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Ph. D. Dissertation in Engineering

Exploring Factors Influencing Energy Transition Towards Sustainable Smart Cities from Sociotechnical Perspective: Insights for Iraq

사회 기술적 관점에서 지속 가능한 스마트 도시로의 에너지 전환에 영향을 미치는 요인 탐색: 이라크를 위한 통찰력

August 2023

Graduate School of Seoul National University

Technology Management, Economics, and Policy Program

Ammar Zaidan Khalaf Al-Lami

Exploring Factors Influencing Energy Transition Towards Sustainable Smart Cities from Sociotechnical Perspective: Insights for Iraq

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이 논문을 공학박사학위 논문으로 제출함

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Dedicated to

My beloved wife Shahad, and lovely sons Wateen and Makeen

Abstract

Exploring Factors Influencing Energy Transition Towards Sustainable Smart Cities from Sociotechnical Perspective: Insights for Iraq

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Cities serve as centers of innovation; however, urbanization brings along its own set of challenges, such as overpopulation and unstable energy supplies. Traditional energy systems have led to high energy consumption levels, negatively impacting sustainability, infrastructure, services, and the environment. This is evident in oil-rich countries such as Iraq, where dependence on petroleum resources has resulted in structural imbalances that contributed to destabilizing the country's security. Smart city initiatives offer innovative solutions to these challenges, but a smart city may not necessarily be sustainable. To be truly sustainable, smart people with an awareness of sustainability are required. The energy transition is not just a technical term relying on renewable energy resources and smart grids to improve the energy system. It is also a socio-technical and socio-economic process, with social and economic aspects interacting to strengthen or weaken the technical aspect of the transition process. Regulation and legislation play a vital role in all transition phases, and without proper implementation, the transition process cannot be successful. Therefore, it is crucial to accurately identify the stakeholders involved and explore their background knowledge, perceptions, and readiness for policy implementation. This thesis examines the influence of energy transition and its relationship with the smart city concept and diagnoses the endeavor of developing countries to overcome the expected challenges, particularly Iraq. The literature on energy transition was reviewed using a PRISMA analysis, identifying 41 determinants related to decision-making mechanisms and social and technical influences. The study presents insights to the governments to sustain the residential projects by analyzing the power consumption pattern, focusing on Bismayah City in Baghdad. This research confirmed that solar energy share could contribute 29.8% of Bismayah power consumption. Furthermore, it proposed that adopting DES will increase the solar PV share according to reliable experts by conducting MCDM theory through the AHP model. Additionally, it examines the motivations and orientations of technical staff in adopting distributed energy systems and proposes a hybrid model to identify the factors for technology acceptance and the motives that drive adoption. With structural equation modeling, this thesis concludes that security concerns and awareness levels are crucial in adopting distributed energy systems. At the same time, the staff specialists do not expect a positive performance impact on their behavioral intention to happen toward distributed energy systems implementation. This research provides valuable insights for the Iraqi government to successfully raise the level of sustainability in urban life. Moreover, it provides updated information about the energy transition drivers for researchers, stakeholders, practitioners, and investors. This research represents a valid base and motivation for further research in developing countries endowed with fossil fuel resources and renewable energy potential to achieve sustainable development objectives.

Keywords: Energy transition, Smart city, Photo Voltaic, Distributed Energy Systems.

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Contents

List of Tables

List of Figures

Chapter 1. Introduction

1.1 Background

Since antiquity, no documented innovation existed before cities emerged in Mesopotamia. Driven by the growing population, the ancient cities showed innovation in urban planning to sustain the city's dynamic (Ur 2014), such as the irrigation canals to avoid floods (An Heyvaert et al. 2008). Since then, cities have been expanding due to the multiplicity of their activities after the industrial revolution (Balland et al. 2020). The economic growth was driven by energy consumption dominated by fossil fuels during the past decades (Mohsin et al. 2021). . The consumption level in the city directly correlates with its economic growth (Shahbaz et al. 2017), but inversely with the sustainability due to traditional energy systems (Marchi et al. 2019). Approximately 75% is consumed in cities worldwide, which is responsible for around 80% of greenhouse gas (GHG) production. (Gimpel et al. 2020; Harjanne et al. 2019).

In the last two decades, the rising concerns surrounding lagging climate change mitigation are driving the adoption of policies aimed at reducing GHG emissions by decreasing fossil fuel consumption particularly in the transportation sector; the electric vehicles (EV) market witnessed steady evolution, especially in emerging economies such as the Republic of Korea (Koo et al. 2021; Choi et al. 2023; Hong et al. 2012), in addition to increasing the renewable energy share (Abolhosseini et al. 2014; IEA 2022). Supporting the research and development to boost energy efficiency has become a priority for the various stakeholders involved in addressing the improvement of energy systems; furthermore, there is a need to examine the factors that impact the diffusion of such technology and to investigate the behaviors of individuals' acceptance or rejecting this approach (Lee et al. 2022).

1.1.1 Energy Transition

The current energy systems are inadequate for achieving a radical shift in energy production and sustainable consumption for alleviating the negative effects of climate change and global warming (Grubler 2012). Consequently, energy transition emerged as a multi-functional framework that transcends the technical and economic aspects to cover social and political factors (Sovacool 2017). Nevertheless, it is also significantly affected by geopolitical factors and international competition for resources and wealth (Singh et al. 2019). The industrialized countries will face a fundamental challenge in the future of energy systems (Miller et al. 2013), corresponding to the current reality already (Mikulčić et al. 2021). The sharp fluctuation in the energy markets with the change of the global marketing compass of petroleum products was directly caused by the war in Ukraine, which severely impacted the global economy (Mbah and Wasum 2022). These repercussions are driving toward accelerating the action to ensure energy security without relying on importing crude oil and natural gas or at least decreasing its contribution to the economies of developed countries (Chepeliev et al. 2022).

Renewable resources play a key factor in mitigating the complexity; (Heshmati et al. 2015; Z. Wang et al. 2021), however, this complexity is increased by the dense population growth. Urbanization is projected to exceed 60 percent globally by 2030, especially in developing countries; (UN 2018), therefore, dependency on the current energy systems in developing countries will be a major approach to face the rising energy demand (Khan et al. 2020). Most of these countries suffer from economic crises and conflicts that depleted their infrastructure (Menyah et al. 2010), thereby disrupting the energy transition and hindering the United Nations' sustainable development agenda (Martínez et al. 2008; Shahbaz et al. 2013). Most of these countries are rich in oil and gas (OPEC 2020) and also have promising solar energy potential (Al-Hamadani 2020). The falling price of the solar energy industry (IRENA 2021); prompted the governments to expand this technology (IEA 2019) to provide low cost power (Hosseini 2020). Stable and reliable power generation from solar panels remains elusive as it is intermittent and weather dependent (Sampath Kumar et al. 2020), which calls for technological solutions to increase its penetration within the grid (Gandhi et al. 2020).

1.1.2 Smart City

The ICT sector development enabled the processing of huge amounts of data in real-time to run cities more efficiently (Lim 2021), where a digital city or knowledge city arose (Cocchia 2014), which contributed to developing the smart city notion during the past ten years to tackle the urbanization intractable problems (Afzalan et al. 2017). It can be considered that IBM's smart city initiative in 2008 was the main encouragement for accelerating the global trend in adopting smart city policies (Biloria 2021). The governments believe that it reduces the administrative bureaucracy, solves security risks, improves urban management efficiency, (Kim and Kang 2023), and attracts skilled people to contribute to the growth competitiveness (Harrison 2011). It can be a promising market for creativity sharing for the none public-sector (Borja et al. 2018). According to Trindade et al. (2017) achieving sustainability requires a strong link between the smart city and energy transition. The smart city is a future-oriented vision that aims to create the ideal city. This overlap reflects the importance of integrating energy-efficient practices and technologies into urban planning and design.

1.1.3 Smart grid

The rising demand for power leads to more complexities in power grids, especially through integrating renewable resources into the energy system (Sinsel et al. 2020). Thus, there is a growing need for greater reliability, security, and improved efficiency. Smart grids, as an emerging concept, can provide these features (Butt et al. 2021). The smart grid is the central pillar of the energy transition toward smart city implementation and has no unified definition. It leads to significant performance efficiency in terms of automation and coordination between producers, consumers, grids, (Broman Toft et al. 2014), and communication devices and advanced software (Perri et al. 2020).

Adopting smart meters and communications is the most important step in transitioning to a smarter power system. The main tasks are to improve the automatic diagnosis of the disturbances and work on enabling the “plug and play” feature, which is the ability to add new power generation sources to the grid (Renström 2019). It provides remote communication with customers through smart display units to send messages and alerts, such as bills and dues. In addition to the main function of these units, they display the value of electricity consumption in real time (Chen et al. 2017), and improve customer service and immediate response to their inquiries or requests due to ease of data access in real time (Ma et al. 2018). The role of e-governance cannot be overlooked through providing services to the citizens in the smart city and meeting sustainability requirements (Van et al. 2018). As though, a city can be smart (Bhati 2017) but not necessarily sustainable (Martínez et al. 2013). Renewable energy convergence with a smart grid is essential for creating sustainable cities. Signorini (2015) argued that an integrated approach could potentially develop urban platforms that support new forms of sustainable energy consumption and production, enabling more efficient and resilient cities.

This research provides a deeper understanding of how the energy transition will support sustainable and smart cities and how sustainable and smart city principles are implemented in residential projects and tries to highlight the societal acceptance by related stakeholders. In addition to decreasing the bias caused by focusing on technological design and urban planning driven by companies to meet the government's desire. A smart city needs environmentally aware and smart citizens to achieve sustainability goals, but some may not act on their beliefs toward the sustainability essence. In addition to the misled perceptions about renewable energy and its limitations, they do not realize the transition cost or the impacts on their security and privacy. The skilled and educated citizens boost innovation while the technologies facilitate those innovations.

1.2 Purpose of the Research

The existing literature on energy transition and smart cities can be classified into three categories: computer and engineering-based technologies, urbanization and social science-based policies, and socio-technical-based perspectives. The computer and engineering-based technologies focus on developing innovative systems and platforms under the smart city theme. The urbanization and social science-based policies focus on theoretical frameworks and analyzing smart city operations. The socio-technical perspective within the smart city emphasizes the interaction between social and technical elements. The discussed research takes a path between these three categories, focusing on energy transition means for urban sustainability through smart city concepts.

The enormity and diversity of the literature indicate the need to categorize literature related to energy transition in smart cities and identify areas that require further research. Research aspects such as technology, socio-economic, policies, culture, and governance have been carried out extensively. Therefore, the direction of this dissertation is to discover the literature trend and to understand the papers published with a socio-technical perspective through conducting a systematic literature review, and aims to recognize the areas that should be focused on. The limited amount of research available on augmenting the renewable part within a smart city's energy system is particularly noticeable in low-income or developing nations that rely heavily on non-renewable resources[1]. This research

[1] There is overlap between developing and low income countries terms sometimes, in this study Developing countries refers to the countries that are experiencing economic growth and social development. While the Low-income countries specifically refers to countries with low average incomes according to the UN and the World Bank.

gap is noteworthy because the factors that impact energy transition may differ in those regions compared to developed countries. Identifying the factors that impact energy transition is crucial to measure the potential positive influence of renewable resources on urban growth. This requires examining the possibilities of renewable resources and selecting appropriate types for sustainable smart cities. A case study must be selected to analyze the consumption pattern through actual data and identify a specific type of renewable energy. A simulation-based analysis must also be conducted to determine feasibility and potential contribution. This research will select the Bismayah new city in Iraq to explore the contribution of solar PV by analyzing formal power consumption data and predicting energy production through simulation-based analysis.

Further research is crucial to enhance the renewable resources contribution in the smart city system in developing or low-income countries. These regions face unique challenges, such as limited knowledge, resources, funding, and infrastructure, which can impede energy transition. Thus, it is necessary to address these gaps to recognize the influencing factors of energy transition and evaluate the potential positive impact of renewable energy on urban development. Moreover, this research can guide policymakers in selecting the appropriate renewable energy type for implementation in such countries.

