in this expanding industry. Businesses and consumers may choose which energy management system would be the most effective and efficient for their needs by knowing the costs involved, taking into account elements like up-front installation expenses, continuing maintenance costs, and possible cost savings. By utilizing the findings from cost analysis, policymakers, companies, and investors may also collaborate to overcome adoption hurdles and encourage the use of energy management systems.

Building size, the quantity of energy-consuming appliances, and the amount of automation needed are a few variables that might affect the price of establishing an intelligent energy management system in a building. Moreover, the cost of installing a smart IoT-based system in a building depends on the cost of the hardware included in the system and the software that works with it (Kashan Ali Shah & Mahmood, 2020).

1.4.1.3.3 System type

The cost of a smart system in a building varies according to the type of system in terms of implementing functions related to it, which means that making the system fully control the building will cost more than the cost of the same system, but for specific tasks such as lighting and air conditioning, for example (Kashan Ali Shah & Mahmood, 2020).

Studying the costs associated with smart energy consumption management can help in choosing the appropriate type of energy management system for a building. This includes determining whether a full system or a system designed to detect a specific function is more appropriate. By studying the costs of different system types, residents can identify the most cost-effective option for their needs and potential cost savings associated with different system types.

1.4.1.4 Environmental Effect

Energy engineers, planners, designers, and researchers across the industry are actively seeking ways to incorporate smart technologies into buildings. Their ultimate objective is to achieve the ambitious goal of minimizing energy costs while ensuring a negligible environmental impact throughout the entire life cycle of a building. These professionals recognize the immense potential of smart technologies in optimizing energy efficiency, reducing wastage, and enhancing sustainability in building operations. By harnessing the power of innovative solutions, they aim to strike a balance between economic viability and environmental responsibility in the pursuit of sustainable development (Bhutta, 2017).

1.4.1.4.1 Sustainability

Sustainability is a major consideration in designing and implementing an energy consumption management system in smart buildings because such a system is designed to optimize energy use and reduce losses, which not only helps reduce operating costs but also has a positive impact on the environment.

To reach the future with sustainable green energy, this is done through the deployment of smart energy technologies through which traditional buildings can be transformed into smart energy buildings that lead to this through less energy consumption and better management of it (Bhutta, 2017).

1.4.1.4.2 Residential role

Residents can play an important role in contributing to the success of the Smart energy consumption management System by adopting energy efficient behaviors and using the tools and resources provided by the system.

Currently, most of the population chooses high-efficiency air conditioners and home appliances with an energy rating mark and few change their behavior. Residents are likely to save more energy if they are interested in changing their behavior in low-cost activities and minor modifications to the structure of the building. Understanding home energy conservation behaviors can contribute greatly to developing an effective energy policy that suits the needs of residents and encourages home energy savings (Jareemit & Limmeechokchai, 2017).

1.4.1.4.3 Governmental role

The government can play a critical role in promoting and motivating the adoption of smart management of energy consumption in buildings by developing policies and regulations to encourage the adoption of energy saving technologies and providing financial incentives to support the implementation of smart energy consumption management systems. Understanding the needs of the population in relation to energy-saving activities and preferred behavioral changes can be used by the government in defining household energy-saving strategies and guidelines (Jareemit & Limmeechokchai, 2017).

In this research model, various constructs related to smart energy consumption management in buildings are defined and operationalized. These constructs help to understand the different aspects of smart energy consumption management and its implications on energy efficiency, user behavior, and environmental impact. Each construct is associated with specific items and indicators to measure and analyze the relevant variables. The following table is a summarization of each construct and its indicators with the references cited from.

Table 1

Operationalization of Model Constructs

Construct	Item	Indicator	Reference
Knowledge.	K1	Task.	(Al-Ghaili et al., 2021)
	K2	Time.	(Yang et al., 2017)
	K3	Effort.	(Bhutta, 2017)
	K4	IoT principals.	(Mataloto et al., 2019)
Behavior.	B1	Lightening.	(Chew et al., 2017)
	B2	Conditioners.	(Hu et al., 2019)
	B3	Heaters.	(Wang et al., 2020)
Cost.	SCMC1	Energy Consumption.	(Kashan Ali Shah & Mahmood, 2020) (Bhutta, 2017)
	SCMC2	Installation.	(Kashan Ali Shah & Mahmood, 2020)
	SCMC3	Type.	(Kashan Ali Shah & Mahmood, 2020)
Environmental Effect.	EE1	Sustainability.	(Bhutta, 2017)
	EE2	Residential role.	(Jareemit & Limmeechokchai, 2017)
	EE3	Governmental role.	(Jareemit & Limmeechokchai, 2017).

1.4.2 Hypothesis Development

After examining pertinent previous research, a comprehensive understanding of the existing knowledge and deficiencies in the realm of smart energy consumption management in residential settings was gained. Through a thorough literature review, it was revealed that there is a notable research gap in Palestine regarding smart energy consumption management in the residential sector. This gap served as the foundation for formulating hypotheses to address the identified research gap. Developing a hypothesis involves formulating a research question and proposing a tentative explanation or prediction that can be tested through the empirical research we will do later.

Hypothesis development is an important step in conducting this current research on smart energy consumption management in buildings, by formulating testable hypotheses. We can focus our investigations on specific questions and determine whether smart energy consumption management systems are effective in achieving energy savings and promoting sustainability in the construction sector within the West Bank.

Residents' knowledge of smart management technologies for energy consumption in buildings can be tested by questioning them about these technologies and their energy consumption and observing whether they modify their energy behavior to reduce consumption based on their knowledge. Therefore, we can assume:

Hypothesis 1 (H1): “Residents with knowledge about smart energy consumption management in buildings will adopt more sustainable energy behaviors".

Residential knowledge trade-offs between the financial dimensions of smart energy consumption management cost and the environmental impacts of smart energy consumption management systems in buildings. The main objective of all intelligent energy management systems is to obtain the best approach to managing energy consumption, at the lowest possible cost, with the least effect on the environment. Therefore, the effect of knowledge on the cost is denoted by (H2), and the impact of knowledge on the environment is denoted by (H3). Hypotheses (H2) and (H3) are drawn as follows:

Hypotheses 2 (H2): “Residents' knowledge of smart energy consumption management systems in buildings helps positively reduce costs associated with smart energy consumption management systems in buildings”.

Hypotheses 3 (H3): “Residents' knowledge of smart energy consumption management systems in buildings helps positively to reduce environmental damage”.

The behavior of residents plays a major role in how energy is consumed in homes, for example, negligence in saving energy increases the costs needed to manage and regulate the negligence of residents by the smart system inside the building. Hence, the following fourth hypothesis is drawn:

Hypotheses 4 (H4): “Good residents’ behavior inside buildings positively impacts the reduction of costs associated with smart energy consumption management systems in buildings”.

As mentioned earlier, the behavior of residents plays a major role in how energy is consumed in homes. Based on this, the behavior of the residents in the way they deal with energy consumption has repercussions on the environmental situation, hence the following fifth hypothesis:

Hypotheses 5 (H5): "The good behavior of residents inside buildings has a positive impact on minimizing potential damage to the environment".

In addition, we can create a new hypothesis to examine the relationship between residents' knowledge and their possession of a smart system for managing the energy consumption of their buildings. According to the idea, there could be a connection between inhabitants' knowledge and their buildings' smart energy consumption control systems. While the alternative hypothesis contends that there is a link between these two variables, the null hypothesis contends that there is none. According to this theory, people who know more about energy management are more likely to have smart energy consumption management systems installed in their buildings than people who know less. This might be as a result of homeowners' increased awareness of the advantages of utilizing a smart energy consumption management system, such as lower energy costs and a smaller carbon impact.

Derived from the aforementioned exposition, it is evident that:
Hypothesis 6 (H6): "There is a significant positive relationship between the knowledge of the residents and their possession of a smart energy consumption management system in their buildings".

As in the case of knowledge, this hypothesis can be applied to behavior, so we can assume that:

Hypothesis 7 (H7): "Residents who possess a smart system for managing the energy consumption of their buildings are more likely to engage in energy-saving behaviors compared to those who do not possess such a system".

Chapter Two
Methodology

2.1 Chapter Overview

This chapter discusses the thesis' approach in detail. The description of the methodology flow chart is followed by an introduction to the various study kinds and methodologies. Additionally, the chapter elaborates on the data collection strategy, including instrument development and sampling techniques. Finally, the data analysis techniques are presented to examine the relationships between the model constructs.

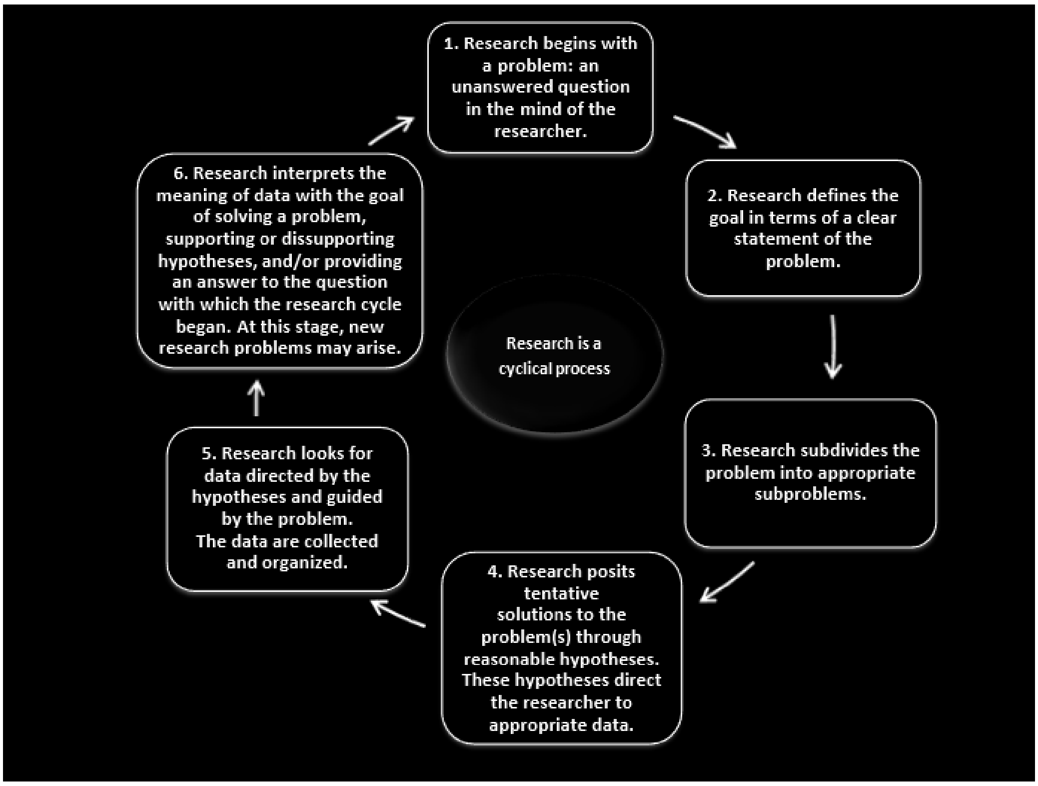
2.2 Research Type

Hair et al., (2011) characterized research as a "discerning pursuit of the truth" (p. 3), while Stragier et al., (2010) defined it as a methodical approach to gather, examine, and interpret data in order to improve our comprehension of a phenomenon that is significant or of interest. Stragier et al., (2010) propose that research is a cyclic process that commences with a problem or an unanswered question and culminates with interpreting the problem. Nevertheless, the confirmed or unconfirmed hypotheses may give rise to emerging issues. The complete concept of the cyclic process is illustrated in Figure 2 on page 7, as cited from (Stragier et al., 2010).

According to Islamia, (2016), the type or design of research refers to the conceptual framework used to conduct research. In addition, the author suggests that a good research design should be grounded in theory, situational, feasible, redundant, and efficient. Research types can be broadly categorized into exploratory, descriptive, and causal designs. When there is little or stale material accessible on a given topic, exploratory research, sometimes referred to as formulative research, is helpful. Researchers who want to find novel links, patterns, and concepts, among other things, should do this kind of study. The literature review is regarded as the initial stage in comprehending the problem in exploratory research. Although qualitative research methods are frequently used, quantitative methods may also be used (Islamia, 2016; Hair et al., 2011).

Figure 2

Research Cycle



Note: Refer to (Stragier et al., 2010) p. 7

Researchers frequently employ descriptive research or statistical research when they need to characterize a specific topic of interest, such as a community or social event. Structured data gathering techniques are used in this kind of study, including data observation, structured question interviews, and questionnaires. A confirmatory form of study, hypothesis testing is frequently employed in descriptive research Islamia, (2016) Hair et al., (2011). The two types of descriptive studies are cross-sectional and longitudinal. Cross-sectional studies provide a snapshot or description of a business issue at a particular time, while longitudinal studies describe events over time by collecting data about sample units at multiple times to pursue the business element Hair et al., (2011). On the other hand, causal research or explanatory research aims to interpret the relationship between two events. A causal relationship occurs when a change in one event (the cause) results in a change in the second event (the effect) (Islamia, 2016; Hair et al., 2011).

In addition to the research designs previously discussed, Islamia, (2016) also describes experimental research design. This type of research is used to test causal relationships under controlled conditions, meaning that the variables being studied are manipulated and conditions are kept constant throughout the experiment. According to (Islamia, 2016a).

x A offers a table describing the typical uses of study designs.
According to Hair et al., (2011), scholars frequently combine several forms of study into a single project. For instance, they could begin with qualitatively-based exploratory research before switching to quantitatively-based descriptive designs. The objectives and research questions will determine the best sort of study. Exploratory research is often utilized when the study topic aims to elucidate a problem. The descriptive approach is best suitable if the research question focuses on characterizing an instance, a sum, or a variable. The most effective method for determining how one variable affects another is causal research. However, exploratory research can be employed in descriptive research to develop a research instrument for the topic. In conclusion, the type of research questions and objectives will determine the study design.

There is a noteworthy shortage of information accessible when it comes to researching the use of smart energy consumption management systems in buildings and their prospective use in the Palestinian residential building industry. According to Hair et al., (2011) recommendations, exploratory research would be the best type of research design for this study. This is because exploratory research, which may be carried out using either qualitative or quantitative research methodologies, can give a better understanding of business difficulties when there is little information available regarding an issue or problem. Literature research was also completed to help with the creation of the questionnaire that was utilized in this study to gather data and examine correlations. In conclusion, exploratory research was chosen for this study since it was thought to be the most appropriate style of research given the nature of the investigation.

2.3 Research Approach

The research topic and the sort of data needed for the study, whether it be textual or quantitative, are often taken into when choosing which research technique to use. According to John & Creswell David, (2014)definition, the research approach encompasses all the steps involved in a study, from assumptions to data collection, analysis, and interpretation. Generally, there are three main research approaches: quantitative, qualitative, and mixed methods. A quantitative approach is typically selected when the research question requires numerical data, whereas a qualitative approach is used when the research question requires textual data. Mixed methods, on the other hand, are employed when the research question necessitates both numerical and textual data (Marvasti, 2018).