Urban development aims to enhance the value of citizens' lives by considering various dimensions, including social, economic, environmental, political, and technological aspects. The smart city concept leverages technology and innovation to foster sustainable development. An essential component of sustainability is the transition to clean energy, which entails the phasing out of fossil fuels to ensure energy security and environmental sustainability. Although some studies suggest complete abandonment of fossil fuels is possible, weak economies and limited resources hinder progress in developing countries such as Iraq; despite initiatives to transition toward clean energy, progress has been slow. Thus, it is crucial to consider their unique conditions and support efforts to accelerate energy transition to achieve urban sustainability.

This thesis aims to investigate integrating solar PV into smart city energy systems by exploring the decision-making for selecting grid connections to accommodate the generated energy. The MCDM method will be employed to examine the factors influencing the selection process and relationships among them through experts' judgment in the Iraq case. This thesis will explore the perspectives of specialists in the DES field regarding their adoption in smart cities. While previous studies have emphasized the significance of DES in accelerating renewable energy penetration, none have explored the specialists' perspectives. To fill this research gap, the study will survey power sector staff specialists in Iraq to investigate the factors impacting the motivations of DES adoption and the relationships among these factors. PLS-SEM will be used to test the professionals' perceptions.

The findings will submit worthy intuitions for energy companies, policymakers, and other stakeholders in developing sustainable smart cities. Furthermore, this research tries to contribute to the international society's endeavor toward achieving the UN's SDGs. This research focuses on Iraq's efforts to transition toward sustainable and smart cities. Energy transition involves collaboration among actors and community engagement, with the government, firms, citizens, and research institutes playing major roles in defining the policy framework. However, energy transition and smart city development require significant financial, technological, human, and institutional resources, which can divert attention from other important issues. It is crucial to recognize these characteristics and understand the potential impacts. While there is promising expectancy, there is a scarcity of empirical evidence to support it.

1.3 Research Questions

This research tries to provide tangible evidence and new indicators for countries that are going through the experience of the energy transition, as well as adopting smart city projects to succeed in these endeavors and achieve sustainable development goals. With this regard, the main questions arise here:

What are the limitations of energy transition towards sustainable smart cities in Iraq? How to overcome them?

The research question is branch out into seven sub-questions answered through four studies as follows:

1- Study 1 “The impact of the energy transition role in achieving sustainability towards smart cities – Systematic literature review” will address the question below:

Q1: What domain specific energy transition determinants are being revealed in the present literature in social sciences perspective?

2- Study 2 “The contribution of solar PV in the energy system of Bismayah new city in

Iraq" will answer the following question:

Q2: What is the contribution of solar PV in the energy system of the smart city?

3- Study 3 "Assessment and decision making for grid connection of photovoltaic systems in residential projects in Iraq" will address the next questions:

Q3: What is the best grid connection type for PV penetration in the energy mix of the cities?

Q4: What are the influencing factors of PV integration into the power system of the residential projects towards smart and sustainable cities in Iraq?

4- Study 4 "Staff specialist's perspective of distributed energy systems adoption in Iraq: perceptions and policy implications" will answer the following questions:

Q5: Will the perception of Power staff specialists towards DES affect the implementation of distributed energy systems in the smart cities projects?

Q6: What are the influenced factors of power staff specialists 's perception on distributed energy systems implementation?

Q7: What are the relationships among these factors? What are the impacts?

The thesis questions aim to explain the recent path and reshape future directions. It provides evidence-based knowledge on how energy transition development affects urbanization.

1.4 Research Philosophy

The positivist approach by using empirical observation and measurement to realize the reality of the phenomenon is directed in this dissertation. An inductive approach will be taken to build a theory based on collected data from surveys and governmental databases. A quotative approach will be used to ensure the data validity by using direct quotes from participants. Surveys will be conducted to gather knowledge from diverse participants. The data collected from multiple groups of participants will be analyzed using a cross-sectional approach. Diverse tools and software packages will be used to test hypotheses and generate new knowledge. Figure 1 shows the details of the research philosophy. The first study will use the PRISMA approach for the literature review, the second study will conduct data analysis with simulation to support the third study using the AHP model for decision-making, and the fourth study will utilize partial least squares for structural equations modeling.

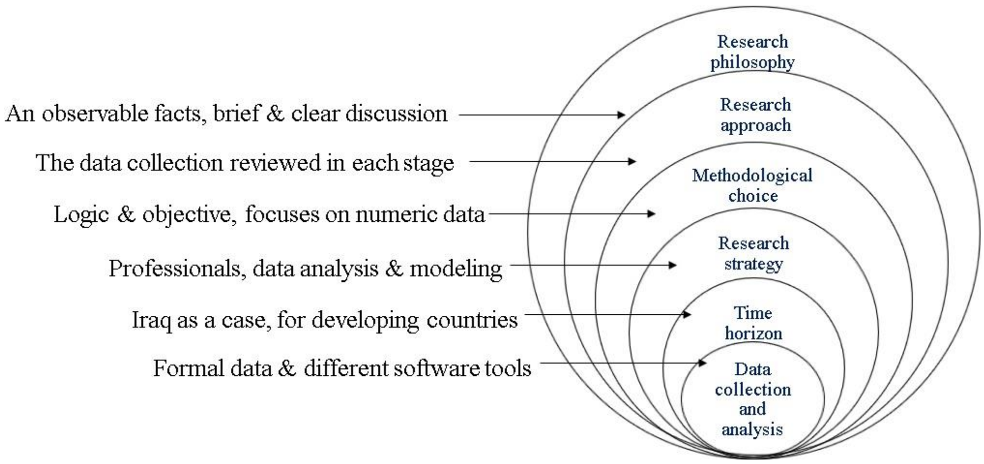


Figure 1: Research philosophy

1.5 Research Contribution

This thesis tackles the role of energy transition in developing urban life by contributing to implementing sustainable cities before being smart cities. The energy transition is a major topic of interest among governments, organizations, and scholars trying to develop technologies and policy frameworks to achieve sustainable development goals. Despite several research works that have studied the influence of energy transition on urbanization development in the last ten years, there is a lack of comprehensive studies investigating the impact of energy transition on smart city development. This research addresses a gap in academia and provides relevant implications for researchers, practitioners, and policymakers.

First, this research presented for the first time a comprehensive review of the publications during the last decade that identified the limitations of the energy transition on smart city adoption within sustainability. PRISMA Protocol was adopted as the study's methodology, whereby 39 valuable papers were selected. Through the literature analysis, 41 determinants were extracted and categorized into decision-making for renewable energy policy, socio-economic limitations of the energy transition, and social acceptance of smart energy adoption. Therefore, this study indicated the need to examine these limitations to provide more effective and comprehensive recommendations for policymakers and practitioners interested in energy transition initiatives.

Secondly, the gap in finding the solar energy contribution share to the actual power consumption in the housing complexes in Iraq as a developing country has been addressed. Previous studies were limited to analyzing unofficial data for power consumption and using the simulation process to find the amount of energy generated from solar panels that were limited to a house or building. This research presented an accurate perception of solar PV share in the energy system by inferring official data from the Iraqi Ministry of Electricity for more than 14280 consumers between 2020 and 2021. Thus, the study provided an accurate understanding of the reality of renewable energy in Iraq and similar countries.

Thirdly, this research focus on the gap in the literature for the first time on selecting the best option for solar PV grid connection in the energy system by applying the AHP model. A multidimensional approach has always been used in studies related to clean energy, both in identifying obstacles and selecting alternatives from various sources and even suitable sites for installing renewable energy units. Decision-making theory allows the integration of different factors according to certain dimensions to understand the effect of these factors within the same rank or group. This research presents a unique experience in identifying the dimensions and factors affecting the types of power grids, which is crucial for a smart city that relies on the smart grid, smart meter, and other tools regarding renewable energy.

Fourthly, the technology acceptance theory was presented with a different content from previous studies. Usually, the extent of renewable resources and smart technologies acceptance were revealed from a consumer's perspective. In contrast, this research relied for the first time on highlighting the acceptance of DES technology, which represents an essence of the smart city notion in its comprehensive content, by revealing the perceptions of professionals in the energy sector, which is an addition to the theoretical level. Employees' opinions were surveyed in many sectors, such as information technology and health, but this was not observed in the energy sector. In order to do so, new constructs were added to the body of the UTAUT model in a way that suits the nature of developing countries, especially Iraq. The results proved stability and validity remarkably through the explanatory power and predictive capability of the study model, which provides high content recommendations at the level of practitioners, decision-makers, and government institutions that lead to supporting the trend toward energy transition projects of sustainable smart cities.

This research presents a detailed analysis of transition challenges and opportunities in the developing countries toward sustainable energy. These countries possess both abundant fossil fuel resources and promising potential for renewable resources, making it difficult to shift from affordable fuel sources. Promoting new technology, such as solar panels, smart grids, and smart cities, may also raise concerns about privacy violations, consumption reduction, and increased costs in brittle economies.

1.6 Structure of Research

This research tackles the relationship of the energy transition with smart cities from a socio-technical perspective through four studies with various methods that can be summarized as follows:

1) Chapter 1 consists of a general introduction explaining the significance of energy transition and smart cities within the sustainability context. 2) Chapter 2 represents a literature review on topics related to the energy transition between 2010 and 2020 presented through SLR to identify the publication direction and provide insight into the global distribution of these publications. Moreover, to categorize the synthesized determinants for identifying the research gaps and possible research areas for the upcoming studies. 3) Chapter 3 represents the base for Chapter 4, which is focused on conducting a statistical analysis of energy consumers' data in one of the modern residential cities of Iraq, followed

by conducting a simulation to predict the solar PV contribution in the energy mix to present a vision of how to achieve a sustainable city through renewable energy.

The findings of this thesis are essential to investigate the influencing factors of selecting the appropriate grid connection among the grid types, which improve the renewable energy penetration and provide insight to the decision maker to maximize the city's sustainability and renewable energy usefulness. 4) Based on Chapter 2 (SLR) and related to the Decision-making of the renewable energy policy category in particular, Chapter 4 will present the importance of solar PV to Iraq's energy situation and address the gap in selecting the appropriate grid connection for the solar PV output according to the hybrid AHP model. The findings of Chapter 3 will facilitate the experts' judgments based on actual PV contribution data for the first time in a whole city. The SLR in Chapter 2 provides the influencing factors and contributes to developing this study's TES-AHP model to select the best grid connection among three alternatives. 5) According to the findings of Chapter 2 (SLR), which indicated the social acceptance of the smart energy adoption category, in addition to the findings of Chapter 4, which indicates the distributed energy systems as the best alternative for accommodating the solar PV output; Chapter 5 will address the literature gap in examining the power staff specialists' perceptions and motivations toward the distributed energy systems implementation. To the best of our information, this study represents the first attempt at tackling the DES adoption from the professional's perspective. Based on the findings of the previously mentioned Chapters and discussions with a group of specialists in the Iraqi government, the variables were identified to develop the extended model inspired by the UTAUT and the theory of reasoned action behavior. 6) Chapter 6 summarizes the whole research, implications derived from all studies, the research contribution and originality, limitations, and future research. The detailed research outlines are shown in Figure 2.