2.3.1 Quantitative Approach

The quantitative approach involves the collection of numerical data and the use of mathematical models for data analysis. According to Marvasti, (2018), researchers using this approach typically employ a deductive style and test objective theories by examining relationships among variables. The resulting research report usually includes an introduction, theory and literature review, methodology, results, and discussion.

Marvasti, (2018) classified the quantitative approach into three categories: descriptive research, experimental research, and causal comparative research. Descriptive research methods include correlational research, development design, observational study, and survey research. Experimental research evaluates the outcomes of treatments, while causal comparative research analyzes cause and effect relationships between independent and dependent variables.

John & Creswell David, (2014) focused on two designs of quantitative research: experimental research, which investigates the effects of treatments on outcomes, and survey research, which provides numerical descriptions of population trends, opinions, and attitudes using questionnaires or structured interviews. These designs can be applied through cross-sectional or longitudinal studies.

2.3.2 Qualitative Approach

Qualitative research, as defined by John & Creswell David, (2014), relies on textual and visual data and is an approach that seeks to explore and understand the meanings that individuals or groups ascribe to social or human problems. This approach typically employs an inductive style, in which data is collected in the participant's setting, the general theme is derived from the particular setting, and data interpretation is provided.

Marvasti, (2018) similarly noted that in a qualitative approach, social phenomena are investigated from the viewpoint of the participants, which is a distinguishing characteristic of this research approach. Qualitative research can be conducted using various methods, including case study or idiographic research, which provides an in-depth analysis of a program, event, activity, process, or one or more individuals.

Ethnography study is another method of qualitative research that focuses on the culture of a group, such as their behaviors and languages, over an extended period. Grounded theory study is a method in which the researcher derives a general, abstract theory of a process, action, or interaction grounded in the views of participants.

Phenomenological study, on the other hand, is a method that aims to understand people's perceptions and perspectives regarding a particular situation, while content analysis study involves a detailed and systematic examination of the contents of a particular body of material to identify patterns, themes, or biases.

2.3.3 Mixed Approach

According to Marvasti, (2018), the mixed method approach allows researchers to employ both quantitative and qualitative approaches in a single study, thereby collecting numerical and narrative data. For instance, researchers can collect numerical data through closed-ended questions and narrative data through interviews using open-ended questions, both of which are used to answer the research question. The main premise of using this approach is to gain a more comprehensive understanding of a research problem than can be achieved by using a single approach alone, as noted by John & Creswell David, (2014). This mixed research approach combines the strengths of both quantitative and qualitative methods to provide a more robust and nuanced understanding of the research problem.

Several studies have been conducted in Palestine utilizing the mixed method approach. Al Qadi et al., (2018), for instance, applied this approach in assessing and choosing the most effective practices for energy consumption in the residential sector. Given that the current study also pertains to energy management in the Palestinian residential sector context, the mixed approach was deemed suitable based on the aforementioned study.

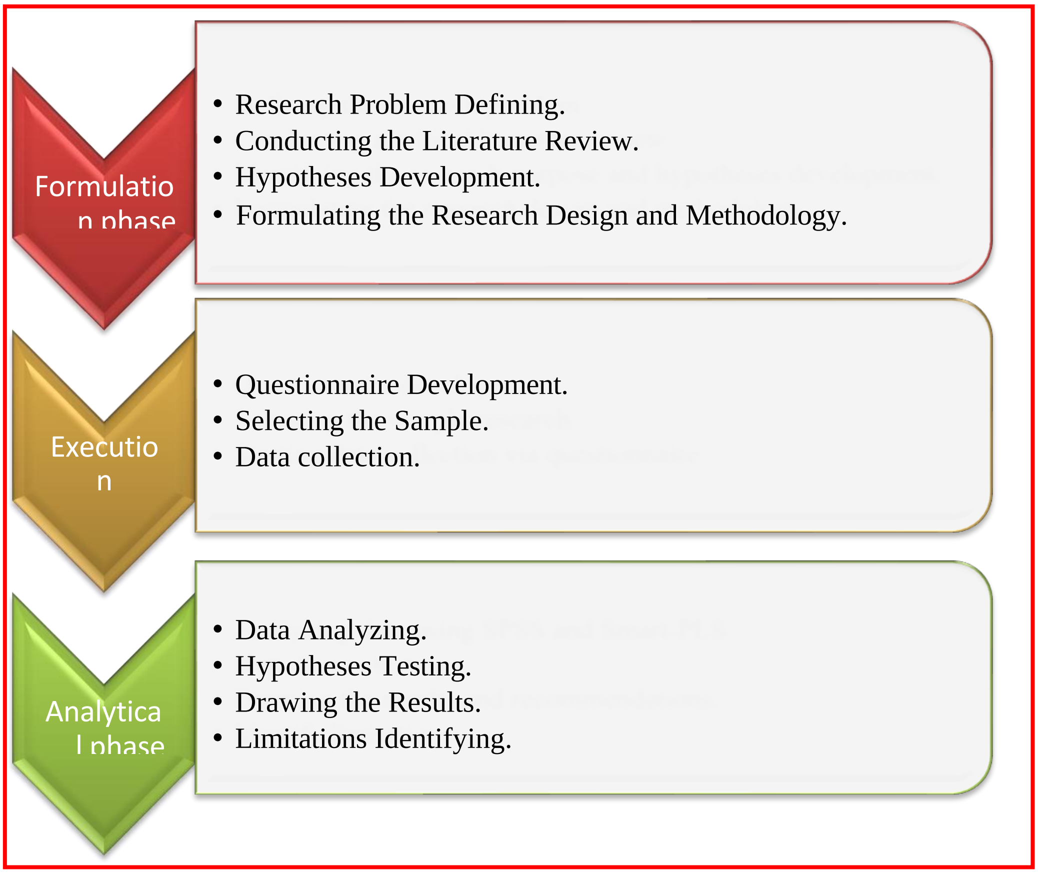
2.4 Research Methodology

Stragier et al., (2010) define research methodology as the general approach adopted by a researcher to conduct their study, including the specific research strategy and mechanisms used to collect data. According to Hair et al., (2011), the research process consists of three main phases: formulation, execution, and analytical. During the formulation phase, the research problem is identified, a comprehensive literature review is conducted, research questions and objectives are established, hypotheses are formulated, and the research design is determined. In the execution phase, the researcher selects a sampling method, designs the data collection tools, collects the data, and stores it. The analytical phase involves data analysis, interpretation, hypothesis testing, and drawing conclusions and recommendations based on the results.

Figure 3 illustrates the research flow chart in this study. The methodology employed three general stages, commencing with defining the study problem, which centered on exploring the role of residents in sustainable performance concerning smart energy consumption management in Palestine, including the impact of residents' consumption behavior in this association. A literature review of essential concepts was conducted, and the research gap was identified. Based on the literature, hypotheses were formulated, and a mixed research approach was adopted.

Figure 3

Research Methodology



The next stage commenced with designing interview questions to be administered to government and private institutions involved in the research subject, while simultaneously designing and assessing the questionnaire with the assistance of academic experts. The study population for this research consisted of a representative sample of 100 accurate responses from the West Bank. And to ensure randomness, the questionnaire was electronically distributed through social media platforms among various groups associated with the providences and it was made clear that the data we aim to collect will be treated at a high level of confidentiality and professionalism, and that its purpose is for research only. Once data was collected, the smart-PLS software was utilized to analyze the data and test the hypotheses, and the results, discussion, and recommendations were presented.

2.5 Design of The Research

In this sub-phase, we will present the overall plan and strategy used to conduct our research study, including selection of research participants, data collection methods, and analysis techniques. This research is carefully designed to be research on duality in terms of type, in other words, it is research that bears the characteristics of research, both quantitative and qualitative.

From a quantitative point of view, an online survey was designed to collect residential opinions for testing the hypotheses of the research model. The online survey was structured into five main sections. The initial section focused on gathering general information about the respondents' buildings, such as the province, building size, monthly electricity bill, and whether it had a traditional or smart system. The second section comprised questions pertaining to residents' awareness and understanding of smart energy consumption management in buildings. In the third section, general inquiries were made regarding residents' consumption behaviors within their homes. The fourth section aimed to gauge residents' opinions on the costs associated with implementing smart systems for energy management. Lastly, the fifth section examined the environmental impacts resulting from the implementation of these systems. The last four sections implemented a five-point Likert scale for rating responses. The questions were used to develop multi-item reflective measures for the four constructs of the research model.

Regarding the qualitative approach to pickling, we have conducted a number of systematic interviews with the most important companies in the smart systems sector in the Palestinian market, namely (Al - Seder) and (Al-Takamul), in addition to our glow to one of the most important governmental institutions concerned in this field, which is the PEA. We had a full dialogue with these organizations about the aforementioned research hypotheses, in addition to some general information about the Palestinian market in this field.

2.6 Data Collection Analysis Tools

To test the hypotheses, this study targeted the residents in the West Bank. Therefore, the survey was intended to collect data as a primary source for testing the hypotheses of the model's constructs. Although we aimed for a recommended sample size of 170 participants based on a 10-times rule of thumb, and unfortunately, we were only able to collect only 100 valid responses, resulting in a response rate of 58.8%. Despite the smaller sample size, we can still proceed with analyzing our research model using Smart-PLS. This software utilizes partial least squares (PLS) analysis, which is particularly well-suited for smaller sample sizes compared to other techniques. PLS is renowned for its resilience, capacity to manage assumptions violations, and superior performance with lower sample sets. The Partial Least Squares-Structural Equation Modeling (PLS-SEM) statistical software technique was utilized in this study to evaluate the data and verify the validity of our hypotheses since it is good at examining sample sizes and efficient at evaluating intermediary variables and indirect correlations (Sarstedt et al., 2014). The suggested model's validity and dependability may also be directly tested using the Smart Partial Least Squares (Smart-PLS) program. It boasts an extremely user-friendly UI and excellent graphics.

Chapter Three
Analysis And Results

3.1 Chapter Overview

The results of analyzing the data collected from the people and organizations in charge of monitoring energy use are highlighted in this chapter. The Smart-PLS4 program was used to analyze the survey responses, evaluate the model's validity and reliability, and validate the assumptions. At this point, our goal is to evaluate and interpret the data gathered through research to find trends, correlations, and patterns that may be utilized to guide decision-making. Our goal is to assess research results in order to support judgments and decisions. Large volumes of quantitative and qualitative data are gathered, arranged, and interpreted during the analysis stage utilizing a variety of techniques such descriptive statistics, illustrations, and visualizations.

3.2 Qualitative Analysis

We will now analyze the information gathered through open-ended questions, observations, and other non-numerical techniques used in the interviews with representatives of the aforementioned institutions, specifically the businesses "Al-Takamul" and "Seder" in addition to the Palestinian Energy Authority.

In Palestine, a notable distributor of electrical supplies is Al-Takamul Engineering Company. They have established a solid reputation for their superior expertise, vast experience, and superb assistance in the field of electrical solutions thanks to a committed staff of highly experienced engineers and technicians. Al-Takamul is renowned as a dependable one-stop shop for Electrical Contractors, Utility Companies, and Big Calibre Projects and is one of the biggest participants in the sector. Their dedication to providing top-notch services has strengthened their standing in the industry and brought them considerable accolades.

In order to oversee the energy industry in the Palestinian territories, the Oslo Accords led to the establishment of the Palestinian Energy Authority in 1994. Promoting openness, effectiveness, and sustainability in the energy industry are among its objectives. The authority is in charge of creating energy-related laws and regulations, promoting investment in renewable energy projects, and overseeing the electrical industry.

Additionally, it wants international collaboration in the energy sector and encounters difficulties including Israeli limitations and financial and technological barriers. Despite these obstacles, the authority is dedicated to developing the energy industry and attaining both economic and environmental sustainability.

Since 1987, Seder, a privately held Palestinian company, has been doing business in Palestine. It was formally incorporated as a private firm in 2004 and works in a number of areas related to security and electricity in Palestine. Seder Company holds a prominent position as an electrical service contractor in the Palestinian market. It specializes in several sectors related to low voltage systems, including burglar alarm systems, fire alarm systems, satellite system installation (DTH, SMATV, CATV), CCTV systems, and Automatic Gates, among others. Additionally, Seder Company collaborates with the technical institute (PITTI) to offer training programs in these fields. These trainings aim to enhance technical skills and expertise in the industry.

Qualitative data provided valuable insights into the hypotheses we put forward throughout this study, and we discuss each hypothesis from the point of view of the institutional representatives we interviewed.

3.2.1 First Hypothesis, Knowledge -> Behavior

The project manager at Al-Takamul Engineering company Engineer M, T, emphasized that residents' knowledge of smart management of energy consumption can play an important role in enhancing energy efficiency and sustainability in buildings. By educating residents, providing feedback and offering incentives, in addition, the Electrical Engineer at the same company, Q, A, S, confirmed that decision makers can encourage residents to adopt behaviors that contribute to a more sustainable future. On the other hand, the engineer at the Palestinian Energy Authority, M, A, M pointed out some details about some aspect in the hypothesis, which are the knowledge of smart energy consumption management, education, feedback, and incentives. The engineer said during the interview that individuals who are knowledgeable about smart energy consumption management know how to efficiently control their energy use in buildings. It involves teaching locals on ways to save energy, such altering thermostat settings, utilizing energy-efficient equipment, upgrading lighting, and using less standby power. Residents in these locations may make wise judgments and take activities that result in lower energy use by becoming more knowledgeable. While he noted that Palestinian leaders can play a significant role in informing the populace about wise energy usage management. This can be accomplished in a number of ways, including giving seminars, disseminating educational materials (pamphlets, notes, or internet resources), or planning awareness campaigns. The objective is to arm locals with the information and expertise they need to make decisions that are energy-efficient in their everyday lives. Additionally, it has been noted that resident feedback is crucial in shaping their behavior. Through energy monitoring devices or utility bills, decision-makers can regularly update people on their energy usage. Residents are more likely to be aware of their energy use and motivated to make good changes if information is provided about their energy consumption habits and suggestions for methods to increase efficiency. Residents may be inspired to adopt energy-saving habits via incentives. These inducements may take the shape of monetary awards, energy bill reductions, or other non-financial advantages. By recognizing and rewarding residents for their efforts to save energy, decision makers can reinforce positive behaviors and encourage long-term sustainable practices.

In another interview with Engineer O, H, an Electrical Engineer at “Seder” Company, he emphasized that by implementing the strategies mentioned above, decision-makers can create a supportive environment that promotes energy efficiency and sustainability. The ultimate goal is to enable residents to actively participate in smart energy consumption practices, leading to less energy waste, a lower carbon footprint, and a more sustainable future.

3.2.2 Second Hypothesis, Knowledge -> Cost

H2 states that the residents' knowledge of smart systems in buildings has an impact on the overall cost of smart management of energy consumption. Engineer M, T, confirmed that smart systems in buildings are designed to automate and improve energy use by monitoring and controlling various systems such as lighting, heating and cooling. While his colleague in the company Engineer Q, A, S pointed out that the effectiveness of these smart systems depends on the understanding and use of the building's occupants. If the residents have little or no knowledge about how these smart systems work, they may not take full advantage of the available features.