Chapter	Section	Main detailed and highlights
Chapters 1 Introduction	**Background**	* Traditional energy systems decrease city sustainability. * Energy transition is crucial for sustainable smart city. * Iraq's Initiatives are lagging due to mismanagement.
	Purpose of Research	* Examining the impact factors of energy transition and the relations among these factors with smart city context. * Contribute with the efforts of 4 SDGs achievement.
	Research Questions	What are the limitations of energy transition towards sustainable smart cities? How to overcome them?
Chapter 2 The Impact of the Energy Transition Role in Achieving Sustainability Towards Smart Cities	**Research Questions**	What domain specific energy transition determinants are being revealed in the present literature?
	Methodology	*Systematic literature review with PRISMA protocol. * Identifying the limitations in the energy transition.
	Findings	* 39 study selected to address the research question. * Asia and Middle East leading the publications after 2019. * Identifying 41 determinants with three domains: 1) Decision making of RE policy 2) Socio-economic limitation. 3) Social acceptance of smart energy adoption.
Chapter 3 The contribution of solar PV in the energy system of Bismayah new city in Iraq	**Research Questions**	What is the contribution of solar PV in the energy system of the smart city?
	Methodology	* Data analysis for 14280 consumers in Bismayah new city (2020 - 2021). * Simulation and 3D design to calculate the PV output for Bismayah new city.
	Findings	* PV contribution significant to the peak demand in July. * 29.8%of energy can be provided through PV.
Chapters 4 Assessment and decision making for grid connection of photovoltaic systems in residential project in Iraq	**Research Questions**	* What is the best grid connection type for PV penetration in the energy mix of the cities? * What are the influencing factors of PV integration into the power system of the residential projects towards smart and sustainable cities in Iraq?
	Methodology	MCDM with AHP to select the best alternative.
	Findings	* Distributed On-Grid is the best option for PV in the residential projects. * The social factors are most important than others. * Staff experience is important most technical factor. * developing countries have deferent perspective than developing countries of the grid connections types priority.
Chapters 5 Staff specialist's perspective of distributed energy systems adoption in Iraq: perceptions and policy implications	**Research Questions**	* Will the perception of Power staff specialists towards distributed energy systems affect the implementation of distributed energy systems in the smart cities projects? * What are the influenced factors of power staff specialists 's perception on distributed energy systems implementation? * What are the relationships among these factors? What are the impacts
	Methodology	* Empirical study on power sector staff in Iraq. * Modifying the UTAUT model by adding Attitude, Awareness and Security constructs to the core. * Using PLS-SEM to test the hypothesis.
	Findings	* DES implementation is directly influenced by attitude and behavioral intention. * The awareness level of the staff is high abought DES implementation. * Security concerns influence the behavioral intention toward DES implmentation * Performance expectancy is negatively influence the behavioral intention.
Chapters 6 Discussion and Conclusion	**Discussion**	* Energy transition is the corner stone of the sustainable smart city * The determinants that have been addressed in the literature are vary from developed and developing countries. * Developing countries have to shift to the renewable energy with upgrading the energy system by the distributed energy systems. * The professionals of power sector have the intention to implement the DES in them works but they don't expect a quality due to government policies.
	Implications	* Reviewing current transition policies will improve the energy transition action. * Convert consumers into prosumers will decrease the cost and risk, boost the social acceptance and offer an efficient use for resources. * Support Research and development will address the challenges of energy transition and create new fields of studies related smart cities.
	Contribution	* Addressing a gap in academia for energy transition of smart cities. * Expanding the UTAUT. The accuracy of the extended model was proven through its predictive and explanatory strength, and the variance in the results.

Figure 2: Research Outlines

Chapter 2. The Impact of the Energy Transition Role in Achieving Sustainability Towards Smart Cities - SLR

2.1 Introduction

2.1.1 Background

Reviews studies like systematic review (SLR) is a valuable and organized process to the research problem by identifying appropriate primary sources. Within twenty years, SLR has become accepted in the academic community because of its accuracy in summarizing areas within a specific research field (Tranfield et al. 2003). The integrity and quality demonstrated in examining similarities, assessing existing intellectual discoveries, recognizing possible deficiencies, and suggesting valuable prospects for forthcoming research. It also takes scientific methods to reduce bias and selectivity to provide valid answers to research questions (Petticrew et al. 2008). Given to the successes in medical research, SLR has spread and covers all research areas currently (Higgins et al. 2019). One of the most important areas presented in extensive detail by SLR is sustainable development and related sub-fields such as energy, environment, etc.(Khalid et al. 2021).

2.1.2 Smart cities and the Need for Energy Transition

Smart cities utilize advanced technologies and digital infrastructure to enhance urban systems' efficiency, sustainability, and livability. These cities use data-driven technologies to manage resources, infrastructure, and services, aiming to improve the life quality for urban residents while reducing environmental impact and enhancing economic growth (Lim 2021). The integration of advanced technologies and engagement with citizens and stakeholders is the key to smart cities' success (Afzalan et al. 2017). However, smart cities face challenges in the impacts of energy consumption on the environment, it responsible for significant share of global consumption and GHG, leading to the need for innovative solutions. (Martínez et al. 2013; Signorini 2015).

In order to treat the challenges encountered by smart city, various measures can be adopted. Bhati (2017). confirmed the necessity of energy transition towards sustainable urban development. This involves shifting to renewable and low-carbon resources, upgrading energy systems into more efficient and flexible, and balancing economic, social, and environmental goals in urban planning and management (Heshmati et al. 2015; Oryani et al. 2021b). Distributing energy systems will be the key factor in this transition (Di Somma et al. 2015), its enable the energy consumption to be close to the production centers. Smart city technologies like smart grids, renewable energy, and energy storage systems can boost integrate renewable resources into the urban systems, while demand-side management technologies can optimize energy use (Ma et al. 2018). Smart city can improve monitoring and management of energy systems and enhance citizen commitment in the decision making. The concept of smart cities and energy transition towards sustainable urban development are interconnected. Smart city development should prioritize sustainability and energy transition to ensure the contribution to a livable, equitable, and resilient urban future. Figure 3. explain the relation among the main drivers of sustainable smart city concept.

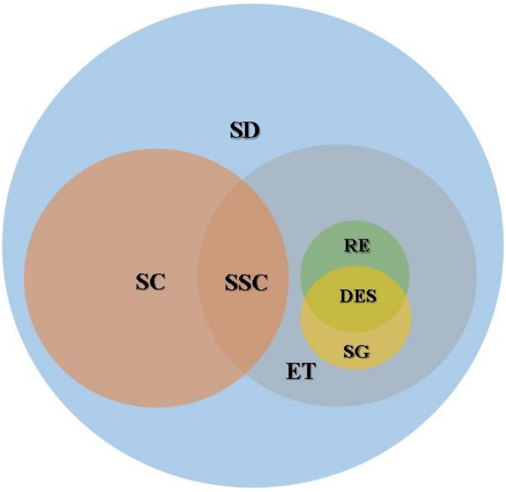


Figure 3: Drivers of sustainable smart city

Not: RE=Renewable energy, DES=distributed energy systems, SG=Smart grid, ET=Energy transition, SD=Sustainable development, SSC Sustainable smart city, SC=Smart city

2.1.3 Research Question

This study the energy transition function of the switching into sustainable smart cities and contributes to the current understanding of the transition's policy implications. Furthermore, to identify the challenges and opportunities for policy makers and stakeholders in the energy transition and urban sustainability fields. The review will conduct systematic literature review to collect and analyze relevant studies on the research topic. It will provide comprehensive recommendations based on the review findings. The review's significance lies in addressing the integration of smart city technologies and energy transition towards sustainable urban development, which is a new area of research and policy. It will provide insights into the topic, highlight gaps and limitations, and recommend future research and policy development. The review will also be relevant to policy makers and stakeholders in the energy transition and sustainable urban development fields, as it will provide insights into the policy implications of energy transition for smart city adoption and the challenges of decision making in complex socio-technical systems. To this point, the study directs to address this question:

RQ1: What domain specific energy transition limitations are being revealed in the present literature in social sciences perspective?

2.1.4 Previous related studies

Because of energy transition novelty and the wide range of terms that refer to the energy transition contents, it is noted that the prior SLR studies were diverse despite their scarcity. To study the alleviation of climate change influences, Wimbadi et al. (2020) investigated the transition criteria of low-carbon policy, also examined the essential ideas through a bibliographic information spanning from 1995 to 2019. The review revealed that development of these concepts has been influenced by the developing landscape of climate politics and the priorities of prominent emitter nations like China and European states. Moreover, the study affirmed that Chinese scholars have been the most creative in generating knowledge in this field, while researchers affiliated with organizations based in the United Kingdom have utilized the greatest impact. Additionally, the researchers identified imperative concepts that shed light on the effort towards attaining carbon neutrality, specifically in terms of reducing carbon emissions.

With the same context, Curtin et al. (2017) conducted an evaluation of the influence of economic and financial incentives specific to various technologies. Their aim was to determine how these incentives could facilitate the mobilization of private finance, bridging the funding gap required to achieve climate objectives, and simultaneously fostering public support for the transition to low-carbon technologies. The researchers specifically focused on feed-in tariffs in comparison to various financial incentives and quota schemes like tax and loans. Their findings indicated the irrational economic manner done by citizens investing in low-carbon technologies as a response to the incentives. This outcome highlights the significance a significance of comprehending the preferences of targeted citizens and technologies properties within domestic context.

Bourcet (2020), examined the movement towards renewable energy adoption and the consequential decrease in fossil fuel usage, focusing on the analysis of its determinants. The research revealed a hardship to reach a consensus concerning the influence of energy related factors, which have been predominantly explored. In a parallel vein, Serrano et al. (2020) delved the green energy transition within sustainable society theme and investigated the factors that drive this transition and analyzed them using data from the European Union. The study highlighted the necessity of green energy transition in terms of shared social and scientific perception. Additionally, it identified governmental regulations procedures and household income as potential indicators for energy transition anticipation. Table 1 provides a reference to previous systematic literature reviews (SLRs) that closely align with the present study.

Table 1: The prior SLR studies

Author	keyword in the title	ET Limitations	Global scope	Policy Implications
Serrano et al. (2020)	Green Energy Transition			
Bourcet (2020)	Renewable energy deployment		√	
Wimbadi et al. (2020)	low carbon transition, net-zero carbon dioxide emission		√	
Curtin et al. (2017)	low-carbon technologies			√
This study	Energy transition	√	√	√

So as to pursuit a new SLR findings released after 2022 regarding the energy transition, Google Scholar search was conducted in May 2023. Four published studies were obtained as indicated in Table 2. Bhattarai et al. (2022) was limited to the assessing the factors that hinder and encourage renewable energy transition through technology, economic, environmental, policy and social aspects. While this study provides a wider perspective of energy transition including renewable transition, the socioeconomic and social acceptance related to smart energy as a main factor of the comprehensive energy transition framework.

Although the similarity in the results related to focusing on research and development and indicating the global south backwardness as presented in the upcoming sections. Nevertheless, our study also indicated that energy transition publication level in the Middle East witnessed remarkable growth during the past five years, which have not been noted in Bhattarai et al. (2022) works. As it was not observed in these studies a similar review to the objectives of this review according to the research question, which validate and prove the significance of this study. Furthermore, the increasing of energy transition reviews papers theses years, prove the importance of the energy transition topic.

Table 2: Related SLR released after this study

Author	keyword in the title	ET Limitations	Global scope	Policy Implications
Bhattarai et al. (2022)	Renewable energy transition:	√	√	√
Manjon,et al. (2022)	Energy transition			√
Lode et al. (2022)	A transition on Energy Communities:			
Sulaimanova et al. (2023)	Energy Transition			
This study	Energy	√	√	√

Author	keyword in the title	ET Limitations	Global scope	Policy Implications
	transition			

2.2 Methodology

This study conducted systematic review to tool up an inclusive indication of the limitations and challenges of energy transition studies in the social sciences using PRISMA. It is a type of literature review that use rigorous methods to identify, evaluate, and synthesize the findings of multiple studies on a particular research question (Moher et al. 2010). The objective of the PRISMA guideline is to enhance the transparency, precision, and comprehensiveness of systematic reviews and meta-analyses. It offers a uniform checklist comprising specific components that ought to be incorporated in the report. These include details regarding the search strategy employed to identify pertinent studies, the criteria for selecting studies (inclusion criteria), as well as the methodologies employed to evaluate the quality of the chosen studies (Sohrabi et al. 2021). When researchers adhere to the PRISMA guideline, they can guarantee their systematic review or meta-analysis is carried out and presented in a thorough and clear way. This increases the reliability and replicability of their results, which can benefit other researchers, policymakers, and practitioners in making informed decisions based on evidence and promoting progress in their field. (Wen et al. 2008).

To commence the search process, Web of Science, Scopus, and Google Scholar online platforms were preferred. Recently published reviews on energy transition were consulted for direction. Systematic literature review (SLR) has become increasingly important in energy transition field. According to PRISMA protocol, the taken procedural steps are presented distinctly in a detailed diagram (Moher et al. 2015). Finally, as stated in Table 3, total of thirty-nine valuable studies were selected, the selected papers focused on energy transition limitations.

Table 3: Included literature

Author	Country	Decision making of renewable energy policy	Socio-technical limitations of energy transition	Social acceptance of smart energy adoption
Oryani et al.(2021)	Iran	√		
Alizadeh et al.(2020)	Iran	√		
Jahangoshai Rezaee et al. (2019)	Iran	√		
Ullah et al. (2021)	Pakistan	√		
Mastrocinque et al. (2020)	7 EU countries	√		
Ruiz et al. (2020)	Indonesia	√		
Wu et al. (2019)	China	√		
Anser et al. (2020)	Turkey	√		
Rediske et al. (2020)	Brazil	√		
C. N. Wang et al.(2021)	Taiwan	√		
Wu et al. (2019)	China	√		

Author	Country	Decision making of renewable energy policy	Socio-technical limitations of energy transition	Social acceptance of smart energy adoption
Firoozi et al. (2021)	Iran	√		
Shetaya et al. (2015)	Egypt	√		
Omar et al. (2019)	USA	√		
(Lim 2021)	Korea		√	
Chawla et al. (2020)	India		√	
Döbelt et al. (2015)	Austria		√	
Overland et al. (2019)	Germany		√	
Mikhno et al. (2021).	Ukraine &Lithuania		√	
Renström (2019)	Sweden		√	
Schick et al. (2015)	Denmark		√	
Milchram et al. (2018)	Netherland and UK		√	
Kumar (2019)	India		√	
Bouzarovski et al.(2017)	Eastern EU		√	
Rohde et al. (2021)	Germany		√	
Sovacool et al. (2021)	Global		√	
Throndsen et al. (2015)	Norway			√
Chou et al. (2015)	Korea,			√

Author	Country	Decision making of renewable energy policy	Socio-technical limitations of energy transition	Social acceptance of smart energy adoption
	Taiwan Indonesia and Vietnam			
Broman Toft et al. (2014)	Norway, Denmark, and Switzerland			√
C. fei Chen et al. (2017)	USA			√
Perri et al. (2020)	Italy			√
(Gimpel et al. 2020).	Global			√
Abdmouleh et al. (2018)	Qatar			√
Acakpovi et al. (2019)	Ghana			√
Shuhaiber (2021)	Jordan			√
Chen et al.(2017)	USA			√
Düştegör et al. (2018)	KSA			√
Shuhaiber et al. (2021)	UAE			√
Park et al. (2014)	Korea			√

2.2.1 The strategy of search

To verify relevant literature related to energy transition, a search strategy was employed using selected keywords such as renewable, environment, sustainable, smart, and DES. The keywords were chosen broadly, including distributed energy systems (DES) and distributed energy resources (DER), to ensure the inclusion of studies using alternative terms. The search string utilized Boolean connectors such as “AND” for term concatenation and “OR” for alternative spellings. Only studies with titles including energy transition or energy transformation, renewable energy or sustainable energy, and distributed energy resources or distributed energy systems were considered for inclusion. The query was directed across Scopus data base, Web of Science papers, and Google Scholar online platform between 2012 and 2022, selected for two reasons: these databases are most commonly used by social science researchers, and they represent a mix of citation, subject area, and generic databases, providing an inclusive list of articles. The terms "energy transition," "energy transformation," "distributed energy systems," and "distributed energy resources" were considered synonymous throughout the study. The terms "transition" and "DES" were given particular attention and were used interchangeably.

2.2.2 Inclusion criteria

In order to recognize studies pertinent to the research goal, specific inclusion criteria were employed. A study was categorized as a major source if it fulfilled all of the inclusion criteria, whereas it was excluded if it met any of the exclusion criteria. It should be noted here that studies related to pure economic analysis and improving technical aspects are not the focus of this research also not consistent with its objectives, moreover, these topics were investigated extensively through the literature, the details explained in Table 4.

Table 4: Criteria for papers selection

Inclusion	Exclusion
English language	Technical and economic analysis
Related to	Grey literature, conference,
Energy transition	review, summaries etc.
Clear methodology	Duplicate papers
Between 2012–2022	
Form of papers	

2.2.3 Filtering process

The initial search query yielded 1725 papers, which were then screened by examining their abstracts. Predefined inclusion criteria were applied to minimize the biased likelihood. Irrelevant and duplicate papers were eliminated, figure. 4 illustrates the resulting number of selected papers after the filtering process. Out of the total 119 related studies, after two stage of screening, only 39 studies provided direct evidence that could address the study question. Knowledge was collected from each eligible study in a specific format as outlined in table 2, including the names of the authors, year of publication, country of origin, study type, and focused dimension. Figure 4 show the filtering process.

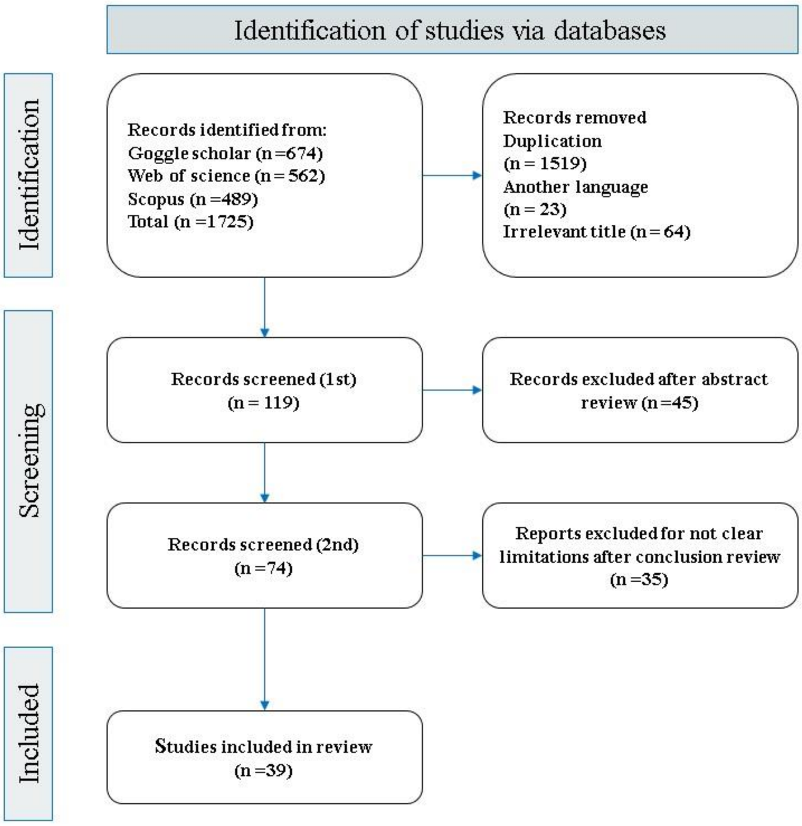


Figure 4: PRISMA approach for retrieved records

2.2.4 Validity and reliability

Examining of reliability and Validity is a key feature of SLR (Mubarkoot et al. 2022), the outcomes of this investigation were based on high-quality studies that were devoid of publication bias. The authors conducted an independent review and analysis of each article before entering the data into a standardized format (Table 2) after reaching a consensus. Cross-checking of papers was conducted to minimize potential bias, and extra care was taken to mitigate errors during the study. The SLR method prioritizes assessment quality to guarantee the reliability of findings. The main of the examined papers in this review directed the challenges and various aspects of energy transition worldwide. Two researchers conducted the review and compared each step of the process to boost the reliability during the analysis of the literature. Figure 4 illustrates the search process, outlining all the stages involved. It includes the platforms referred, the documents acquired and eliminated at each stage, as well as the rejection reasons. (Moher et al. 2015). The researchers made every effort to ensure the robustness of the study and to minimize the potential for errors and bias.

2.2.5 Energy transition publication trend

This review examined the papers published between 2012 and 2022, revealing the point that the field of energy transition is relatively new. However, a growing interest is noted in this field over the past decade, as shown by the upward trend in the publications. Figure 5 illustrates the number of papers published per journal during the study period. The studies focused on various countries across the Americas, Europe, Africa, and Asia. Europe having the highest number of papers, while the Middle East and Asia ranked first in the last three years. This suggests that energy transition is an important issue in these regions, given that the Middle East is a major supplier of fossil fuels to Asian countries. The research area gained momentum after 2019, as evidenced by the increased number of papers published in the years that followed.

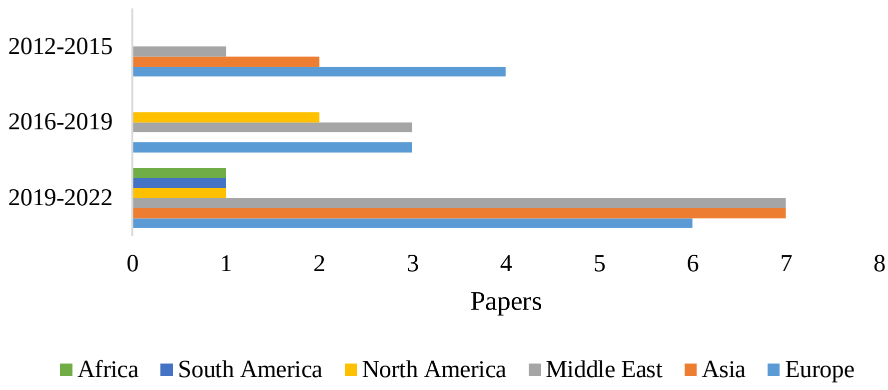


Figure 5: Papers distribution by region

2.3 Concept of energy transition

Among new emerging terms in recent years, energy transition raised as a natural consequence as a response to climate change issues. Historically, the shift in energy took place many times, in the industrial revolution when coal mining flourished to replace the wood, the dominance of oil last century, then the shift towards the natural gas in recently after the spread of liquefaction technology and its convenient transportation across the oceans (Smil 2010). In all previous transitions, there was a new source of energy that supplanted what came before it and dominated the markets. Unless the recent calls for transition meet with major ferocity in competition with traditional sources. It seems unlikely that it will be able to displace fossil fuels from the current energy system for geopolitical and socio-economic reasons in addition to technological factors. In addition, the alternative is not ready enough to displace fossil fuel from the throne of primacy (Fronk et al. 2010). Thus, the current energy transition has included multiple components and methods interact together to gradually reduce fossil fuel consumption towards low-carbon economy and policy. More precisely, we will coexist with fossil fuel for many years to come, according to demonstrated scenarios. Many researchers and institutions specialized in energy policy agreed that energy transition target is adoption of renewable resources based systems instead of fossil fuel to reduce GHG emissions. The transition mortgaged with steps related to rising energy systems performance, rationalizing consumption and investing in modernizing energy grids to enable flexible diffusion of renewable energy resources within the upgraded energy system. It should be noted that the orientation towards energy storage methods such as batteries and pump storage role cannot be overlooked (Mazzone 2020).

2.4 Decision making of renewable energy policy

Decision-making approaches are crucial to ensure the transition towards renewable energy is efficient and sustainable. The publications concerning decision-making in energy field are widely distributed in many aspects. Under the political limitations, Alizadeh et al.(2020) confirmed that political will to transition towards renewable energy can be influenced by a scope of factors, involving the perception of energy security, environmental concerns, and international commitments. Whilst Oryani et al. (2021) added the factors of international sanctions and the cooperation with the international organization as a barriers for the energy transition policy in Iran. Similarly, Jahangoshai et al. (2019) called for three suggestions including: 1) Calibration of bureaucratic behaviors and environmental research to expedite the licenses, 2) creating a special funds or specialized banks for renewable energy investment, and 3) Encouraging investment, subsidy, and governmental support for bank loans. Governments committed to reducing GHG emissions and achieving environmental goals are more likely to support renewable energy policies. However, political considerations can also limit the adoption of renewable energy, such as the influence of petroleum lobbies or the perceived costs of renewable energy technologies (Griffiths 2017).

Economic factors also influence decision-making approaches regarding the policy of renewable energy adoption. The reported technologies cost has been decreased recently, making them more competitive with traditional fossil fuel. The works of Ullah et al. (2021) found that off-grid system provide relatively higher employment opportunities in addition to reducing emissions further, while the on-grid system reduced the area of land used according to the reliability, economy, ecology, topography, and society criteria in Pakistan. Mastrocinque et al. (2020) examined renewable energy supply chain through conducting Triple Bottom Line principles framework (TBL) in five European countries. However, the technology cost of renewable energy varies depending on the location and availability of resources. Governmental policies able to reduce the costs further, for instance through subsidies or tax incentives (Anser et al. 2020; Aryanfar et al. 2020). Similarly, Wu et al. (2019) examined the criteria influencing sustainability of PV poverty mitigation projects to recover the Chinese rural poverty.