In our interview with the Palestinian Energy Authority, Engineer M, A, M a real-world example of what was previously mentioned, whereby residents who lack knowledge may not adjust thermostat settings to optimize energy use or forget to turn off lights and appliances. On the contrary, residents with a good knowledge of these systems can actively participate in reducing the building's total energy consumption.

Engineer O. H. stressed that residents' understanding of smart systems is crucial for lowering the cost of smart management of energy consumption in a building. To maximize the efficiency of these systems in decreasing energy usage and attaining sustainability objectives, homeowners must be educated about their characteristics and advantages. When citizens are better educated, they can make more intelligent decisions and actively participate in energy conservation, which eventually reduces costs by controlling wise energy usage.

3.2.3 Third Hypothesis: Environmental Impact > Knowledge

H3 claims that the environment is significantly impacted by the locals' understanding of smart systems. Engineer M. T. made the point that intelligent energy management systems in buildings have the power to cut energy consumption, which results in a more ecologically friendly and sustainable living environment. When inhabitants are aware of the smart technologies placed in their buildings and understand how to utilize them effectively, they may take practical efforts to cut energy consumption and carbon emissions, said engineer Q, A, and S. They may, for instance, utilize smart thermostats to customize the temperature in their houses to suit their requirements and prevent overheating or chilling. Residents may help to energy conservation and prevent energy waste by turning off lights and appliances when not in use. They may also utilize low-flow faucets and shower heads to save water, which is another crucial element of environmental sustainability.

Engineer M, A, M said: “Through knowledge about the features and capabilities of smart systems, residents are empowered to make informed decisions and actively participate in sustainable living practices. Combined, their actions can have a significant impact in reducing energy consumption and mitigating the overall impact of climate change on the environment.”

Engineer O, H summarized what was reported by saying that residents' knowledge of smart energy consumption management systems in buildings plays an important role in promoting sustainable living practices and reducing the environmental footprint. By understanding and using these systems, residents can actively contribute to reducing energy consumption, adopting energy-efficient behaviors, and mitigating the negative effects of climate change.

3.2.4 Fourth Hypothesis, Behavior -> Cost

H4 indicates that resident’s behavior has a significant impact on the energy consumption management cost of smart systems. Engineer M, T, claimed that the behavior of residents may undermine the effectiveness of these systems designed to improve energy use and reduce waste. For optimal energy use and waste reduction, it is imperative that residents are aware of the energy saving features of their smart systems and make effective use of them. This includes understanding how to operate and program smart thermostats, lighting controls, and other energy management devices for maximum efficiency.

Engineer Q, A, S explained that residents should also avoid overriding system settings in a way that renders them ineffective. Setting temperature settings that are too high or too low, for example, can lead to excessive power consumption. It is important for residents to follow recommended guidelines and use system settings intelligently to ensure energy efficiency.

Moreover, Engineer M, A, M added that residents should pay attention to turning off devices when not in use. Unnecessarily leaving appliances, lights, or other electrical devices on can waste energy. By developing habits of turning off appliances and making sure they are not left idle, residents can contribute significantly to reducing energy consumption and lowering associated costs.

Engineer O, H concluded the discussion on this hypothesis that residents’ behavior plays an important role in determining the cost of energy consumption management for smart systems. By being aware of the energy saving features, using the system effectively, avoiding excesses, and practicing responsible energy use, residents can increase the efficiency of these systems and help reduce overall energy costs. Adopting energy-conscious behaviors is essential for optimizing energy consumption and achieving cost savings in smart energy management.

3.2.5 Fifth Hypothesis, Behavior -> Environmental Effect

H5 states that resident's behavior directly affects the environment, resulting in both positive and negative effects. Engineer M, T stated that this hypothesis confirms the crucial role played by the behavior of individuals in determining the impact of smart systems in buildings on the environment. Engineer Q, A, S added that the hypothesis assumes that the behavior of residents is directly related to the effectiveness of smart systems in buildings and their general impact on the environment. Residents may significantly help reduce energy use, choose more sustainable activities, and ultimately improve the environment by making efficient use of these systems.

Engineer M, A, and M analyzed some of the key issues surrounding this concept, including energy efficiency, smart systems' effects, environmental behavior and effects, and sustainability possibilities.

The idea accepts that individual actions may directly affect the environment, the engineer continued. This covers both constructive actions that help preserve the environment, including energy efficiency and sustainable practices, and destructive actions that harm it.

Additionally, he supported the theory that claims resident behavior influences how smart building technologies affect the environment. Smart systems can provide citizens the knowledge and resources they need to make better informed decisions and adopt sustainable habits. However, how the inhabitants utilize and engage with these tools will determine how beneficial they are.

Furthermore, he said that smart technologies may make it possible for occupants to more effectively monitor and regulate the energy consumption within their properties. Residents may help reduce energy use and the environmental impact it has by adopting energy-saving behaviors including regulating thermostats, controlling lighting systems, and maximizing appliance use.

"The hypothesis highlighting that resident's behavior can be instrumental in promoting sustainable choices," the engineer said as she wrapped off the conversation. This can include options such as using renewable energy sources, recycling, reducing waste, and adopting environmentally friendly practices. By actively engaging in sustainable behaviors, residents can contribute to a healthier environment."

In conclusion of our last interview with Engineer O, H, he said: "In general, H5 recognizes the critical role of individual behavior in shaping the environmental impact of smart systems in buildings. It emphasizes the ability of the population to positively influence the environment through the effective use of these systems, reducing energy consumption and adopting sustainable practices to reach a balanced future."

At the appendices, Appendix E presents the qualitative analysis coding table that summarizes key points and themes discussed by representative engineers from Al-Takamul Engineering, the Palestinian Energy Authority, and Seder Company in relation to the hypotheses explored previously. This coding table provides a structured overview of the discussions and highlights the main points raised regarding the relationship between knowledge, behavior, smart energy consumption management, cost implications, and environmental effects. The representatives' insights shed light on the significance of residents' knowledge and behavior in promoting energy efficiency, reducing costs, and mitigating environmental impact. The table serves as a valuable reference to better understand and analyze the key themes and codes identified during the interviews.

Several insightful conclusions may be taken from the qualitative analysis and the results of the interviews with representatives of Al-Takamul Engineering, the Palestinian Energy Authority, and Seder Company.

Smart Energy Consumption Management Knowledge is Essential:
The Al-Takamul Engineering officials underlined that improving energy efficiency and sustainability in buildings may benefit greatly from inhabitants' understanding of smart energy consumption management (KB1). It was discovered that understanding smart energy consumption management and its components (KB3) was essential for maximizing energy efficiency and lowering total energy consumption management costs

(KC3, KC4). The promotion of behaviors that lead to a more sustainable future among inhabitants was shown to be facilitated by education and feedback (KB2) (KB4).

Knowledge of Locals' Effect on Cost:

The Al-Takamul Engineering and Palestinian Energy Authority representatives emphasized that smart building systems (KC1) are intended to automate and enhance energy consumption. But how well residents utilize and comprehend them determines how well they work (KC2). It was discovered that optimizing energy use and lowering the total cost of energy consumption management (KC3, KC4) depended greatly on residents' understanding of smart energy consumption management and its components (KB3).

Residents' Knowledge and Environmental Effect: The representatives from Al-Takamul Engineering and the Palestinian Energy Authority highlighted the significant impact of residents' behavior on the environment (KE1). When residents are aware of the smart systems installed in their buildings and understand how to use them efficiently (KE2), they can take effective steps to reduce energy consumption and carbon emissions. A more sustainable living environment is made possible through responsible conduct and minimizing environmental impact (KE3, KE4).

Cost implications and resident behavior:

Al-Takamul Engineering and Seder Company executives stressed that inhabitants' behavior (BC1) significantly affects the cost of energy consumption management for smart systems. Optimizing energy usage and generating cost savings (BC4) depend heavily on the effective use of smart technologies and energy efficiency (BC2). Responsible actions, such as shutting off gadgets when not in use (BC3), also help to manage energy usage more economically.

The Function of Behavior in Promoting Sustainability

Al-Takamul Engineering and Seder Company leaders acknowledged the crucial role played by resident behavior in supporting sustainable choices (BE1, BE4). Positive behaviors, such as adopting renewable energy sources and reducing waste (BE3), contribute to a healthier environment. In order to promote sustainability, the speakers also emphasized the necessity of citizens' conduct in fostering a healthy environment (BE4).

3.3 Quantitative Analysis

The analysis will make use of the Smart-PLS4 program. A statistical technique called smart PLS (Partial Least Squares) analysis may be used to examine large data sets. It is frequently employed when there are several variables and a small sample size(Hair et al., 2016). To analyze data and find links between variables, Smart PLS use a number of graphical and statistical approaches, including structural equation modeling and variance-based structural equation modeling. This approach can help us understand which factors are most crucial and how they interact, enabling us to develop strategies and take better informed decisions. Additionally, Smart PLS enables automatic model parameter estimation and offers the capability of swiftly and simply evaluating various measurement models.

In our research, regarding that we are in the context of analyzing via Smart-PLS platform, the analysis will be conducted as a tow-steps-approach, which are: a) building and testing the measurement model, and b) building and testing the structural model.

3.3.1 Assessment of the measurement model (Outer Model)

The reflective measurement model analysis is assumed to be a vital analysis to check the reliability and validity of the construct. When we state that it is necessary to examine reliability and validity, by reliability we mean the ability to measure what is required, and what we mean by validity is the ability to measure what is required under several different circumstances.

One important step in PLS-SEM analysis is to evaluate the measurement model, which includes the measurement items and their relationship to their respective latent variables Hair et al., (2011). The measurement model assessment including the convergent validity tests and the discriminate validity tests.

3.3.1.1 Convergent Validity

Convergent validity is an important concept in SEM and refers to the degree to which different measures of the same construct are related to each other. Convergent validity can be assessed using several methods, one of these common methods is to examine the factor loadings of the indicators on their respective latent variables.

The factor loading stands for the measure that represents the strength of the relationship between the indicator and the underlying construct in the structural equation model. In other words, it indicates the amount of variance in the observed variable (i.e., the indicator) that is explained by the underlying construct Henseler et al., (2015). The factor loadings for the indicators are listed in Table 2.

Table 2

Factor Loadings

Indicator / Constrict	Knowledge.	Behavior.	Cost.	Environmental Effect.
K1	0.832			
K2	0.830			
K3	0.887			
K4	0.778			
B1		0.902		
B2		0.832		
B3		0.832		
SCMC1			0.867	
SCMC2			0.836	
SCMC3			0.844	
EE1				0.810
EE2				0.837
EE3				0.873

According to Hair et al., (2016), if the factor loadings are high (usually above 0.7 or 0.8), it suggests that the indicators are measuring the same construct and are converging on the latent variable. In order to examine the reflection factor loading, which indicates the degree of validity of the outer model for this research, we applied the PLS-SEM algorithm with the default settings of the system which are a factor weighting scheme and standardized type of results. The results of the mentioned factor loadings for this extrapolation are listed in

Table 2 above and it should be noted that the factor load values were obtained using the path analysis method.

Factor loadings are a measure of the strength of the relationship between each indicator and its underlying construct in the PLS-SEM analytics. In general, the factor loadings with a value above 0.7 is considered strong, which indicates that the indicator is a good measure of its basic construct Hair et al., (2016). In this research, all the indicators in the study model, namely: Tasks of smart systems in buildings (K1), Time(K2), Effort (K3), IoT principles (K4), lightening (B1), conditioners (B2), heaters (B3), energy consumption (SCMC1), installation (SCMC2), system type (SCMC3), sustainability (EE1), residential role (EE2), and governmental role (EE3) have load factors greater than 0.7, which indicates that they are all relatively strong indicators for their constructs, and the constructs are well measured by the indicators, which is considered a positive indicator of validity and reliability of our PLS-SEM analysis.

Another method is to examine the average variance extracted (AVE) for each latent variable, which is a measure of the amount of variance that is captured by the indicators. AVE values above 0.5 are generally considered acceptable for convergent validity Hair et al., (2016). In general, an Average Variance Extracted (AVE) value of 0.5 or higher indicates that the structure is considered to have good asymmetric validity in PLS-SEM analysis. However, it is important to note that the specific threshold for an acceptable AVE value can vary depending on the research context and theoretical expectations of the research model's constructs. In our case, as what can be seen in Table 3, all constructs in the research model have AVE values greater than 0.5, this indicates that they are measured relatively well and that the indicators are strongly associated with the combinations they aim to measure. This is a positive indicator of the validity of our model.

Additionally, other several tools for assessing convergent validity can be Implemented, such as the assessment of composite reliability (CR) which is a measure of the internal consistency of the indicators and is computed as the ratio of the variance of the indicators to the variance of the errors, and CR value above 0.7 is considered acceptable value according to (Hair et al., 2011).

Cronbach's alpha is another measure of the internal consistency of the measurement items, and it should be above 0.7 for each latent variable. As what can be seen from Table

3 below, all constructs in the model have Cronbach Alpha values greater than 0.7, this indicates that the metrics used to run these constructs are reliable and internally consistent which means that the items used to measure each construct measure the same underlying concept, and that the scores that were given obtained from these items is consistent and reliable Hair et al., (2016). In other words, the presence of elevated Cronbach Alpha values indicates that the constructs in the model measure what they are supposed to measure, and that the results obtained from the analysis are likely to be more accurate and reliable. However, it is important to note that Cronbach Alpha is only one measure of reliability, and should be used in conjunction with other measures of validity and reliability to fully assess the quality of the instrument and model.

Table 3

Construct Reliability and Validity

Construct / Method	Cronbach's alpha	CR	AVE
Knowledge.	0.852	0.858	0.693
Behavior.	0.817	0.824	0.732
Cost.	0.807	0.808	0.721
Environmental Effect.	0.792	0.797	0.707

Similar to Cronbach's alpha, a composite reliability value of 0.7 or higher is generally considered to indicate good internal consistency Hair et al., (2016). Therefore, all constructs in our model had CR values greater than 0.7, indicating that the measures used to operate these constructs are reliable and internally consistent. Composite reliability is a more appropriate measure of reliability for models with few constructs (e.g. three or four constructs as in our case) and when there is a high degree of correlation between the constructs Hair et al., (2016). However, as with Cronbach's alpha, it is important to use composite reliability in conjunction with other measures of validity and reliability to fully assess tool and model quality.

However, in addition to the above, it is also important to consider other factors such as discriminatory validity, reliability, and fit of the model when evaluating the overall quality of our PLS-SEM analysis.

3.3.1.2 Discriminant Validity

Discriminant validity is a concept that refers to the degree to which the constructs being measured in a study are distinct from one another. In other words, it measures whether two constructs are measuring the same thing or are truly distinct Hair et al., (2016). Discriminant validity is important in research because if two constructs are not distinct from each other, then it can lead to inflated correlations and affect the validity of the results. In this context, discriminant validity can be assessed using several methods. The first commonly used method is the Fornell-Larcker criterion, which involves comparing the square root of the average variance extracted for each construct with the correlation coefficients between the constructs.