Considerable research has been observed regarding the mechanism of selecting the appropriate site, especially in developing countries. The standards were different and varied according to each country, Anser et al. (2020) targeted selecting adequate locations of PV farms validated to suggest different sites in Turkey according to levelized costs of energy (LCOE), decrease carbon emissions, distance from the infrastructure and radiance distribution, global horizontal and diffused horizontal irradiance. Similar approach used by Ruiz et al. (2020), by adding the wild fire in Indonesia as a challenge for the decision maker in Plant expansion. Meanwhile Rediske et al. (2020) offered a new model to indicates the ideal place for install a large-scale PV plants through GIS-MCDM tools, the study pointed that potential locals may impact the project and exclude protected areas as well as water bodies. Furthermore, C. N. Wang et al.(2021) proposed selecting the best locations in Taiwan by measuring the efficiency indicators through specific technical parameters like humidity, precipitation, and air pressure, etc.

Many studies in risk assessment of renewable energy projects have been based on decision-making methods such as Wu et al. (2019), it specified the conclusive risk factors and offered comprehensive framework for risk valuation of urban rooftop solar PV policy in China. The study suggested policy risk factors like subsidy, regulations, governmental support, in addition to the economic risk factors like, price volatility, annual rate of return. For the technical factors, operation and maintenance, grid connection, and power supply reliability were proposed. Similarly with Firoozi et al. (2021), the primary focus was to investigate the risk elements that impact sustainable development of Iran's PV plants. The study utilized almost the same factors as previous studies, the factors of insufficient knowledge, experience, and skills of the employees have been added.

A new approach in the electrical grids domain submitted by Shetaya et al. (2015) to support the concentrated PV integration in the smart grid by measuring the current grid flexibility to operate grid steadily. Detailed technical criteria were used for the first time; controllability, minimum power, ramp rate capability of generation and startup time. While Omar et al. (2019) proposed flexible assessment to classify the energy management control algorithms of the residential buildings based on the cost, amount of energy and discomfort index factors.

2.5 Socio- technical limitation of energy transition

Socio-technical limitations refer to the challenges that arise when social and technical factors interact during the energy transition process. This process involves changes in how energy of the energy generating, transmitting, distributing and consuming, which require technical solutions as well as social and behavioral changes. Limitations can occur due to cultural norms, values, behaviors, infrastructure, technology, and policy, which can lead to resistance from communities, lack of political will, and technical barriers. Despite awareness of climate change, people may be reluctant to modify their energy consumption behavior or adopt new smart energy technologies due to cost, convenience, and lack of knowledge. Policymakers and energy companies must address these impediments to promote smart energy technologies adoption (Lim 2021). These limitations can hinder the renewable energy integration with other power system components, as well as the development of supportive policies and infrastructure. Addressing socio-technical limitations requires a all-inclusive approach that considers the socio-economic and political context of energy transition in addition to the technical feasibility of new solutions. Chawla et al. (2020) argued that some companies, organizations, and stakeholders are trying to present smart grids as a key to the energy consumption matters and climate change challenges, even though experts have doubts about their effectiveness. They are trying to sugarcoat the reality by offering evidence that smart meters can address both environmental and consumer concerns. Implicitly, stakeholders may be over-promising the benefits of smart grid technology without fully considering its limitations and challenges. Moreover, individuals' energy consumption as a private issue flows into the public domains, some researchers invoke about data security and privacy issues like Döbelt et al. (2015), or concerns about electromagnetic radiation (Park et al. 2014), thus, on employment due to the creation of promising job opportunities through green transition and the renewal of the necessary infrastructure (Mikhno et al. 2021).

Although energy transition is closely related to smart grids application, nevertheless, Unrestricted to technological smartness and the networks of social and governmental smartness. It consists of multi-layers of social cultural processes and governmental organizations that produce, sustain, limit and hinder smart grids in the same time. Major players in the electricity sectors resort to the principle of incremental solutions, believing that radical changes may destabilize the system and increase consumer anxiety about new policies and technologies (Acakpovi et al. 2019). Additionally, it is indicated that successful outcome of implementing DES relies on the consumers' willingness for adoption. With this context, Renström (2019) confirmed that majority of research related to smart energy systems is targeted the households that concerned in energy issues or intend to perform an effective role in such systems. To create effective support, there is a need to embrace the diversity through looking beyond energy use and finding ways to encourage the use of fewer resources in daily activities. Schick et al. (2015) argued that concept of a 'flexible electricity consumer' is based on a techno-centric and inflexible view of the consumer through investigating reports from Denmark's national Smart Grid Network.

As a method to rectify the social and ethical dimensions of energy transition, Milchram et al. (2018) proposed a new framework for energy justice in the United Kingdom and the Netherlands, it has been posited that smart grids have the power to solve the justice concerns by enabling small-scale power production and transparent billing practices. In smart grids realm, Kumar (2019) affirmed the necessity of social, financial, and governmental actions to reach the "smartness." The study underscored the significance of implementing sociotechnical strategies to create smart grids that are cost-efficient, fair, inclusive, democratic, and environmentally sustainable.

Bouzarovski et al. (2017) argued that energy transitions have caused extensive material, economic, and institutional changes globally, leading to increased social vulnerability of affected actors. Nevertheless, there is still a limited perception of the connection between energy defenselessness and energy transition. Rohde et al. (2021) confirmed that smart grids are promoted as a promising resolution to the grid challenges caused by renewable energy integration, but their implementation requires fundamental changes to current institutional arrangements.

Recently, Sovacool et al. (2021) emphasized on the importance of smart meters as a critical component of any future smart grid. The study evaluated the conditions required for the widespread adoption of these meters, including how information is provided to consumers, the role of existing power companies, and how people's behavior may change. The study explored how smart meters could lead to reduced energy consumption, lower carbon emissions, and how policies could facilitate the adoption. Furthermore, the study examined the connection between smart meters and acceptance of renewable and energy efficiency.

2.6 Social acceptance of smart energy adoption

The direction of the last decade publication indicated that smart grid applications bring in parallel many various factors. In addition to the physical and moral participation of citizens in the energy transition and smart grid applications (Shim et al. 2018). Throndsen et al (2015) find citizens coolly accepting the notion of GHG emissions concerns, while they were dissatisfied by current narrow range of engagement in Norway. The works of Chou et al. (2015) presented a new model for comparison between developed countries (Korea and Taiwan) and developing countries (Indonesia and Vietnam) for smart meter adoption, the resulted differences between these countries are attributed primarily to the social and cultural conditions, in addition to economic differences. In them survey of consumers in Norway, Denmark, and Switzerland, Broman et al. (2014) suggested that individuals accept the idea of the smart grid if it positively affects the environment and society, which means a great focus on consumer awareness. Through a set of psychological and social predictors that support the idea of adopting smart meters adoption, C. fei Chen et al. (2017) investigated sustainable energy by surveying the people who do not possess smart meters and they concluded that preconception of environmental and energy issues had a direct impact on energy saving measures and support government regulations. Perri et al. (2020) conducted an attempt to understand the behavioral change processes of Italian consumers, the study found that participation of experts in smart energy technologies initiatives is more effective and that environmental sustainability has no effect on the adoption process.

The awareness issues represent a major challenge to the adoption of projects in all fields especially in the energy technology, where it represents a great incentive stemming from the desire for change or its resistance (Gimpel et al. 2020). According to Abdmouleh et al. (2018), the effective deployment of smart grid technologies and the incorporation of renewable energy resources heavily depend on public attitudes and acceptance. The researchers discovered that in Qatar, the public exhibits the highest level of awareness regarding climate change fears, accompanied by the concerns of renewable energy resources impacts and energy efficiency on the society. Acakpovi et al. (2019) attributed the weak adoption of smart grid in Ghana mainly to mismanagement, in addition to his criticism of the accumulative adoption through the study of education and government policies factors, in addition to them assertion that social impact is limited to consumer behavior.

The adoption of smart meters as a form of expert systems has the potential to revolutionize the energy sector. However, the level of acceptance of smart meter technology varies across different countries and is influenced by a collection of factors. Shuhaiber (2021) argued the current stage of evolvement of smart meters in the low income countries is yet in its initial phases. In Jordan, observed security and technical risks were identified as major factors negatively impacting residents' willingness to adopt smart meters. Though, unexpectedly, supposed privacy and health dangers were found to have no significant adverse effect on the intention to use smart meters. In the USA, Chen et al.(2017) affirmed that perceived usefulness and concerns regarding privacy risks directly influenced the level of encouragement for smart meter installation and the intention to adopt them. However, they found that perceived cost hadn't any impact on these factors.

In the United Arab Emirates, Shuhaiber et al. (2021) proposed a smarter energy meter and validated it based on users' viewpoint. The study discovered that users' intention to use smart meters was influenced with various perceived values, such as epistemic values (related to knowledge and understanding). Each of these values had varying degrees of significance in shaping users' intentions. On a separate note, in Saudi Arabia, the public displayed willingness to embrace green energy, smart meters, and even developed to be a co-producer. Though, concerns regarding unfamiliar technologies and perceptions of high costs were identified as significant barriers to widespread adoption. Düştegör et al. (2018), suggested that improving public knowledge, especially in terms of ecological sensitivity, and providing governmental incentives were recognized as potential strategies to gain public acceptance.

Park et al. (2014) examined the adoption factors of smart grid applications adoption, specifically focusing on advanced metering services, among Korean consumers. The researchers introduced a model called the Risk Integrated TAM (RITAM) model to assess the smart grid understanding. Their findings indicated that factors such as the awareness of cyber security fears, concerns about electromagnetic radiation, and worries about device breakdown and performance decline influenced the perception of risks associated with the smart grid.

Consequently, the level of acceptance of the smart grid applications is influenced by a range of factors, including perceived usefulness, cost, security, privacy, and health risks, as well as awareness of cyber security fears and electromagnetic radiation dangers. Enhancing knowledge, providing governmental incentives, and implementing dynamic pricing could help to overcome the obstacles to adoption and encourage the public to accept and use smart meters. Table 5 summarizes the limitations reported in the literature.

Table 5: Extracted limitations

Limitations	Type	Ref.
Political will	Policy	Alizadeh et al.(2020), Wu et al. (2019), Sovacool et al. (2021)
Perception of energy security	Policy	Alizadeh et al.(2020), Park et al. (2014)Sovacool et al. (2021), Chen et al.(2017)
Environmental concerns	Environment	Alizadeh et al.(2020), Sovacool et al. (2021) , Jahangoshai et al. (2019), Chen et al.(2017), Rediske et al. (2020)

Limitations	Type	Ref.
International commitments	Policy	Alizadeh et al.(2020)
international sanctions	Policy	Oryani et al.(2021)
Cooperation with the international organization	Policy	Oryani et al.(2021)
Bureaucratic behaviors	Regulation	Jahangoshai et al. (2019) Rohde et al. (2021), Acakpovi et al. (2019)
Special funds for renewable energy investment	Economic	Jahangoshai et al. (2019)
Encouraging investment	Economic	Jahangoshai et al. (2019), Kumar (2019)
Subsidy	Economic	Jahangoshai et al. (2019), Mastrocinque et al. (2020), Wu et al. (2019), Wu et al. (2019)
Governmental support for bank loans	Economic	Jahangoshai et al. (2019), Wu et al. (2019)
Employment opportunities	Social	Ullah et al. (2021), Overland et al. (2019), Wu et al. (2019)
land used	Economic	Ullah et al. (2021), Anser et al. (2020), Rediske et al. (2020)
Tax incentives	Economic	Mastrocinque et al. (2020)

Limitations	Type	Ref.
Levelized costs of energy (LCOE),	Economic	Anser et al. (2020)
Decrease of carbon emissions	Environment	Anser et al. (2020), Sovacool et al. (2021)
Local community acceptance	Social	Anser et al. (2020), Schick et al. (2015), Sovacool et al. (2021), Rediske et al. (2020), Gimpel et al. (2020)
Infrastructure distance risk	Technical	Anser et al. (2020), Mikhno et al. (2021). Sovacool et al. (2021)
sky radiance distribution, global horizontal and diffused horizontal irradiance	Technical	Anser et al. (2020)
efficiency indicators through temperature, wind speed, humidity, precipitation, and air pressure.	Technical	C. N. Wang et al.(2021)
Wildfire risk	Environment	Ruiz et al. (2020)
volatility of price,	Economic	Wu and Zhou. (2019)
annual rate of return	Economic	Wu and Zhou. (2019)
operation and maintenance cost	Economic	Wu and Zhou. (2019), Düştegör et al. (2018), Park et al. (2014)