If the square root of the AVE for a construct is greater than its correlation coefficient with another construct, then discriminant validity is said to be achieved Hair et al., (2016). In this study, Table 4 above, where listing the results for the Fornell-Larcker discriminant validity test. Fornell-Larker criteria values are usually reported to indicate whether discrimination validity was met for each construct in the study model. Fornell-Larcker criterion values can be found in Table 4. The diagonal elements in the table represent the AVE values, while the non-diagonal elements represent the correlations between the construct.

To evaluate the validity of the discriminator, we can compare each AVE value to the relationship between the construct and other constructs in the model. As can be seen, the value of AVE for each construct is greater than the correlations between it and the other constructs in the model of our study, and this indicates the discriminatory validity achieved. For example, the AVE value for the Knowledge (0.833) is greater than the correlation between it and Behavior (0.814), greater than the correlation with Cost (0.790), and greater than the correlation with the Environmental Effect (0.804).

Table 4

Latent Variable Correlation

Construct	Knowledge.	Behavior.	Cost.	Environmental Effect.
Knowledge.	0.833			
Behavior.	0.814	0.856		
Cost.	0.790	0.799	0.849	
Environmental Effect.	0.804	0.803	0.795	0.841

Another method to assess discriminant validity is the Cross-loadings which is refer to the extent to which an indicator loads onto a different construct than the one it is intended to measure. Cross-loadings of each measurement item on its own and other latent variables should be assessed to ensure that each item is measuring its intended construct. The results shown in Table 5 shows the placed indicators positioned in relation to the constructs the model.

The cross-loading criterion is another method used to assess the discriminatory validity of the constructs in this study's model. As mentioned, it involves checking whether the indicators of a given construct have higher loads in its own configuration than other constructs in the research model. Cross-loading parameter values can be found in Table 5. The values in the table represent the standard factor loads for each indicator in each construct in the model.

Table 5

Cross Loading

Indicator / Construct	Knowledge.	Behavior.	Cost.	Environmental Effect.
K1	0.832	0.639	0.629	0.637
K2	0.830	0.729	0.718	0.713
K3	0.887	0.719	0.704	0.711
K4	0.778	0.614	0.568	0.609
B1	0.761	0.902	0.731	0.752
B2	0.663	0.832	0.680	0.702
B3	0.660	0.832	0.635	0.600
SCMC1	0.658	0.744	0.867	0.693
SCMC2	0.709	0.612	0.836	0.628
SCMC3	0.649	0.675	0.844	0.704
EE1	0.597	0.637	0.648	0.810
EE2	0.698	0.685	0.663	0.837
EE3	0.726	0.702	0.693	0.873

By examining the values in the column for a particular construct (Behavior, for example) and looking for indicators that have higher loads in other constructs than in their own construct, we will find that all indicators (in this case B1, B2, and B3) were loaded more strongly in their construct than in the other constructs, which is an indication that the criterion is met cross-loading, it is deemed that the discriminatory validity has been achieved. To complete the example above, we notice that the factor loadings for B1, B2, and B3 with Behavior are (0.902), (0.832), and (0.832). Meanwhile (0.761), (0.663), (0.660) with Knowledge, (0.731), (0.680), and (0.635) with Cost, and (0.752), (0.702), and (0.600) with the Environmental Effect. Hence, it validates the discriminately.

In partial least squares structural equation modeling, the Heterotrait-Monotrait (HTMT) matrix is a frequently used technique for assessing discriminant validity. It offers details on the relationships between the model's constructs and aids in determining whether they are separate and do not overlap Henseler et al., (2015). Heterozygous correlations across constructs and unilateral correlations between each construct's average variance extracted (AVE) are compared in order to comprehend how this works Henseler et al., (2015). The HTMT values for our research constructs are displayed in Table 6 below.

The Heterotrait-Monotrait ratio was employed in this study's Table 6 and Appendix F as a gauge of discriminant validity. It assesses if the correlation between two constructs is appreciably larger than the correlation between each construct and its measures, as was previously established. An HTMT score less than 1 denotes strong discriminatory validity, but a value more than 1 denotes possible issues with discriminatory validity, as in our study. The fact that an HTMT value of less than 0.9 is regarded as acceptable in the analysis raises a little problem, although this cutoff point may change depending on the situation and study objective. In this study, HTMT values between 0.1 to 0.9 suggest that the discriminating validity of the constructs may be adequate, although more investigation may be necessary. Therefore, it is important to remember that numerous aspects, including the sample size, which is 100, and the model's complexity, which is very basic in our research, must be taken into consideration when evaluating HTMT findings (Henseler et al., 2015).

It is essential to remember that the HTMT matrix is only one method for evaluating discriminatory validity. The Fornell-Larcker criteria and our previous cross-loading method are other methods. Therefore, it is advised to employ a variety of techniques to evaluate discriminant validity and guarantee the reliability of results. It is also important to note that HTMT values must be interpreted in conjunction with other indices of discriminatory validity, such as the Fornell-Larcker criterion and cross-loading processes, to ensure robustness of results that would have confirmed the discriminatory validity of the research model.

Table 6

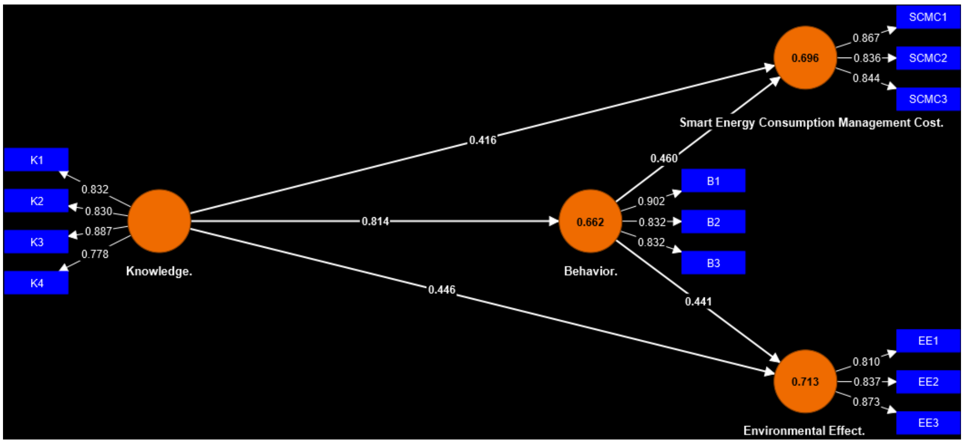
Heterotrait-Monotrait (HTMT) Matrix

Relation	Heterotrait-Monotrait ratio (HTMT)
Knowledge. <-> Behavior.	0.970
Knowledge. <-> Cost.	0.950
Knowledge. <-> Environmental Effect.	0.972
Behavior. <-> Environmental Effect.	0.993
Behavior. <-> Cost.	0.980
Cost. <-> Environmental Effect.	0.994

Figure 4 presents a set of information that resulted from the PLS-SEM algorithm analysis on the model framework, such as the factor loadings that appears between the indicators and constructs in addition to the path coefficient which is the estimated strength and direction of the relationship between two constructs in a structural model which is also called a path weight or beta coefficient (Leguina, 2015).

Figure 4

Model Framework - PLS-SEM Algorithm



By analyzing convergent validity, it was found that the measurement model fulfilled this test in all analytical respects. Appendix G summarizes the results of the convergent validity test for our model.

3.3.2 Assessment Of Structural Model (Inner Model)

The structural model specifies the relationships between the latent variables themselves. This is done by specifying the path coefficients, which represent the strength and direction of the relationship between each pair of latent variables Hair et al., (2016). These various statistical measures to evaluate the model fit, and at this section, we will shed light on some these methods.

3.3.2.1 Testing Hypothesis

Testing hypotheses in Smart-PLS involves running a statistical analysis of the structural model, which includes the measurement model and the structural relationships between the constructs Hair et al., (2016). It is necessary to check the path coefficient sizes and the statistical significance of the relationships in the structural model between the latent variables. For this reason, this check was performed by observing standard path coefficients (B-values) equal to or greater than 0.1 (presented in Figure 4), whereby the relationship can be assessed as 'significant'. statistic “If the t-value is equal to or greater than 1.96 at the 5% significance level (where 1.96 is a two-tailed significance level). Table 7 shows the results obtained by the bootstrapping procedure which conducted by adjusting the default settings with a 0.05 significance level, and a 100 number of iterations. Furthermore, Figure 5 and Figure 6 shows the P-Values and T – Statistics between the indicators and their underlining construct, and between the constructs themselves presented on the model framework that resulted from the bootstrapping analysis.

Table 7

Path Coefficient, STDEV, T values, and P-Values

Hypothesis / Criteria	Original sample (O)	Standard deviation (STDEV)	T statistics (|O/STDEV|)	P-Values
Knowledge. -> Behavior.	0.814	0.026	31.514	0.000
Knowledge. -> Cost.	0.416	0.084	4.925	0.000
Knowledge. -> Environmental Effect.	0.446	0.064	6.982	0.000
Behavior. -> Cost.	0.460	0.082	5.632	0.000
Behavior. -> Environmental Effect.	0.441	0.064	6.928	0.000

Figure 5

Model Framework - P-values

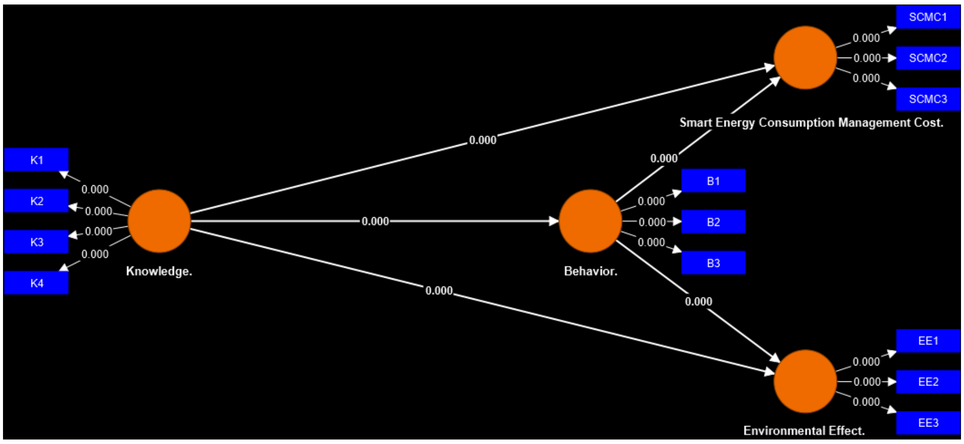
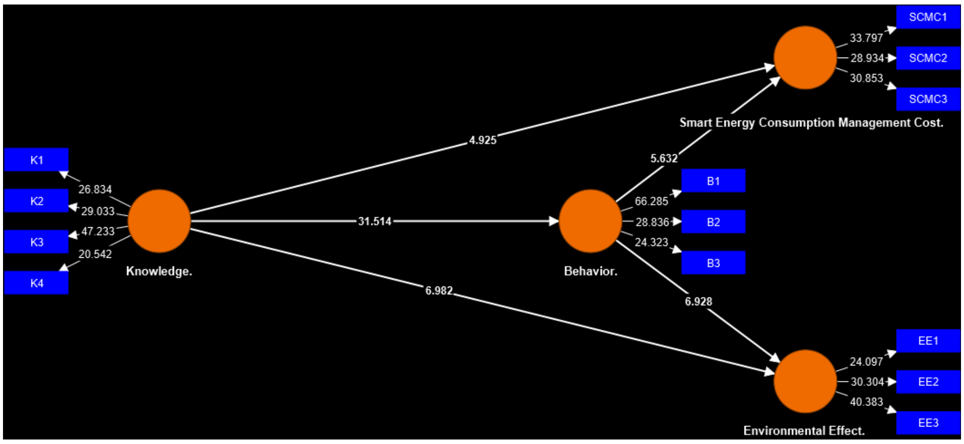


Figure 6

Model Framework - T-Statistics



A P-Value of (0.000) that emerged for H1 presented in Table 7 indicates that the results are statistically significant and provides strong evidence for rejecting the null hypothesis which assumed that there is no relationship between knowledge about smart management of energy consumption and sustainable energy behaviors. In this case, the results indicate that residents with knowledge of smart energy consumption management in buildings are more likely to adopt sustainable energy behaviors and reduce their energy use. However, it is important to note that statistical significance does not necessarily imply practical significance, and more research may be required to determine the practical implications of this relationship. Here it was necessary to use the qualitative analysis represented by the personal interviews that we have already mentioned which its results confirmed what we reached in the quantitative analysis above.

According to H2, a P-Value of (0.000) which is shown in Table 7 indicates that the results are statistically significant and provide strong evidence to reject the null hypothesis that there is no relationship between residents' knowledge of smart energy consumption management systems and the reduction of costs associated with smart energy consumption management systems in buildings. In this case, it suggests that residents' knowledge of smart energy consumption management systems in buildings is positively related to the reduction of costs associated with smart energy consumption management systems. At the same time, the results of the personal interviews confirmed the validity of what we reached in the quantitative statistical analysis above.

With regard to H3, the P-Value of H3 "Residents' knowledge of smart energy consumption management systems in buildings helps positively in reducing environmental damage" was less than 0.05, specifically (0.000), which means that the results are statistically significant. At the level of significance of 5% and provide some evidence to reject the null hypothesis that "there is no relationship between the residents' knowledge of smart energy consumption management systems and environmental damage reduction". In the results presented in Table 7, it indicates that the residents' knowledge of smart energy consumption management systems in buildings is positively associated with reducing environmental damage, which is consistent with what we obtained from our interview with decision makers in this field.

H4 with a P-Value of (0.000) indicates that the results are statistically significant and provides strong evidence to reject the null hypothesis that "there is no relationship between good behavior of residents inside buildings and lower costs associated with smart energy consumption management systems. In this study, there is a clear indication that good indoor residents' behavior is positively associated with lower costs associated with smart energy consumption management systems. This finding could have significant implications for building management and decision makers seeking to reduce costs associated with smart energy consumption management systems in buildings.

The project manager at Al-Takamul Engineering company Engineer M, T, stressed the importance of taking into account the specific behaviors that constitute the "good behavior of the residents" and how they can be effectively promoted and stimulated by the government, either through the development of legislation to limit the overall energy consumption or by holding educational seminars among the residents themselves with regard to smart energy consumption management.

H5 "The good behavior of residents inside buildings has a positive impact on minimizing potential damage to the environment" is a statement that needs to be tested using statistical analysis. When the P-Value equals (0.000), it suggests that the results of the statistical test are highly significant. Typically, the P-Value is used as a measure of the strength of evidence against the null hypothesis. A P-Value of (0.000) means that the probability of observing the test results if the null hypothesis were true is very low, indicating that the null hypothesis can be rejected. In the context of the hypothesis stated above, a low P-Value of (0.000) would suggest that there is strong evidence to support the hypothesis that “good behavior of residents inside buildings has a positive impact on minimizing potential damage to the environment”. In other words, the data provides evidence that the behavior of residents plays an important role in reducing environmental damage.