Limitations	Type	Ref.
grid connection quality	Technical	Wu et al. (2019)
power supply reliability	Technical	Wu et al. (2019)
Shortage of knowledge	Technical	Firoozi et al. (2021), Perri et al. (2020), Düştegör et al. (2018)
experience & skill of the employees	Technical	Firoozi et al. (2021), Perri et al. (2020)
Amount and quality of generation	Technical	Shetaya et al. (2015), Omar et al. (2019)
the discomfort index	environmental	Omar et al. (2019)
Consumer behavior relation with the green economy	Social	Chawla et al. (2020) Milchram et al. (2018)
Individuals' energy consumption behavior	Social	Döbelt et al. (2015), Schick et al. (2015) , Milchram et al. (2018), Chou et al. (2015
data security and privacy	Technical	Döbelt et al. (2015), Shuhaiber (2021)
the role of consumers in energy systems activities	Social	Renström (2019)
electromagnetic radiation	Technical	Park et al. (2014)

Limitations	Type	Ref.
Justice and democracy,	policy	Milchram et al. (2018), Kumar (2019)
energy vulnerability		Bouzarovski et al.(2017)
re-institutionalization processes related to smart grids	Regulation	Rohde et al. (2021)
environment awareness	Social	Throndsen et al. (2015), Broman Toft et al. (2014), Abdmouleh et al. (2018) , C. fei Chen et al. (2017), Chou et al. (2015)
narrow range of engagement	Social	Broman Toft et al. (2014), Abdmouleh et al. (2018)
accumulative adoption	policy	Acakpovi et al. (2019)
perceived epistemic , emotional, monetary, and convenience values	Social	Shuhaiber (2021)

2.7 Discussion of findings

The depletion of resources due to unbalanced consumption policies and the growing demand across all aspects, is becoming the main challenge for the human beings. This problem is relevant in with energy supplies in particular, where the recent policies and systems need to be reviewed to safeguard a sustainable future. Therefore, the study emphasizes on the consequence of participation in the energy transition, which can guide to a rapid change towards securing a stable and environmentally friendly energy supply. Thus, implementing smart cities that are sustainable will be achievable. The current study is a SLR that explores published research on the challenges and determinants of energy transition. Through highlights the usefulness of literature reviews, we define a general information about energy transition and addressing the specific research question.

The study examined the determinants of energy transition identified in current SLR. The study analyzed 39 relevant empirical research studies and found that problems related to decision-making and socio-technical systems are crucial for expanding the energy transition. These findings are significant as they can contribute to heightened awareness of these issues, subsequently fostering the development of new and effective approaches to securing a sustainable energy supply.

The results highlight the cross-cutting limitations identified in the study. The current research identified forty-one limitations that can be addressed through comprehensive studies, this offers a prospect for future research to cover the neglected topics (table 3). The geographical diversity of research indicates the international significance of energy transition, and the clear increase of publications related to energy transition in recent years is a positive development.

The study discussed the need for further exploration, specifically decision-making methods, social awareness of technology, and the impact of socio-technical systems on energy transition as a targeted policy. The discussion underscores the consequence of understanding these issues in the evolving of effective policies for a sustainable energy transition. It outlines the key outcomes of the study and emphasizes the dearth of research in Iraq regarding this topic. Although this inquiry represents a limited effort to address this issue, it has wider ramifications for forthcoming studies, in addition to importance of conducting more research to better understand the challenges of energy transition in Iraq and other countries. Table 6 illustrates the main findings.

Table 6: The main findings

Findings	
1	Categorizing the current energy transition literature into the 1) Decision making of renewable energy policy 2) Socio-technical limitation of energy transition 3) Social acceptance of smart energy adoption.
2	Extract 41 limitations which hinder the energy transition process.
3	The geographical diversity of research indicates the international significance of the energy transition.
4	Increasing of the publication related to the energy transition currently is a positive development.
5	Developing countries publications still behind the trend.
6	Middle East publications are growing last 5 years.
7	Exploring new research areas in 1) Decision making of renewable energy policy 2) Socio-technical limitation of energy transition 3) Social acceptance of smart energy adoption.

The study offers a comprehensive assessment of the research findings, highlights the implication, and provides recommendations for future studies. It underscores the significance of real involvement in the energy transition and emphasizes the challenges that must be addressed to attain a sustainable energy supply. Additionally, Table 7 outlines the areas that require further investigation in future research endeavors.

Table 7: Research areas for future studies

Future research areas	
Decision making of renewable energy policy	The factors influencing the grid connection for PV penetration in the energy system not covered in MCDM
Socio-technical limitation of energy transition	Unequal access to renewable energy, social inequities in the circulation of costs and welfares, and its impact on developing communities
Social acceptance of smart energy adoption	Exploring the perception of professionals "staff specialists" about the smart energy applications. The literature was limited to the consumer's perspective in the developed countries. The lack of studies on the developing countries related to adoption of the smart grid, smart meters renewable energy etc.

2.8 Conclusion and Implications

The study widens the recent knowledge in the energy transition domain through synthesizing and evaluating the determinants discussed in previous literature. The study findings provide solid evidence of the variability of challenges and limitations associated with energy transition across various sources. The research was conducted by using reliable data sources, however, it is indorsed that future studies should emphasis on investigating additional determinants to enhance the understanding of new energy transition approaches for both researchers and decision-makers. The results of our explained the complexities of energy transition issues within the framework of the smart city concept. Considering the synthesized factors identified in this study, the energy transition theoretical and conceptual progress will be accelerated. To this end, this study provides several implications that can be strained from the findings:

Firstly, reviewing the current energy transition policies by redesign the governmental procedures according to the available resources. The policy should focus on promoting renewable energy and changing the traditional fossil fuel usage. In light of this, it is essential to reform the governmental sector and reduce bureaucratic obstacles that hinder the transition. Moreover, drafting laws and regulations to support the consumers in moving towards clean energy, includes tax cuts and financial support through grants and subsidy, in addition to providing banking facilities through soft loans to encouraging the public participation.

Secondly, addressing decision-making issues, the study highlights the importance of addressing decision-making issues related to energy transition. Governments should promote transparency and stakeholder engagement in decision-making processes to ensure that the concerns of all stakeholders are considered. In this regards, the stakeholders should be well defined.

Thirdly, increasing social awareness of technology related to energy transition. Governments should allocate funds and resources towards creating educational programs and campaigns that help people comprehend and realize the benefits of using renewable energy. The goal is to increase awareness among the public about the significance of sustainable energy resources and their task in protecting the environment and reducing carbon emissions. By investing in such initiatives, governments can encourage people to adopt more sustainable practices and create a culture of energy conservation.

Fourthly, infrastructure rehabilitation will ensure the quality of the transition and to accelerate the penetration of clean energy into the energy system of the cities. This study confirmed the need to move forward with the upgrading the infrastructure of energy sector to allow the assimilation of various energy resources in the system. In addition to train specialized staff and work on creating intensive training programs to ensure the quality of performance, also to ensure flexible operation and maintenance.

Fifthly, conducting further research: Developing countries has to pay more attention for further research on the challenges of energy transition. Governments should fund research and development in renewable energy and related fields to identify new approaches to solve problems related to securing a stable and environmentally friendly energy supply. Establishing research centers and encouraging non-governmental organizations to get involved will be one of the innovative solutions.

Finally, at the international level, geopolitical issues play a pivotal role in promoting energy transition. International sanctions policy significantly weakens the success of initiatives of the developing countries. Furthermore, international cooperation is essential to support the climate change mitigation, it is a collective action that is not limited to a country or region.

2.9 Limitations

This study encountered several limitations. One of the significant challenges was finding appropriate literature due to the uniqueness of the research and the inadequate research addressing it. The lack of systematic literature reviews of energy transition from the perspective of smart cities hindered the review process. Future research should conduct more comprehensive reviews to identify relevant future research directions. This field represents an opportunity to expand smart city research in the developing countries in particular through universities and research centers.

Chapter 3. The contribution of solar PV in the energy system of Bismayah new city in Iraq

3.1 Introduction

Renewable energy resources are becoming increasingly popular as the seek to decrease the reliance on petroleum products, which contribute to climate change mitigation by decreasing GHG emissions. Solar PV energy has obtained significant attentiveness recently (Ahmad et al. 2020). This technology plays a momentous role in the energy system of the cities, where the majority of the world's population lives and where energy demand is projected to raise in the upcoming decades. Solar PV installations are growing faster than any other renewable energy technology, and projected to be the major resource of electricity generation within next twenty years (IEA-Pvp 2020). This growth is driven by declining costs, technological advancements, and supportive policies in many countries. In urban areas, PV energy can provide multiple benefits, including reducing local air pollution, enhancing energy security, and creating local jobs. Figure 6 show the installed capacity of renewable energy by type. The growth of the global trend is noticeable in the direction of installing solar PV panels compared to other types.

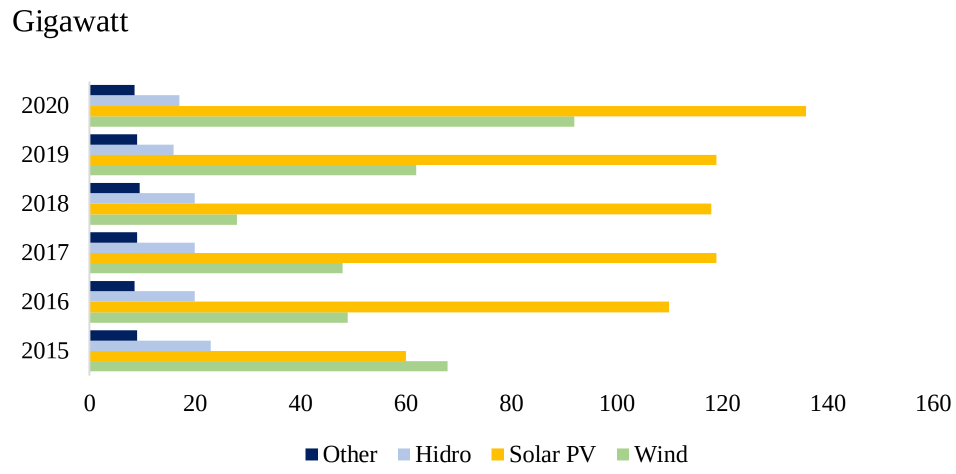


Figure 6. Renewable energy installed capacity by type

For instance, a study conducted in the USA found that rooftop PV systems in urban areas could generate up to 40% of the electricity demand in those areas (Castellanos et al. 2017). While Manoj et al. (2019) proposed to install 1 MW solar PV power plant in two different places in two university campuses in Malaysia. By conducting simulations, the results indicate that 5% of the total power consumption in the universities can met through the proposed power station. PV energy has an ability to boost the energy transition processes in the cities, serving to reduce GHG emissions. By addressing several challenges and seizing the opportunities presented by this technology, cities can contribute to a more sustainable and livable future (Pan et al. 2022).

Iraqi government has taken multiple steps to address the shortfall in the power supply and utilize renewable energy resources. The most recent initiative involves a contract to install solar PV farms that contribute with 12 Gw to the national power grid, which make up 31% of the total energy supplied in 2025. Figure 7explain the projection of PV contribution in 2025.

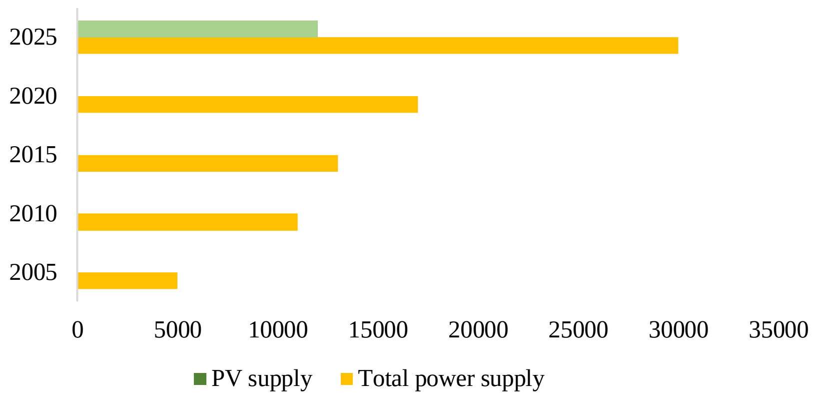


Figure 7. Iraq's 2025 plan for PV farms

3.2 Research Objectives and question

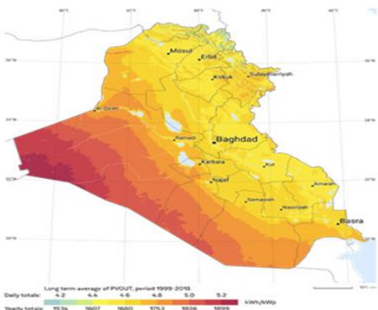
This chapter will review the current status and potential of PV energy in urban areas. Through analyze the consuming behavior depending on the formal data collected from the ministry of electricity in Iraq and conduct a simulation for PV output, we will discuss the PV contribution in the energy system. In this regard, the following question will be raised:

Q2: What is the contribution of solar PV in the energy system of the smart city?

To answer this question, Bismayah project will be selected as a case study of successful implementation. The study findings enhance the perceptions of the solar energy potential in the residential projects, enabling decision-makers, investors and researchers to develop and designs the energy transition framework towards sustainable smart cities. Moreover, through the technology used to integrate the renewable energy, the requirements of modernizing conventional energy systems will be clear and practical. Furthermore, the findings provide a solid ground for the experts who will investigate the factors influencing the selection of the appropriate electrical network for the purpose of optimally accommodating the solar energy outputs, as will be explained in Chapter 4.

3.3 Solar PV contribution in the energy system from previous studies in Iraq

Solar PV energy is attractive in Iraq according to the mean of sunshine duration, solar radiation per month and the daily data collected. Baghdad receives solar radiance more than 3000 hours per year (Al-Hamadani 2020). Figure 8 shows that highest radiation ratio is in the summer season at June, July and August, given these three months represents the peak demand what indicates that SE can solve the power shortage efficiently (Aziz et al. 2020).



Month	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Sun-shine	5.7	6.7	7.9	9.9	10.1	12.6	12.3	12.1	10.5	9.2	7.7	6.3
Irradiance	10.6	13.33	17.7	21.6	23.4	27.0	26.0	24.6	20.8	15.8	11.9	9.8

Figure 8. PV potential in Iraq

Power consuming data and PV simulations are essential tools for accurately determining the contribution of solar energy within the electricity grid. By analyzing power consumption patterns, it is possible to optimize the placement and operation of PV systems to ensure that they provide reliable and cost-effective energy for communities and businesses (Ahmad et al. 2020). Additionally, PV simulations provide an accurate prediction of energy output, enabling the integration of solar energy into large-scale electricity grids and can be used to optimize the placement and operation of PV systems. The importance of power consuming data and PV simulations cannot be overstated in the transition to a more sustainable and decarbonized energy system, its depend on the location conditions and the technology used (Ghadami et al. 2021).

There are many studies that dealt with calculating the contribution of solar energy from PV panels, for example, Bamisile et al. (2019) evaluated three different locations in the north part of Iraq to investigate the best location for solar PV installation and check the viability by simulate a 10 MW PV plant economic-based, they found that payback period is viable. Similarly, In a study by Ali et al. (2022) the economic and environmental aspects of a 1 MW plant located in the northern region of Iraq were examined, it revealed that payback period for the initial cost of the plant was approximately 7 years, while the payback period for the embedded energy of PV panels was 2 years, which is almost the same result comparing with Bamisile et al. (2019). What noted in these studies is the locations weren't residential and they didn't compare the actual load consumption data with the generated power. Aziz et al. (2020) presented a technical-economic assessment of a PV grid connected installed on the rooftop of a home in Baghdad, the consumption was evaluated in the summer, which represents the peak load. The study did not rely on the official data to investigate the total energy consumption. All studies in the literature suffer from the same problem. In addition to the absence of a study related to residential complexes in Iraq, the PV energy for one house contributes significantly to the energy consumed, unlike a residential building consisting of tens apartments and sharing the same rooftop. What mentioned in the previous sections, essential problem facing researchers in the Iraqi issue, there is no region in Iraq supplied with electricity 24 hours a day through the national grid, except for the new city of Bismayah. Thus, it is not possible to recognize the contribution of PV to the total power supply accurately, which constitutes a big gap in the literature.

3.4 Consumption data analysis in Bismayah new city

The New Bismayah City is considered the largest housing project in the world (Hanwha 2022). It extends over 18,300 km2 and consists of eight towns in which 834 buildings are distributed. Each building containing 120 units, for a total of 100,080 units to accommodate 600,000 residents (NIC 2021) as shown in Figure 9. At this size, it is nine times larger than Monaco. The project under constructions, town A and around 24% of town B are occupied. In this study we will work on town A as sample to analysis the consumption pattern.

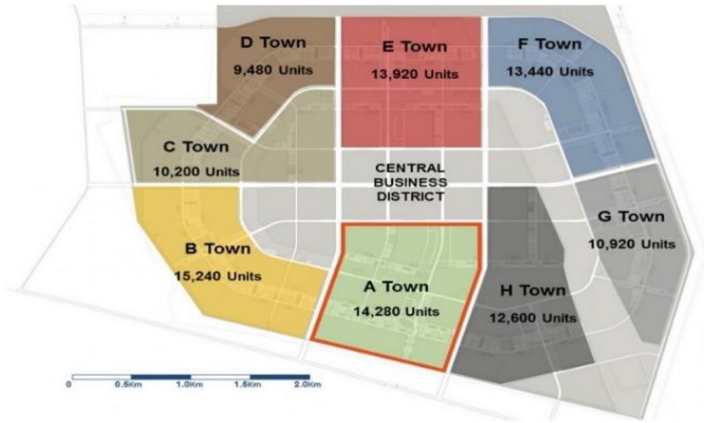


Figure 9. Bismayah new city project

In 2021, 51176 people occupied 119 building with total of 14280 units. The ministry of electricity provided us with the electricity consumption bills records for all residents during the years 2020 and 2021, given there are no smart meters, in addition to the fluctuation in issuance of electricity bills. It is not possible to find ordered data for a building or residential complex for a full year to do the measurement. The bills were more like random, this is considered one of the most important reasons for adopting smart grid and smart meters for real-time monitoring of consumption and for research and development purposes. It was necessary first to arrange the data records despite their huge size, therefore, an annual consumption of the Town A was calculated. The total power consumed was 195.2 Gw/h, Figure 10show the annual power consumption and its annual distributed data according to the official data.

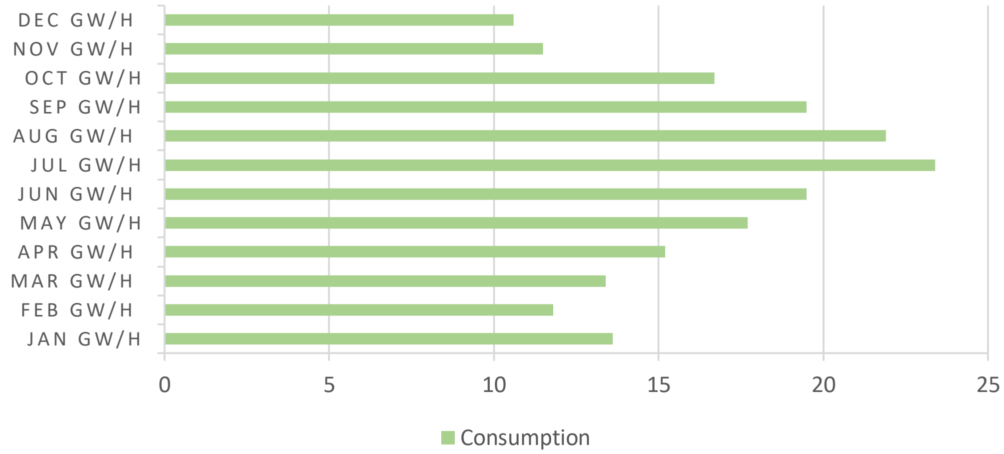


Figure 10. The annual power consumption for town A in Bismayah city

3.5 The PV potential in Bismayah new city

Through using the Google Earth application, we calculated the rooftop area of each building which is about 1300 m², we conduct a 3d design for the buildings in town A with Sketch-up 2.5 software and Skillion 2.3 software to calculate the number of PV panels can be installed. In this study, rooftops will only be used to install solar panels and without tracking systems. Many buildings are suitable for installing panels on the walls to maximize the energy production. A rooftop solar PV plant was installed in selected building as shown in Figure 11. In this study we used a solar-mono panel with 18% efficiency, the total number of installed modules is 600, the size of panel is 1.6 x 1 m according to the standard specifications, the PV plant capacity will be 300 kwp. Figure 11 a and b shows the design of the roof-top PV plant for the simulation.

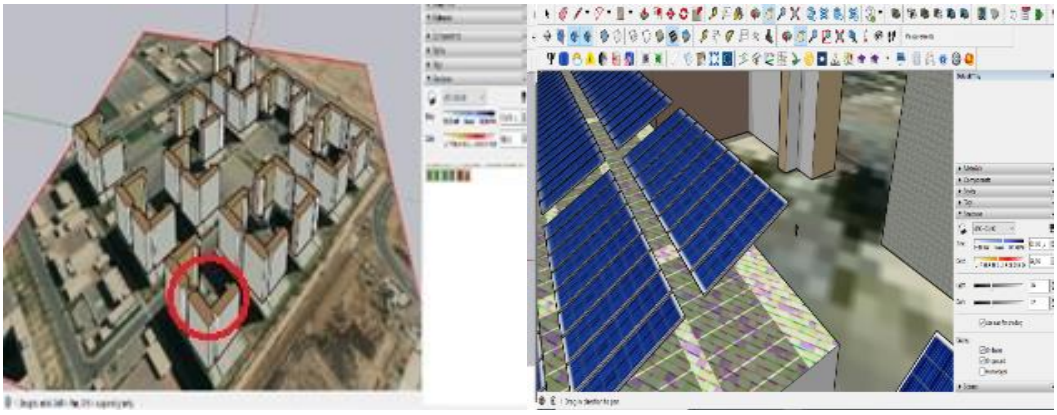


Figure 11. A- The design of buildings B- The roof-top plant

We use Global Solar Atlas online application to calculate the PV production. The simulation results show that possibility to generate 1.341 Mwh/d and 489.346 Mwh/y from the selected building, Figure 12 show the hourly average and the total output distribution through a year. Town A in Bismayah new city total buildings can produce 58.2 Gwh /year.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0 - 1												
1 - 2												
2 - 3												
3 - 4												
4 - 5												
5 - 6				1	4	5	4	1				
6 - 7			4	18	27	30	26	21	16	6	0	
7 - 8	9	21	47	60	69	75	69	67	69	55	38	11
8 - 9	70	79	102	107	113	122	117	118	123	105	97	78
9 - 10	119	129	151	150	152	162	157	160	167	148	141	123
10 - 11	155	168	189	181	179	188	184	189	197	179	169	152
11 - 12	173	189	206	193	189	200	197	203	209	187	178	166
12 - 13	173	187	202	189	186	199	196	202	206	179	171	164
13 - 14	156	171	183	172	169	184	182	187	187	159	148	144
14 - 15	128	143	154	143	142	158	157	160	155	124	114	114
15 - 16	85	102	112	104	104	120	120	120	111	79	69	70
16 - 17	19	49	63	58	61	74	75	71	56	25	11	8
17 - 18		3	11	18	23	31	32	25	8	0		
18 - 19				0	2	5	6	1				
19 - 20												
20 - 21												
21 - 22												
22 - 23												
23 - 24												
Sum	1,088	1,241	1,424	1,393	1,421	1,554	1,523	1,525	1,506	1,246	1,137	1,029

Figure 12.The distribution of output through a year

3.6 Discussion of Results

Figure12 shows that distribution of PV production is highly concentrated in the summer and in the hours between 11 am and 5 pm, this period represents the peak demand for electricity as shown in figure 10, as it turns out that July and August records have the highest consumption. Figure 13 shows the percentage of solar energy's contribution to the daily consumption of the selected building in peak demand in July, when the temperature reaches 50 degrees Celsius, as PV generation exceeds the half of the demand benchmark between 12 noon and 2 pm.