3.3.2.2 Coefficient of determination (R-squared values)

To put it another way, it shows how much of the variance in the dependent variable is explained by the model's independent variables Hair et al., (2016). The coefficient of determination R2 values for the research constructs are shown in Table 8 below. To gauge how much variance the research model could explain, R2 values were employed. R2 estimates the fraction of the model's independent variables (behavior, cost, and environmental effect) that can account for the variation in the dependent variable (knowledge and behavior) Hair et al., (2016). By using Table 8 to evaluate the R2 values, we can see that all of the dependent variables have R2 values larger than 0.6, indicating excellent model agreement and demonstrating that the independent variables in the model can account for a significant portion of the variation in the dependent variable. It is crucial to remember that this advice is not a set formula and may change based on the study situation. Consequently, high R2 values in the research model show that the model has significant concordance and that the independent variables are successful in accounting for a sizable percentage of the variation in the dependent variable (Track Appendix H).

3.3.2.3 Predictive Relevance (Q - squared values)

The Q2 statistic, which gauges a latent variable's capacity to forecast the endogenous variables in the model, is often used to evaluate predictive significance. Additionally, Q2 is determined by the cross-validation method, in which a portion of the data is used to estimate the model's parameters and the remaining portion is used to judge the model's prediction ability. A high Q^2 value indicates that the latent variable is able to predict the endogenous variables well, and therefore has good predictive relevance and the low Q^2 value suggests that the variable may not be a good predictor of the endogenous variables, and further investigation may be required to determine whether the variable is a valid representation of the construct of interest Hair et al., (2016). In addition to the R^2 values, Table 8 below shows the Q^2 predict values for the model's constructs.

In our research model, Q^2 values represent the predictive significance of the structural model. A Q^2 value exceeded (0.6), which indicates that the model has good predictive power and is able to accurately predict the outcome of the dependent variables (track Table 8). However, similar to the R^2 values, the interpretation of the Q^2 values can depend on the context of the analysis and the specific research question being addressed. In some cases, a lower Q^2 value may still be acceptable if the model has other strengths such as goodness of fit or strong path coefficients. It is also important to note that Q^2 values must be interpreted in conjunction with other measures of model quality such as validation indices, effect sizes, and significance levels. Together, these metrics can provide a more complete picture of the overall performance of the structural model.

Table 8

Quality Criteria - R^2 and Q^2

Construct	R-square	Q^2predict
Behavior.	0.662	0.653
Cost.	0.713	0.618
Environmental Effect.	0.696	0.640

3.3.2.4 Effect Size (F-squared values)

Effect size F-Square measures the proportion of variance in a dependent variable explained by an independent variable, and the Standardized Root Mean Square Residual (SRMR), which measures the average difference between the observed and predicted correlations in the model. Table 9 below shows the effect size values for the constructs of this study.

Table 9

Effect Size (F^2)

	Behavior	Cost	Environmental Effect
Knowledge	1.963	0.192	0.233
Behavior		0.235	0.228

In our study, the F^2 values were verified by an effect size solution for a specific predictor variable in the research model. Specifically, F^2 is the amount of variance in the dependent variable explained by the predictor variable, after calculating for the effects of other predictor variables in the model. F^2 values are commonly used in the context of multiple regression analysis, as they provide an estimate of the proportion of variance in the dependent variable that is explained by the predictor variables. In the research model, the F^2 values for each predictor variable in the structural equation model shown in Table 9 can be interpreted according to Cohen 1987 approach as follows:

F^2 values of 0.02, 0.15, and 0.35 represent small, medium, and high effect sizes, respectively. The F^2 values of Knowledge related to environmental Cost and Environmental Effect indicate that the Knowledge variable has a moderate effect on Cost

(0.192) and an Environmental Effect (0.233), while it has a strong effect on Behavior (1.963).

The F^2 values for Behavior related to Cost and Environmental Effect indicate that the Behavior variable has a mean effect on Cost (0.235) and an Environmental Effect (0.228). The F^2 values are useful for us to assess the relative importance of predictor variables in the research model and to make comparisons across models. It is important to note that effect sizes should always be interpreted in conjunction with other model fit statistics, such as R^2 which we previously analyzed, path coefficients and p-values, to fully understand the relationships between variables in the model.

3.3.2.5 Goodness of Fit index (GoF)

The structural model can be evaluated in several ways to ensure its accuracy and reliability so that the structural model can be evaluated using the quality of fit indicators. These indicate the fit of the model to the observed data. In addition, it can be evaluated by comparing the results of the model with an independent test set.

Goodness of fit index (GoF) which in turn means the ability to rely on the proposed model, whether on the measurement model represented by the AVE and structural model represented by the R^2. it can be calculated through a simple equation, which is:

Handing the square root of R^2 average multiplied by the AVE average which can be written in Equation 1 as follows:

$$\text{GoF Index} = \sqrt{\overline{\text{AVE}} * \overline{\text{R}^2}} \text{ ------------- Equation (1)}$$

By going back to the tables related to the previous equation, i.e., Table 3 and Table 8, we can calculate the general rate of excess and the general rate of deficiency and apply equation 1 to show the results as follows:

$$\overline{\text{AVE}} = \frac{(0.693 + 0.732 + 0.721 + 0.707)}{4} = 0.713$$

$$\overline{\text{R}^2} = \frac{(0.662 + 0.713 + 0.696)}{3} = 0.690$$

And by applying equation 1:

$$\text{GoF Index} = \sqrt{0.713 * 0.690} = 0.701$$

A GoF (Goodness-of-Fit) index value of 0.701 in our search model indicates that the model has a moderate fit to the data. It should be emphasized that the GoF index, whose value goes from 0 to 1, was used to gauge how well the model fit the data observed, and that any higher values indicate a better fit. An adequate degree of fit is indicated by a result of 0.701, which shows that the model accounts for around 70.1% of the variation in the data. It is crucial to remember that the complexity of the model and the size of the sample affect how the GoF index should be interpreted. Along with carefully evaluating the model's assumptions and constraints, it's crucial to take into the theoretical and practical importance of the results.

3.3.2.6 Mediation Analysis

The Behavior variable is operating as a mediating variable in this model, which means that it is both an independent variable for the dependent variables Cost and Environmental Effect and a dependent variable for the independent variable Knowledge. These details allow us to categorize the variables in the study model as follows:

- Knowledge of the residents is an independent variable.
- Environmental impact and cost are dependent variables.
- Behavior of the residents is the mediator variable.

The approach of Preacher and Hayes (2008) suggested a widely used procedure for carrying out a mediation analysis, which is a statistical technique used to look into the mechanisms by which an independent variable (Knowledge) influences a dependent variable (Cost and Environmental Effect) through one or more mediator variables (Behavior).

The strategy is frequently known as the "Preacher and Hayes mediation model" or the "bootstrapping method." According to Preacher and Hayes (2008), the approach involves testing three main hypotheses: the independent variable (Knowledge) is related to the mediator variable (Behavior) (path a), and the mediator variable (Behavior) is related to the dependent variable (Cost and Environmental Effect) when controlling for the independent variable (Knowledge) (path b). Additionally, when the mediator variable, behavior, is taken into in the analysis (route c), the link between the independent variable, knowledge, and the dependent variable, cost and environmental effect, weakens or vanishes. We tested these hypotheses using bootstrapping, a non-parametric resampling technique, to estimate the indirect effect of the independent variable which is Knowledge on the dependent variables Cost and Environmental Effect through the mediator variable Behavior.

The indirect effect represents the effect of residents' knowledge on the cost associated with Smart energy consumption management and its impact on the environment through adapting an energy-saving behaviors. Bootstrapping involves repeatedly resampling the data to generate a distribution of indirect effects. By tracking the information and results in appendices I and J, the hypothesis that we previously mentioned are strongly supported during the path coefficient values and p-values.

The confidence interval of this distribution used to test the significance of the indirect effect. A confidence interval is a range of values within which the true value of a population parameter is likely to lie. In this case, the population parameter is the indirect effect of the resident's knowledge on the cost associated with smart energy consumption management and its impact on the environment through adopting more energy-saving behaviors.

Confidence intervals for the indirect effect were calculated using the bootstrap method, which involves iteratively resampling the original data set to create many new samples of the same size. The indirect effect was then calculated for each of these new samples, resulting in a distribution of possible indirect effects. Confidence intervals were then calculated as the range of values at which the indirect effect is likely to decrease, based on the distribution of indirect effects generated by the bootstrapping samples.

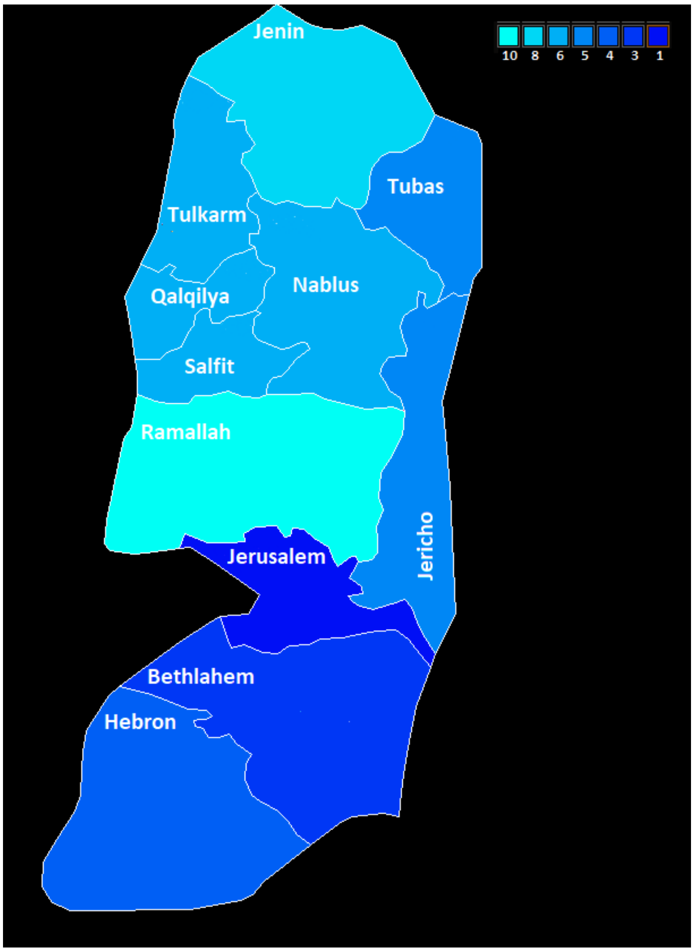
Confidence intervals for indirect effect are reported in Appendix K. The appendix provides information on the bias-corrected and accelerated confidence intervals (BCa) for indirect effects, which are based on a smooth distribution of indirect effects. BCa confidence intervals are more accurate than other types of confidence intervals because they correct for bias and skewness in the bootstrapping distribution. Confidence intervals for the indirect effect were used to determine whether the indirect effect was statistically significant. Obviously, the confidence interval does not include zero, which means that the indirect effect is statistically significant at the specified significance level (0.05), and there is evidence to support the existence of mediation of the behavior construct.

3.3.3 Descriptive Analysis

The survey sample contained 100 responses from various Provinces of the West Bank. Appendix L summarizes the distribution of homes, their sizes, and whether they contain a smart system or not, according to the provinces they belong to, in addition to the average monthly energy consumption for each province per (NIS).

Figure 7

Heat Map for The West Bank Provinces



As for the data collected from the questioner, 60 participants from a deferent providence in West Bank confirmed that they use a smart system in their homes, while another 40 admitted that they do not have a smart system in their homes. In Figure 7, the varying shades of red on the heat map indicate the quantity of households in each province that utilize a smart system to regulate their energy usage.

By examining the questioner (Appendix M), it is clear that the monthly rate of electric energy consumption for homes that have a smart energy consumption management system is lower than for those houses that operate on traditional (manual) systems. Not only that, but the average of these homes is lower than the traditional homes on the level of all sizes.

3.3.4 Hidden Patterns Assessment

In this process, as the oboist of the previous hypothesis testing approach, to examine the relationship between a nominal variable with two values (also called a dichotomous variable) and a construct in Smart-PLS, we can use a technique called the Partial Least Squares-Path Modeling (PLS-PM).

In PLS-PM, we can treat the nominal variable as an exogenous variable (i.e., a predictor variable) and the construct as an endogenous variable (i.e., a dependent variable). Then we can estimate the path coefficient between the nominal variable (i.e., a contain or not in our case) and the construct i.e., the Knowledge and behavior in our case) using the PLS algorithm just like we did in the assessment of the measurement model. It is important to note that the interpretation of the value of the path coefficient parameter in this case depends on the coding of the pointer variable. In our case, the nominal variable represents whether the building has a smart system or not, and the indicator variable is coded as 0 for yes and 1 for no.

After adding the new exogenous to the research model, Figure 8 shows the results of the calculation of the PLS-SEM algorithm, which includes the path coefficient between constructs and the R^2 values of each construct in addition to the factor loading, while Figure 9 presents the results of the bootstrapping calculation, which includes the P-Value between constructs and their indicators.

Figure 8

Model Framework: PLS-SEM Algorithm After Adding the Exogenous Variable

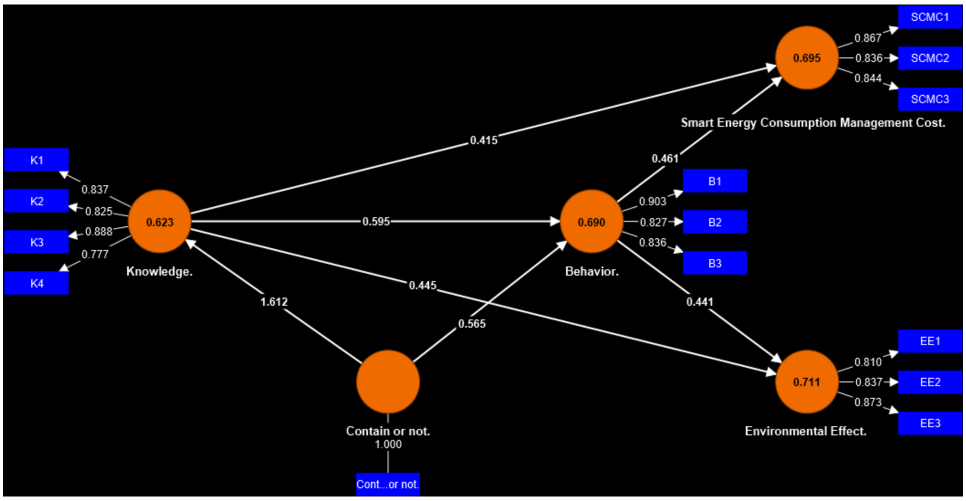
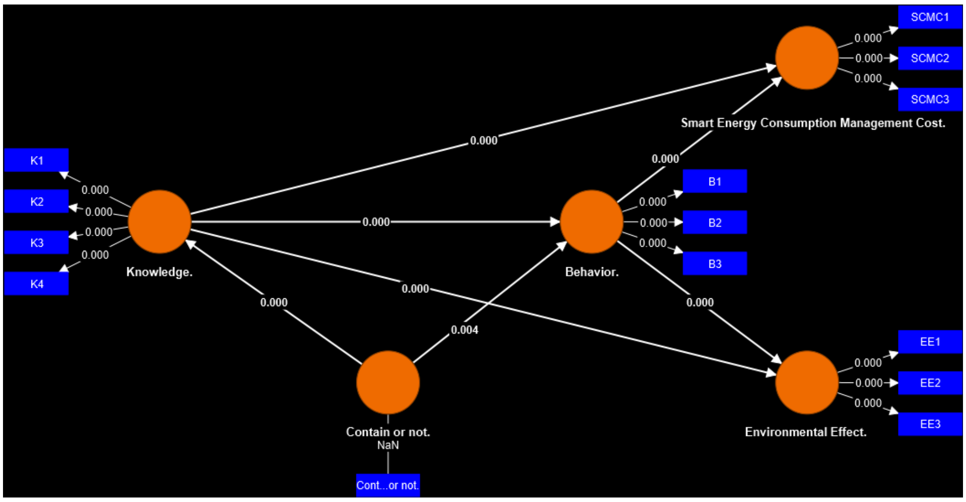


Figure 9

Model Framework: Bootstrapping - P-Values After Adding the Exogenous Variable



When the new exogenous (predictor) variable (contain or not) was included in the research model, it hardly affected any of the results of previous analyzes regarding the validity and reliability of the research model. Therefore, we consider it unnecessary to re-discuss the model's reliability and validity because it has not changed significantly.

The sixth hypothesis (H6) “There is a statistically significant positive relationship between the knowledge of the residents and their possession of a smart energy consumption management system in their buildings” is a statement that needs to be tested using statistical analysis (Track Appendix M, where the X axis representing the series number and the Y axis representing the knowledge level - First 40 series assigned to the traditional system and the rest of it are assigned to the smart system-).

As for Figure 9 the P-Value equals (0.000), it indicates that the results of the statistical test are highly significant. The P-Value is usually used as a measure of the strength of evidence against the null hypothesis. A P-Value of (0.000) means that the probability of observing the test results if the null hypothesis is very low, indicating that the null hypothesis can be rejected. In the context of the aforementioned hypothesis, a low P-Value of (0.000) indicates that there is strong evidence supporting the hypothesis that there is a significant positive relationship between residents' knowledge and their possession of a smart energy consumption management system in their buildings. In other words, the data provides evidence that residents implementing a smart energy consumption management system in their buildings have higher levels of knowledge about smart energy consumption management.

Hypothesis 7 (H7) “Residents who have a smart energy consumption management system in their buildings are more likely to engage in energy saving behaviors than those without such a system” is a statement that needs to be tested using statistical analysis (Track Appendix N, where the X axis representing the series number and the Y axis representing the behavior level - First 40 series assigned to the traditional system and the rest of it are assigned to the smart system-).

As can be seen in Figure 9 the P-Value equals (0.004), which indicates that the test results are statistically significant, although the level of significance is not as strong as if the P-Value was lower. Normally, a P-Value of less than (0.05) is considered statistically significant, meaning that there is strong evidence to reject the null hypothesis. In the context of the above hypothesis, a P-Value of (0.004) indicates that there is evidence to support the hypothesis that residents who have a smart energy consumption management system in their buildings are more likely to engage in energy-saving behaviors than those who do not have such a system. This evidence is statistically significant, indicating that the relationship between the presence of a smart system and energy-saving behaviors is unlikely to be due to chance.

3.3.5 Analysis of the Numerical Data Collected from the Institutions

As for the data collected from companies mentioned in the qualitative analysis that involved in the smart systems sector in buildings, it indicated that there is a clear growth in the use of smart systems (about 45% since 2014 until 2022), and this data indicates that most of these systems are KNX systems. It's probable that the use of smart systems has increased over the past few years, and KNX is one of the systems that many people are embracing. However, it is challenging to verify the veracity of the statement that "most" smart systems are KNX systems in the absence of further context or information.

It is also important to keep in mind that KNX is only one of many different kinds of smart systems. Zigbee, Z-Wave, and Wi-Fi-based smart systems are some additional well-liked smart systems. The best smart system to utilize will rely on a number of variables, including the individual use case, budget, and compatibility with current equipment. Therefore, while making assertions about the expansion and appeal of smart systems as well as the predominance of particular systems like KNX, it is crucial to take the context and data sources into account.

Chapter Four

Discussion, Conclusion and Recommendations

4.1 Chapter Overview

The outcomes of a research investigating the application of intelligent energy consumption management systems in residential structures in Palestine are the main subject of this chapter. Along with a discussion of the study's theoretical and practical consequences, it analyzes the results of the hypothesis testing. The chapter also includes recommendations for the general public and policymakers in this area, as well as a summary of the research results. The chapter's concluding portion analyzes the study's shortcomings and offers potential future research topics.

4.2 Discussion

The increased demand for energy efficiency and sustainability is driving a need for smart energy consumption control in residential structures. It is essential to increase energy efficiency and decrease waste due to the rise in the usage of energy-hungry gadgets, appliances, and other equipment in households.

We have outlined some of the most important facets of smart energy consumption management in residential buildings in this study.

4.2.1 Discussion of Smart Energy Consumption Management in Buildings

Monitoring energy use in buildings is the major responsibility of smart energy consumption management systems. Homeowners may use it to monitor their energy use in real time, spot areas with excessive energy use, and make changes to cut down on energy waste.

These systems can be as straightforward as an extra device that monitors the energy consumption of a single device or as complicated as a whole-house system that keeps track of the energy consumption of every item in the house.

One of the most efficient strategies to lessen energy waste is to use energy-efficient equipment. A few examples of energy-efficient products that may drastically lower energy usage in homes are Energy Star certified appliances, LED light bulbs, and smart thermostats.

Smart energy consumption management systems may also reduce the amount of energy used in a building by automatically altering the temperature, lighting, and other energy-hungry equipment based on occupancy, the time of day, and other variables.

Last but not least, locals can alter their behavior to save energy. By disconnecting appliances when not in use and turning off lights while leaving a room, for instance, you may assist decrease energy wastage and cut down on your electricity costs.

In order to avoid energy waste, save money on utility bills, and encourage sustainability, residential buildings must control their energy use carefully. Residents may considerably lower their energy usage and contribute to environmental protection by establishing energy monitoring systems, utilizing energy-efficient equipment, automating energy management, and changing behavior.

4.2.2 Qualitative Analysis Discussion

The qualitative research involves a thorough investigation of the intricate relationships between knowledge and behavior and how these factors significantly influence the development of intelligent energy management. The study illuminates the many facets of this connection by investigating the viewpoints of representatives from the Al-Takamul Engineering Company, the Seder Company, and the Palestinian Energy Authority. This discussion summarizes the salient points raised in this investigation:

4.2.2.1 Knowledge as The Main Driver

The discussion emphasizes the transformative power of knowledge. From the perspective of Al-Takamul Engineering Company, educating residents on smart energy consumption management stands out as a cornerstone for promoting energy efficiency and sustainability. By imparting knowledge about energy saving practices, residents can make informed choices to reduce energy waste. This education also extends to decision makers who can promote awareness through workshops and campaigns, creating a population equipped to make energy efficient choices in their daily lives. This underscores the importance of disseminating accurate information and providing tools to make informed decisions.

4.2.2.2 The Dual Role of Behavior

Behavior appears as an important link between knowledge and influence. The research demonstrates that population behavior is a key factor in determining the efficiency of intelligent systems, even those that are highly developed. Uninformed people could not make the best use of these technologies, missing out on potential energy savings. Additionally, knowing how to communicate with these systems intelligently makes sure that they make a beneficial difference in energy management. A simple yet effective strategy for minimizing energy consumption and hence expenses is to turn off gadgets when they are not in use. As a result, conduct turns into the practical application of information, serving as a link between knowledge and practical outcomes.

4.2.2.3 Environmental Stewardship

The analysis supports the idea that knowledge and conduct have consequences on the environment in addition to those on personal benefit. We can lessen our carbon impact by using smart technology to control energy use. Residents who are informed may control appliances wisely, optimize energy consumption, and change thermostat settings. This immediately reduces energy waste, which is good for the environment. The topic emphasizes how sustainable behavior and the larger environmental context are interdependent.

4.2.2.4 Contribute To a Sustainable Future

The research highlights the possibilities for educated decision-making and responsible behavior in crafting a more sustainable energy environment by examining these assumptions and gleaning insights from the interviews. The Palestinian Energy Authority, Seder Company, and Al-Takamul Engineering Company provide as examples of how businesses, organizations, and regulatory bodies may help spread information, encourage moral conduct, and eventually achieve sustainable goals. Broader consequences are also highlighted in the conversations, including financial savings, environmental preservation, and teamwork.

Essentially, the conversation placed a focus on the ability of informed knowledge and informed behavior to alter the field of intelligent control of energy usage. Businesses, people, and regulators may work together to create a future that is more energy-efficient, economical, and ecologically conscientious by coordinating these variables. This conversation serves as a microcosm of the worldwide movement toward sustainable practices and emphasizes the significance of each person's choices in determining the overall beneficial outcome.

4.2.3 Hypothesis Testing Discussion

According to H1, people who are knowledgeable about managing energy consumption in buildings intelligently are more likely to embrace sustainable energy practices and reduce their overall energy consumption. This claim is credible because it implies that education and information on the advantages of wise energy use can result in more responsible energy use. This theory has been validated by several research that show how knowledge and education may persuade people to adopt more sustainable energy habits. For instance, studies have demonstrated that giving homeowners feedback on their energy usage might inspire them to modify their behavior and lower their energy usage. Similar to the above, increasing the adoption of sustainable energy practices may be achieved through teaching people about the advantages of smart energy consumption management.

It is vital to take into a wide variety of elements that affect energy consumption and behavior modification, even though the general idea that information about smart energy consumption management might result in more sustainable energy behaviors is a reasonable one.

According to H2, homeowners who are knowledgeable about smart energy management systems may be able to save money on the installation and upkeep of these systems in buildings. The idea is tenable since bettering energy management systems' efficacy and efficiency might help people save money by requiring less frequent and expensive repairs and maintenance.

This theory has been validated by a number of studies, emphasizing the value of including locals in the planning and implementation of smart energy management systems. For instance, studies have shown that educating people on how energy management systems work may improve system efficiency and lower energy use.

Additionally, homeowners' active involvement in energy management techniques, such as modifying thermostat settings or cutting back on energy consumption during times of high demand, might result in additional cost savings. Building managers and energy service providers may customize energy management systems to fit the unique requirements and preferences of residents, resulting in more efficient and cost-effective systems, by incorporating tenants' expertise and input.

It is important to take into a wide range of factors that affect the costs and advantages of smart energy consumption management systems in buildings, even though it is accepted that residents' knowledge of these systems can help to reduce associated costs.

According to H3, tenants' awareness of smart energy management systems in buildings may help to lessen environmental harm. This idea is tenable since understanding sustainable energy practices can result in more responsible energy use and less negative environmental effect.

People may adopt more sustainable habits as a result of being educated on the advantages of renewable energy and energy efficiency. For instance, giving homeowners feedback on their energy usage might inspire them to change their habits and use less energy. Similar to how increasing adoption of sustainable energy practices may help reduce environmental harm, educating on the advantages of smart energy consumption management can do the same. Residents' participation in energy management techniques, such as modifying thermostat settings, utilizing energy-efficient equipment, and cutting back on energy consumption during times of high demand, can also support environmental sustainability.

In general, it is important to take into a wide range of factors that influence energy consumption and behavior change, as well as the efficacy of policy interventions in promoting sustainable energy practices, even though the hypothesis that residents' knowledge of smart energy consumption management systems can assist in reducing environmental damage is valid.

H4 contends that smart energy consumption management systems may be more economically implemented if building occupants behave well. This claim is credible given that wise resident behavior may help reduce energy use and expenditures by utilizing energy-efficient equipment, shutting off lights and devices when not in use, and modifying thermostat settings.

The success of energy management schemes may be shown to be significantly influenced by inhabitants' behavior, which provides evidence in favor of this idea. For instance, studies have shown that providing feedback and educating people about their energy use can result in behavioral adjustments and improved energy efficiency.

The efficacy and efficiency of smart energy consumption management systems may also be improved by excellent resident behavior, which will lead to cheaper maintenance and repair expenses. Residents may help energy management systems last longer and prevent the need for expensive replacements by easing the burden on them.

Finally, while the idea that smart energy consumption management systems might save expenses by reducing costs associated with good resident behavior inside buildings is feasible, it is vital to take a wide variety of factors that affect costs and energy consumption into consideration. It could be important to put in place a thorough strategy that incorporates policy actions, education, and feedback in order to achieve significant cost savings.

H5 contends that environment-harming resident behavior inside of buildings may be reduced. This theory is tenable because local inhabitants' actions may significantly affect energy use and the resulting environmental effect.

This idea is reinforced by evidence showing how important locals' actions are in fostering sustainability and minimizing environmental harm. For instance, research has indicated that energy use feedback and education can result in behavioral changes and improved energy efficiency. Residents' participation in energy management techniques, such as modifying thermostat settings, utilizing energy-efficient equipment, and cutting back on energy consumption during times of high demand, can support environmental sustainability.

A good resident's conduct can also contribute to a reduction in the environmental effect and carbon footprint of buildings. Residents may contribute to a reduction in greenhouse gas emissions and other possible environmental harm by using less energy.

This study's conclusion emphasizes the significance of comprehending the mechanisms by which information influences behavior, which in turn affects the environment and the cost of smart energy consumption management. Promoting sustainable energy habits and achieving significant outcomes in terms of energy reduction, cost savings, and environmental sustainability require a comprehensive strategy that combines education, feedback, and regulatory interventions. It is critical to consider an all-encompassing strategy that includes policy interventions, feedback, and education for decision-makers in this field as well as the general public. This strategy is crucial for advancing sustainable energy and practices and achieving notable reductions in costs, energy use, and environmental sustainability.

4.3 Conclusion

In conclusion, adopting smart energy consumption management systems in the residential sector can lead to significant benefits, including reduced energy use, reduced costs, and improved sustainability.

Smart energy consumption management systems use IoT technology to collect and analyze data on energy consumption and building performance, allowing building occupants to optimize energy use and reduce waste. In addition, residents can benefit from these systems by receiving real-time feedback on their energy use and learning how they can contribute to energy savings.

However, the successful adoption of smart energy consumption management systems requires educational and awareness efforts to increase the residents' knowledge of these systems and how they operate.

To assist residents, understand the advantages of these technologies and how they might contribute to energy savings, building managers can offer information and training. Residents' adoption of energy-saving activities can also be influenced by incentives.

By lowering energy usage, lowering expenses, and raising overall building performance, the adoption of smart energy consumption management systems in the residential sector can, in general, help create a more sustainable future.

At this point in the study, we would like to emphasize that it was primarily based on the residential sector in the West Bank, which leaves the door open for further investigation into the amount to which smart management has embraced energy usage.

4.4 Recommendations

4.4.1 Diversifying Geographical Representation

While the study provides valuable insights from the West Bank, it is recommended that future research endeavors expand its geographical scope to include other Palestinian territories, such as the Gaza Strip. This will provide a more comprehensive understanding of smart energy consumption management practices across different contexts within the region.

4.4.2 Fostering Industry Engagement

Future research should look into ways to promote collaboration and involvement with a wide variety of businesses and organizations linked to smart energy systems, given the difficulties in getting participation from different institutions. This may entail fostering stronger connections, resolving issues, and emphasizing the advantages of participating in research projects.

4.4.3 Incorporate Additional Stakeholders

Expanding the number of stakeholders questioned outside of businesses, such as include representatives from governmental organizations, regulatory bodies, and academic institutions, might further enhance the qualitative study. A more thorough understanding of the variables influencing and having an influence on smart energy consumption management may be provided by this multi-perspective approach.

4.4.4 Evaluation of Implementation Strategies

Conducting research on the best ways to educate the public about smart energy usage management. Analyze the viability and effects of different teaching techniques, seminars, instructional resources, and awareness-raising initiatives that decision-makers might employ to improve the public's comprehension and adoption of energy-saving habits.

4.4.5 Explore technology integration

To further enhance the control of energy use, look at the integration of smart systems with technology advancements like artificial intelligence and data analytics. This investigation may shed light on how cutting-edge technology might increase the efficiency and sustainability of smart systems while also enhancing their efficacy.

4.4.6 Assessment of long-term behavioral change

Studies of long-term behavior to track and assess the long-term impacts of public knowledge and behavior on intelligent energy management. The durability of energy-saving strategies and their effects on cost savings and environmental protection can be better understood by tracking behavioral patterns over time.

4.4.7 Policy and Regulatory Frameworks

Examining how laws and regulations affect the promotion and motivation of smart energy management methods. Examine the possible effects of legislative changes, financial assistance, or other incentives on influencing people and companies to adopt energy-efficient practices and innovations.

4.4.8 Cross-Sector Collaboration

Find ways for the commercial sector, governmental organizations, and academic institutions to work together to tackle issues with energy management and sustainability. The creation of comprehensive plans and activities to encourage smart energy practices can be facilitated by these relationships.

4.4.9 Case Studies and Best Practices

Create case studies that showcase effective ways to apply smart energy consumption control in various situations. These case studies can be used as models for decision-makers and assessors, showcasing the advantages and practical outcomes of implementing energy-saving practices and technology.

4.4.10 Campaigns for Public Awareness

Collaborate Work together with communication specialists to develop and carry out persuasive public awareness campaigns that highlight the social, political, and financial advantages of smart energy consumption control. Utilizing various platforms for communication, such as social media, seminars, and neighborhood activities, can assist in reaching a larger audience and promoting behavior change.

While this study offered insightful information about how knowledge, behavior, economics, and environmental impacts relate to smart energy consumption management, the recommendations offered here offer opportunities for additional study and action to advance knowledge of and support for sustainability. Energy usage patterns in Palestine and elsewhere.

4.5 Study Limitations

A. **Sample size restrictions:** For our quantitative analysis, the ten-fold rule was used to determine the sample size, which led to an anticipated sample size of 170 participants. Nevertheless, our study was only able to gather 100 analytical samples in the end due to logistical constraints and data collection difficulties. This decrease in sample size presents a potential limitation in the extent to which our findings can be confidently extrapolated to a wider population.

B. **Limited corporate representation:** Within the scope of our qualitative analysis, we sought to interview a variety of companies relevant to the focus of the study. Unfortunately, our efforts were hampered by a large number of organizations who declined to participate, resulting in only three companies being successfully interviewed. This limited engagement with a subset of potential participants raises concerns about the comprehensiveness and representativeness of our results in relation to the growth trajectory of smart systems in the West Bank and the mainstream technology landscape.

C. **Geographical Scope Limitations:** The geographical scope of this study was intentionally limited to focus only on the West Bank region, excluding other Palestinian territories such as the Gaza Strip. This decision was made due to the prevailing restrictions imposed by the Israeli occupation authorities, which have restricted our ability to access and conduct research within these restricted areas. As a result, our findings may not fully reflect the broader Palestinian context, which may limit the generalizability of our conclusions outside the West Bank region.

4.6 Future Research

In this study, we chose not to delve into the examination of certain parameters associated with Society 5.0, such as big data and artificial intelligence. Instead, we concentrated on the characteristics that had already been covered in this study, leaving the other issues for further investigation. Future studies on smart energy management in Palestinian structures may also concentrate on a number of different topics. It might first look at the obstacles that keep homes from using smart energy consumption control strategies. Future study might provide techniques to solve these problems and promote higher acceptance of smart energy consumption management systems by addressing the difficulties linked to cost, technical skill, and cultural or behavioral variables. The integration of smart energy consumption management systems with Palestine's current power grid may be another subject for investigation. Future study may suggest methods to improve the integration process by examining the advantages of such integration, such as improved energy distribution and fewer power interruptions. The cost-benefit evaluation of innovative energy consumption management strategies in Palestine might also be done. A choice on adopting and implementing these solutions might be made with the use of such an analysis, which could also assist stakeholders in understanding the potential economic, social, and environmental advantages of these solutions.

List of Abbreviations

Abbreviation	Meaning
IoT	Internet of Things
PEA	Palestinian Energy Authority
BEMS	Building Energy Management System
EUC	Energy Use Control
EPA	Energy Performance Analysis
ECM	Energy Consumption Monitoring
EDF	Energy Demand Forecasting
KNX	Konnex Association

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Appendices

Appendix A

Tables

Table A.1

The Common Application of Research Design

Design	Best for	Also used for
	Survey	
1. Cross-Section	Description Explanation	Explanation
2. Longitudinal		Exploration
Literature Reviews	Exploration	Description & Explanation
	Unobtrusive Method	
1. Cross-Section	Description	Explanation Exploration
2. Longitudinal	Description Explanation	Exploration
Experiment	Experimentation	
Field Search	Exploration	Description Explanation

Source: (Islamia, 2016a). The non-intrusive approach to gathering information involves obtaining data without disrupting the daily routines of the individuals under investigation. This may entail scrutinizing available statistics, past records, or studying written materials.

Table A.2

Survey Questions (English)

General Question						
Which province do you belong to?						
What is the average cost of your monthly electricity consumption?						
What is the size of your home?						
Do you have a smart system in your home?						
What is the nature of the smart system in your home						
Do you believe in using smart systems in Palestinian homes						
		Rating				
#Q	Knowledge.	1 SA	2 A	3 NI	4 D	5 SD
K1	Energy consumption management is the main task of smart systems in buildings.					
K2	The smart system reduces the effort of monitoring the electrical devices inside the building.					
K3	The smart system reduces the time required for system's installation and maintenance inside the building.					
K4	The use of smart systems in buildings is useful in terms of electrical energy management principle.					
Behavior.		ND	RD	N	RdD	AD
B1	Leave the lights on after you're done.					
B2	Use of the electric heater.					
B3	Use of conditioners.					
Smart Consumption Management Costs.		SA	A	NI	D	SD
SCMC1	Smart systems reduce energy consumption costs in homes.					
SCMC2	The price of installing smart systems is exaggerated in Palestine.					
SCMC3	Using a smart system for a specific function within the home, such as lighting, for example, is much more economically viable than installing a complete system for all of the home's activities.					
Environmental Effects.		SA	A	NI	D	SD
EE1	Smart home systems are more environmentally sustainable than traditional systems in Palestine.					
EE2	There is not enough awareness among people about the sustainability of the environment with regard to energy consumption in Palestine.					
EE3	There is negligence on the part of the government in Palestine to reduce the side effects of domestic energy consumption on the environment.					

Just to mentioned, SA: Strongly Agree, A: Agree, NI: No Idea, SD: Strongly Disagree, D: Disagree, ND: Never Do, RD: Rarely Do, N: Neutral, RdD: Rarely don't Do, and AD: Always Do.

Table A.3

Survey Questions (Arabic)

اسئلة عامة

الى أي محافظة تنتمي؟

ما هو معدل استهلاكك الشهري للكهرباء؟

ما هو حجم منزلك؟

هل يحتوي منزلك على أي نظام ذكي؟

ما هي طبيعة النظام الذكي ان وجد؟

هل تشجع على استخدام انظمة الادارة الذكية لاستهلاك الطاقة في المباني؟

		التقييم				
#س:	المعرفة	1 موافق بشدة	2 موافق	3 محايد	4 معارض	5 معارض بشدة
K1	إدارة استهلاك الطاقة هي المهمة الرئيسية للأنظمة الذكية في المباني.					
K2	. يقلل النظام الذكي من جهد مراقبة الأجهزة الكهربائية داخل المبنى.					
K3	يقلل النظام الذكي من الوقت اللازم لتركيب النظام وصيانته داخل المبنى.					
K4	استخدام الأنظمة الذكية في المباني يتوافق مع مبدأ إدارة الطاقة الكهربائية					
	السلوك	لا افعل	نادرا افعل	محايد	نادرا لا افعل	افعل
B1	ترك الانارة قيد العمل بعد الانتهاء من حاجتها.					
B2	استخدامك لأجهزة التكييف.					
B3	استخدامك للسخان الكهربائي.					
	تكاليف الادارة الذكية لاستهلاك الطاقة في المباني	موافق بشدة	موافق	محايد	معارض	معارض بشدة
SCMC1	تقلل الأنظمة الذكية من استهلاك الطاقة في المنازل.					
SCMC2	سعر تركيب الأنظمة الذكية مبالغ فيه في فلسطين.					
SCMC3	يعد استخدام نظام ذكي لوظيفة معينة داخل ألمنزل مثل الإضاءة على سبيل المثال أكثر جدوى من الناحية الاقتصادية من تثبيت نظام كامل لجميع أنشطة المنزل.					
	الاثر البيئي	موافق بشدة	موافق	محايد	معارض	معارض بشدة
EE1	أنظمة المنزل الذكي أكثر استدامة من الناحية البيئية من الأنظمة التقليدية في فلسطين.					
EE2	لا يوجد وعي كاف بين الناس حول استدامة البيئة فيما يتعلق باستهلاك الطاقة في فلسطين.					
EE3	هناك تقصير من جانب الحكومة في فلسطين للحد من الآثار الجانبية لاستهلاك الطاقة المحلية على البيئة.					

Table A.4

Interviews Uniformed Questions

Uniformed questions
Does residents' knowledge of smart energy consumption management systems in buildings affect their consumption behavior?
Does the residents' knowledge of smart energy consumption management systems in buildings affect the associated costs?
Does the residents' knowledge of smart energy consumption management systems in buildings affect the environment?
Does the consumption behavior of the residents affect the costs associated with smart energy consumption management systems in buildings?
Does the consumption behavior of the residents affect the environment?

Table A.5

Qualitative Analysis Coding Table

Hypothesis	Representative	Key Points/Themes	Quotation	Codes
Hypothesis 1: Knowledge -> Behavior	Engineer M, T, Al-Takamul Engineering	Residents' knowledge of smart energy consumption management	"Residents' knowledge of smart energy consumption management can play an important role in enhancing energy efficiency and sustainability in buildings"	KB1
Hypothesis 1: Knowledge -> Behavior	Engineer Q, A, S, Al-Takamul Engineering	Educating residents and providing feedback	"Decision makers can encourage residents to adopt behaviors that contribute to a more sustainable future by educating residents, providing feedback, and offering incentives"	KB2
Hypothesis 1: Knowledge -> Behavior	Engineer M, A, M, Palestinian Energy Authority	Knowledge of smart energy consumption management and its components	"Knowledge of smart energy consumption management means that residents understand how to effectively manage their energy use in buildings"	KB3
Hypothesis 1: Knowledge -> Behavior	Engineer O, H, Seder Company	Supportive environment and residents' active participation	"By implementing the strategies mentioned above, decision-makers can create a supportive environment that promotes energy efficiency and sustainability"	KB4
Hypothesis 2: Knowledge -> Cost	Engineer M, T, Al-Takamul Engineering	Smart systems in buildings and their impact on cost	"Smart systems in buildings are designed to automate and improve energy use by monitoring and controlling various systems"	KC1
Hypothesis 2: Knowledge -> Cost	Engineer Q, A, S, Al-Takamul Engineering	Effectiveness of smart systems and residents' understanding	"The effectiveness of these smart systems depends on the understanding and use of the building's occupants"	KC2
Hypothesis 2: Knowledge -> Cost	Engineer M, A, M, Palestinian Energy Authority	Residents' behavior and its impact on energy consumption	"Residents who lack knowledge may not adjust thermostat settings to optimize energy use or forget to turn off lights and appliances"	KC3

Hypothesis	Representative	Key Points/Themes	Quotation	Codes
Hypothesis 2: Knowledge -> Cost	Engineer O, H, Seder Company	Educating residents and optimizing energy consumption	"Educating residents about the features and benefits of these systems is essential to increase their effectiveness in reducing energy use and achieving sustainability goals"	KC 4
Hypothesis 3: Knowledge -> Environmental Effect	Engineer M, T, Al-Takamul Engineering	Smart systems' contribution to sustainability	"Smart energy consumption management systems in buildings have the ability to reduce energy consumption, which leads to a more sustainable and environmentally friendly living environment"	KE1
Hypothesis 3: Knowledge -> Environmental Effect	Engineer Q, A, S, Al-Takamul Engineering	Behavior and its impact on energy consumption and carbon emissions	"When residents are aware of the smart systems installed in their buildings and understand how to use them efficiently, they can take effective steps to reduce energy consumption and carbon emissions"	KE2
Hypothesis 3: Knowledge -> Environmental Effect	Engineer M, A, M, Palestinian Energy Authority	Residents' knowledge and sustainable practices	"Through knowledge about the features and capabilities of smart systems, residents are empowered to make informed decisions and actively participate in sustainable living practices"	KE3
Hypothesis 3: Knowledge -> Environmental Effect	Engineer O, H, Seder Company	Residents' behavior and reducing environmental footprint	"Residents' behavior plays an important role in determining the cost of energy consumption management for smart systems"	KE4
Hypothesis 4: Behavior -> Cost	Engineer M, T, Al-Takamul Engineering	Residents' behavior and system effectiveness	"For optimal energy use and waste reduction, it is imperative that residents are aware of the energy-saving features of their smart systems and make effective use of them"	BC1

Hypothesis	Representative	Key Points/Themes	Quotation	Codes
Hypothesis 4: Behavior -> Cost	Engineer Q, A, S, Al-Takamul Engineering	Proper use of smart systems and energy efficiency	"Residents should also avoid overriding system settings in a way that renders them ineffective"	BC2
Hypothesis 4: Behavior -> Cost	Engineer M, A, M, Palestinian Energy Authority	Energy waste and responsible energy use	"Residents should pay attention to turning off devices when not in use to reduce energy waste"	BC3
Hypothesis 4: Behavior -> Cost	Engineer O, H, Seder Company	Energy-conscious behaviors and cost savings	"Residents can increase the efficiency of these systems and help reduce overall energy costs by adopting energy-conscious behaviors"	BC4
Hypothesis 5: Behavior -> Environmental Effect	Engineer M, T, Al-Takamul Engineering	Individual behavior and environmental impact	"The hypothesis recognizes the critical role of individual behavior in shaping the environmental impact of smart systems in buildings"	BE1
Hypothesis 5: Behavior -> Environmental Effect	Engineer Q, A, S, Al-Takamul Engineering	Impact of behavior on smart systems and environment	"The impact of smart systems in buildings on the environment is affected by the behavior of residents"	BE2
Hypothesis 5: Behavior -> Environmental Effect	Engineer M, A, M, Palestinian Energy Authority	Residents' behavior and sustainability options	"Residents' behavior can be instrumental in promoting sustainable choices"	BE3
Hypothesis 5: Behavior -> Environmental Effect	Engineer O, H, Seder Company	Residents' behavior and healthier environment	"Residents' behavior can contribute to a healthier environment"	BE4

Table A.6

Indirect Effects

Relation	Original sample (O)	Standard deviation (STDEV)	T statistics (|O/STDEV|)	P-Values
Knowledge. -> Behavior. -> Cost.	0.374	0.068	5.502	0.000
Knowledge. -> Behavior. -> Environmental Effect.	0.359	0.054	6.700	0.000

Table A.7

Total Effects (Mediation)

Relation	Original sample (O)	Standard deviation (STDEV)	T statistics (|O/STDEV|)	P-Values
Knowledge. -> Behavior.	0.814	0.026	31.514	0.000
Behavior. -> Cost.	0.460	0.082	5.632	0.000
Behavior. -> Environmental Effect.	0.441	0.064	6.928	0.000
Knowledge. -> Cost.	0.374	0.068	5.502	0.000
Knowledge. -> Environmental Effect.	0.359	0.054	6.700	0.000

Table A.8

Confidence Intervals Bias Corrected

Relation	Original sample (O)	Bias	2.5%	97.5%
Knowledge. -> Cost.	0.374	0.010	0.252	0.499
Knowledge. -> Environmental Effect.	0.359	0.001	0.228	0.450

Table A.9

Questioner Summary

	Not Contain.						Contain.					
	Small.		Medium.		Large.		Small.		Medium.		Large.	
Province.	Bill	Nu	Bill	Nu	Bill	Nu	Bill	Nu	Bill	Nu	Bill	Nu
Bethlehe	250	2	400	1	300	1	0	0	0	0	513	3
Hebron.	350	1	450	2	550	2	0	0	500	1	517	3
Jenin.	0	0	400	1	600	1	205	4	0	0	438	4
Jericho.	230	1	515	2	0	0	300	1	300	2	450	2
Jerusale	0	0	350	1	650	4	0	0	0	0	550	1
Nablus.	300	1	400	1	400	2	200	2	375	2	375	2
Qalqilya.	0	0	0	0	475	2	250	3	387	3	0	0
Ramallah	0	0	0	0	467	3	200	1	483	3	425	6
Salfit.	0	0	0	0	600	4	300	1	420	1	475	4
Tubas	0	0	500	1	500	2	250	1	433	3	500	1
Tulkarm.	295	2	480	1	450	2	225	2	500	2	650	2
Total:	1425	7	3495	10	4992	23	1930	15	3398	17	4893	28
Average:	204		350		217		129		200		175	

Table A.10

Convergent Validity

Construct	Cronbach' Alpha	CR	AVE	Indicator	Factor loadings
				K1	0.832
				K2	0.830
Knowledge.	0.852	0.858	0.693	K3	0.887
				K4	0.778
				B1	0.902
Behavior.	0.817	0.824	0.732	B2	0.832
				B3	0.832
				SCMC1	0.810
Cost.	0.807	0.808	0.721	SCMC2	0.837
				SCMC3	0.873
				EE1	0.867
Environmental Effect.	0.792	0.797	0.707	EE2	0.836
				EE3	0.844

Appendix B

Figures

Figure B.1

Heterotrait-Monotrait Ratio

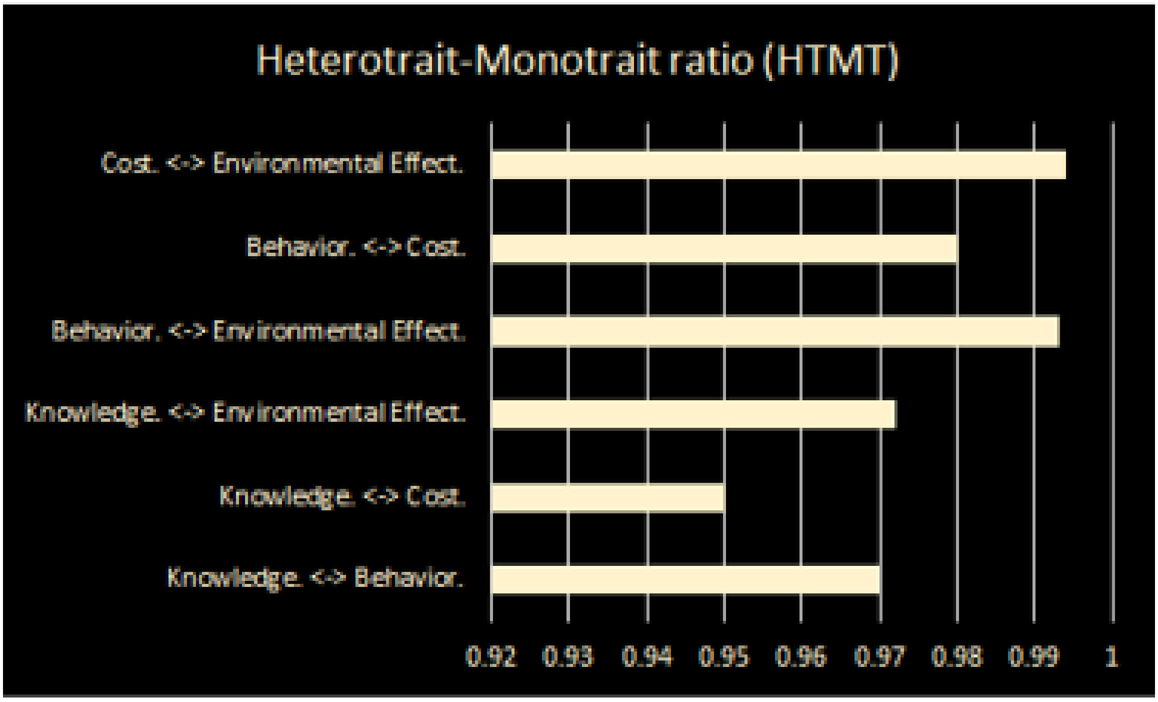


Figure B.2

Coefficient of Determination (R2)

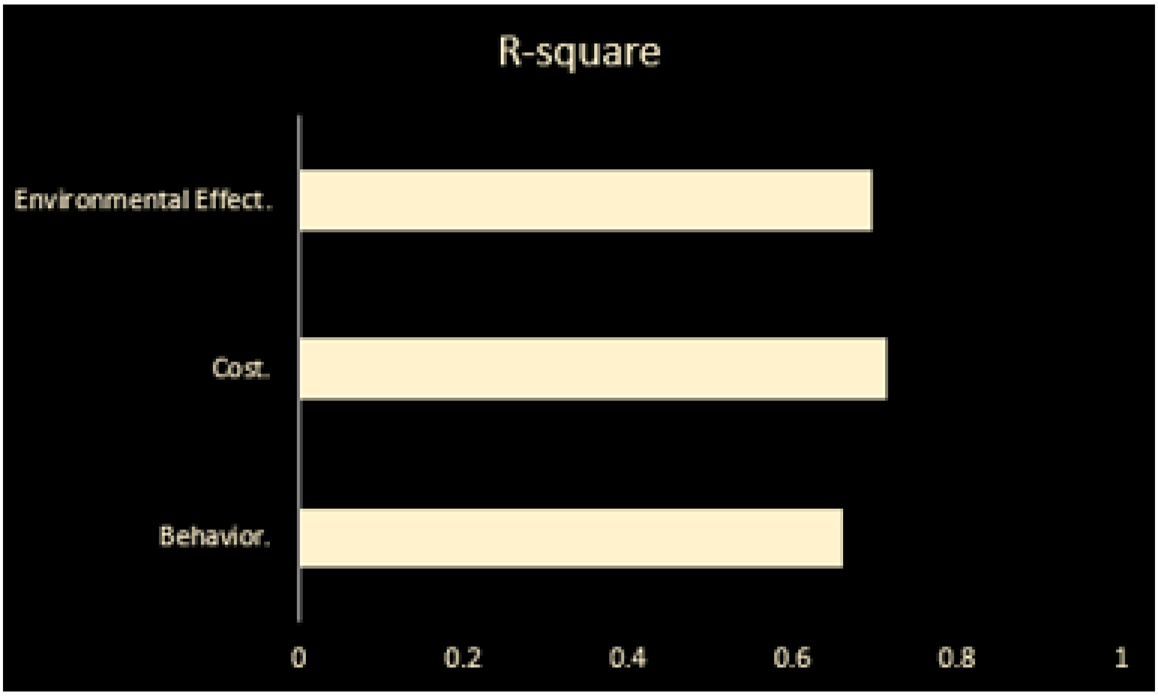


Figure B.3

Knowledge Levels for Residents

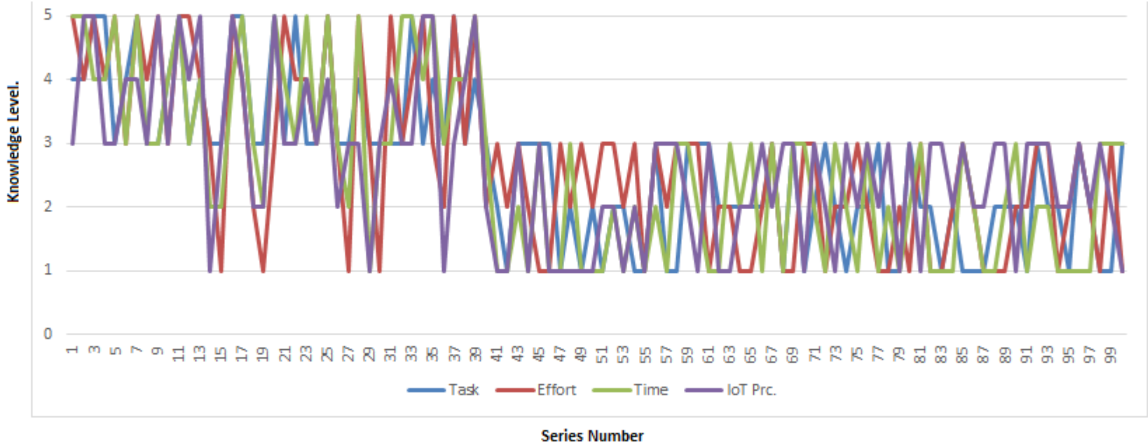
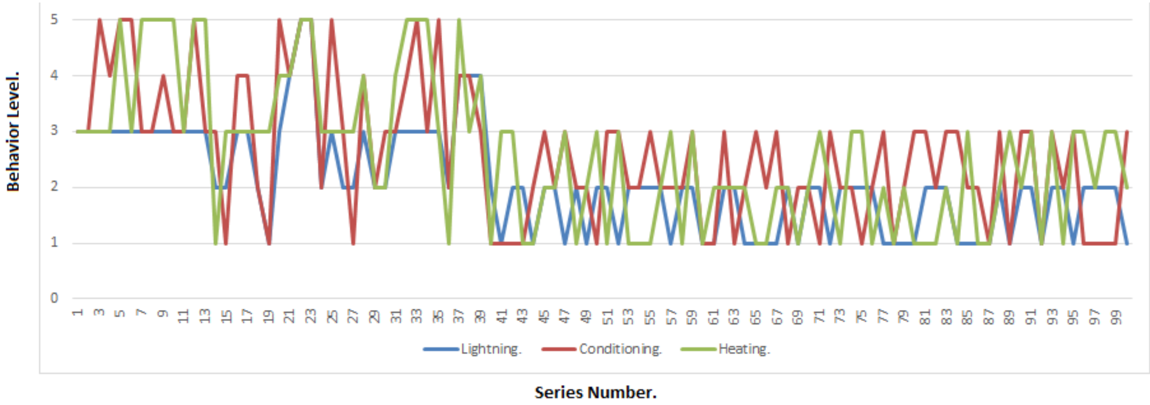


Figure B.4

Behavior Levels for Residents



جــامعـــــة النجاح الوطنية

كليـــة الدراســــات العليــا

الادارة الذكية لاستهلاك الطاقة في المبانـي

إعداد

براء حكواتي

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قدمت هذه الرسالة استكمالا لمتطلبات الحصول على درجة الماجستير في الإدارة الهندسية، من كلية الدراسات العليا، في جامعة النجاح الوطنية، نابلس– فلسطين.

2023

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الملخص

الإدارة الذكية لاستهلاك الطاقة، وهي تقنية جديدة تعمل على زيادة كفاءة الطاقة وتقليل استخدام الطاقة في المباني، تعمل وفقًا لمبادئ إنترنت الأشياء. الغرض من هذه الدراسة هو فهم كيفية تأثير وعي الأسرة بالإدارة الذكية لاستهلاك الطاقة على إدارة استهلاك الطاقة الذكية وتأثيراتها على سلوك المستخدم والنفقات والأثر البيئي. تم استخدام استبيان يحتوي على 100 إجابة صالحة في نموذج البحث لتقييم العادات المعرفية والاستهلاكية لقاطني المباني في فلسطين. ومع ذلك، تم استخدام نمذجة المعادلات الهيكلية بالمربعات الصغرى الجزئية (PLS-SEM) وبرنامج Smart-PLS لتقييم نموذج البحث. وتشير نتائج الدراسة بوضوح إلى أن تركيب أنظمة ذكية لإدارة استهلاك الطاقة في المباني السكنية يمكن أن يؤدي إلى تحسينات كبيرة في كفاءة استخدام الطاقة. إن تنفيذ هذه الأنظمة المتقدمة لإدارة الطاقة يحمل وعدًا كبيرًا بتعزيز الاستدامة، لا سيما عن طريق الحد من التأثير البيئي. إن الكشف المهم من هذا البحث هو ضرورة المبادرات التي تركز على تعزيز إلمام السكان بهذه الأنظمة. تعد حملات التثقيف والتوعية ضرورية لتشجيع الحفاظ على الطاقة والاستخدام المسؤول للمعدات الموفرة للطاقة. وفي الختام، تؤكد هذه الدراسة على الإمكانات التحويلية لإدارة استهلاك الطاقة الذكية في المساهمة في مستقبل أكثر استدامة وكفاءة في استخدام الطاقة للمباني السكنية، ولكنها تؤكد على أن جهود نشر المعرفة والتوعية جزء لا يتجزأ من تحقيق هذه الفوائد.

الكلمات المفتاحية: الإدارة الذكية لاستهلاك الطاقة، سلوك المستخدم، والأثر البيئي.