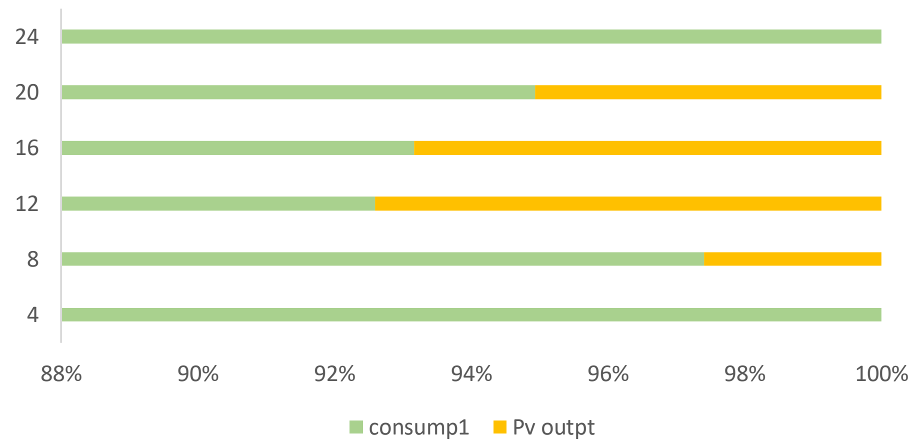


Figure 13. The hourly average of PV output

Figure 14 a and b show the results of the distribution of PV outputs with the actual consumption during a year for all the buildings of town A, where it is noted that the highest contribution rate is in March in view of the low demand for electricity. Also reflected in the quality of PV panels performance, were the standards is about 25 Celsius degrees.

While despite the high production in July and August, the contribution rate is small. Thus, the total contribution of PV to actual consumption during 2021 will be 29.8%. Compared with the results of Castellanos et al. (2017) in the USA case, and Manoj et al. (2019) in Malaysia, were PV contribute to 40% and 5% respectively to the total consumption.

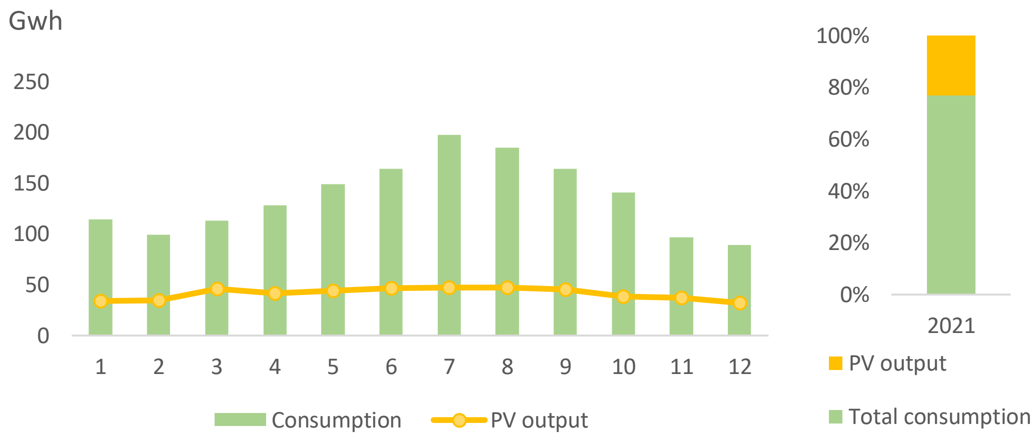


Figure 14. a & b: The annual contribution

The major findings are shown in Table 8.

Table 8: The major findings

Findings	
1	Renewable energy contribution represents 28.9% of the total power consumption in the city.
2	Installing the PV panels in the available spaces of the residential projects represents an opportunity to support the energy system and should be done before the PV farms projects.
3	DES is crucial to support the PV penetration in the energy mix of the city.

3.7 Policy implications

This study presented an accurate perception of the power consumption pattern in Bismayah city, it revealed the urgent need to conduct accurate studies based on governmental data to find out the consumption configuration throughout Iraq. In this study, we were not able to compare between the consumption of Bismayah city and other cities, especially in Baghdad due to the lack of ordered and tabulated data that allows us to provide appropriate implications to the government and investors of energy sector. Infrastructure aging and inaccurate reading of power meters, in addition to the delay of rehabilitation of distribution level, will hinder the planned government policies to expand solar energy projects. The government must start rehabilitating the national control center terminals so that it can provide reports and updated data on consumption periodically. The Ministry of Electricity have to accurately predict the power demand through the updated consumption growth reports. as well as to predict the amount of losses and thefts in the distribution sector, which distorts future policies and plans.

The study revealed that production of PV panels in Bismayah city is attractive to invest the available spaces, as the contribution rate reaches 30% of the total energy consumption. This contributes to reducing the consumption of fossil fuel in the current power stations, while providing sufficient flexibility to address the power shortage especially in the summer season, when the peak of PV production is at the peak of the demand. Therefore, the government should commence providing financial support and regulations that facilitate the private sector in installing PV panels throughout Iraq. Moreover, the aging of the infrastructure in the distribution sector requires moving towards distributed energy systems to overcome the problems of renewable energy within the grid. Investing the available spaces in the residential projects by installing PV panels reduce the investment costs comparing with PV farms. In addition to reducing losses and thefts through consume the generated power at the same place.

3.8 Conclusion

PV potential is a promising resource that is increasingly gaining investment worldwide due to its ease of installation, low investment cost, and short payback period. Its contribution to total energy consumption has exceeded expectations, making it a crucial factor in promoting the concept of sustainable smart cities with reduced carbon footprint. While there is a dearth of accurate studies on the contribution of PV output to total consumption in Iraq, this study presented a comprehensive vision by analyzing consumption data in the new residential city of Bismayah in Baghdad. The simulation conducted in this study showed that 29.8 % of energy can be provided through solar panels, which is an attractive for initiating residential projects towards transforming into sustainable cities and laying the foundation for smart cities in the future. On the professional and academic level, this study made several contributions, which are shortened in Table 9.

Table 9: Contribution categories

Professional level International, Governmental, Stakeholders	Academic level Innovative methodological research approaches, novel theoretical frameworks & original findings
1- Update the renewable energy potential to support government plans, the private sector investment and public participation. 2- Confirm that utilizing the residential projects is useful more than PV farms to decrease the initial cost.	1- Contribution to literature by addressing the gap of the hybrid residential energy system. 2- Real consumption data analysis and provide a PV contribution in a whole city from developing countries. 3- Quantitative analysis of PV adoption rates and pattern.

3.9 Limitations

This study encountered several limitations. One of the significant challenges was finding appropriate literature, the previous studies were relying on prediction of power consumption in Iraq according to some houses or buildings data. In addition, the previous studies were limited to calculate the PV contribution through designing a residential building or small projects, which hinder the comparison with the result of this study. Another limitation was the random of the bills, the ministry of electricity still has no specific schedule for issuing the bills, in some apartments in Bismayah city, we can notice some bills were for 4 months or more. This point forced us in few cases to estimate the monthly consumption based on the consumption rate to fill gaps in the data for some consumers.

Chapter 4. Assessment and decision making for grid connection of photovoltaic systems in residential projects in Iraq

4.1 Introduction

4.1.1 Background

The heavy fossil fuel consumption was the main reason of global economic growth in the past decades, which contributed to develop the urbanization remarkably. Cities consume around 75% of global energy consumption, however, energy demand continues to increase despite environmental concerns (Harjanne et al. 2019; Mohsin et al. 2021). Renewable energy considered as key-factor role in mitigating complexity, the amount of global capacity investments reached 272.9 billion USD, where the installed capacity of solar energy was reached 663 GW in 2018, outperforming all other technologies in this field (IEA 2022). Since solar energy is weather-related, energy produced will led to unbalance between supply and demand consequently, the power system must be flexible to accommodate the sudden fluctuations caused by the energy source (Gandhi et al. 2020). The accommodation PV energy requires a decision about the form of power dispatch and how to distribute the generated power to the consumers. It can be categorized into two techniques. Off-grid systems have no connection to the grid, due to the isolated or remote places like villages, given that unfeasible economically to extend the grid (Sampath et al. 2020). While On-grid systems are connected to the main grid, it can be categorized based on the capacity, the residential is some of KWp, the commercial (less than MWp) and utility scale (more than MWp) (Fu et al. 2017). On-grid distributed and centralized systems both are a global trend of PV installations, while the Off-grid is a unique option in case of unstable or unavailable of infrastructure. Fig.15 shows the global PV installations by grid connection type, off-grid systems represent the low ratio, however this statistic depends on developed-economy countries like china and EU due to the amount of investment and the infrastructure stability (IEA-Pvp 2020).

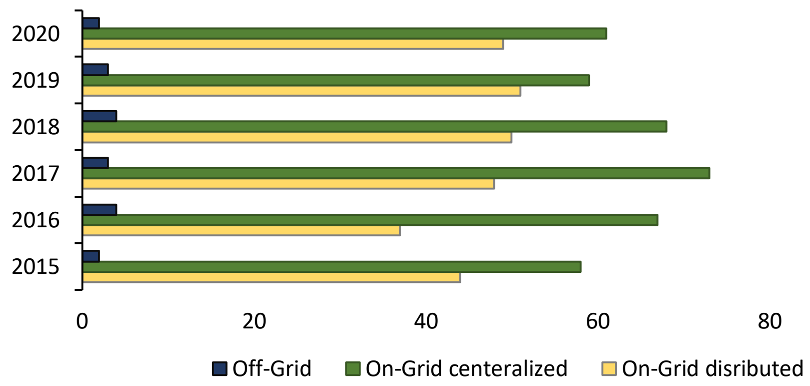


Figure 15. Percentage of PV installations according to the type of grid

Aziz et al., (2020) point that when increasing PV energy share, current power system has to be distributed, otherwise, the risk of further stressing instead of relieving will impact on the main grid (Sumper 2017). Maintaining power quality is vital for the seamless inter-operation between smart communities and the broader power system (Hatta et al. 2021). While the importance of off-grid systems is to accommodate renewable energy due to the weather fluctuation and the inability of the main grid to make the most at average costs (Jurasz et al. 2022).

4.1.2 The influencing factors of selecting the grid type for PVs

There are many factors related to the appropriate type of electric grid selection that maximizes the benefit of PVs and achieves the stability of the energy system. It can be classified into Technical, and Non-technical. In this study, the focus will be on technical, economic factors and social dimensions, given the issue is related to solar energy in all types of grids, environmental factors will be neglected because the impact will not make a big difference on decision-making results. The study develops a framework that facilitates the DM process to maximize the usefulness of PV through selecting the best grid connection. Since it is the first study to address this objective, it will be difficult to find the appropriate literature in order to capture the influencing criteria.

4.1.2.1 Technical Factors

Technical concerns concentrated around voltage violations, power backflow, harmonics, as well as poor coordination among traditional grid protection equipment (Siostrzonek et al. 2017). Also Haque et al. (2016) focused on overvoltage and voltage unbalance issues. Previous studies primarily focused on off-grid PV systems due to high installation costs, but as PV costs declined, larger utility-scale installations gained attention (Nema et al. 2009; Phuangpornpitak et al. 2007). Rakhshani et al., (2019) explored the contributions of large-scale PV, such as voltage regulation and virtual inertia, and evaluated PV integration exertions in some developed countries. Limited studies exist in developing countries, considering local standards, regulations, and policies (Sampath et al. 2020; Wong et al. 2014), putting in mind the local standards, regulations and policies. In countries that do not have a disciplined transmission network as in Iraq, it will be risqué to accommodate PV output within the transmission lines, which raises concerns about the current government policies in PV farms and not paying attention to diversifying the connection through on-grid distributed and off-grid systems. With regard to the technical criteria used in the framework of decision-making, it was not noticed in the literature a precise interest in the influencing technical factors. Omar et al. (2019) and Shetaya et al. (2015) were among few studies that dealt with this aspect. Factors like infrastructure, skillful staff and power generation capacity will be explained in details in section 3, however, Figurer 16 illustrates the characteristics of PV integration issues in the grid, the impacts indicated whether located at the distribution or the transmission level, in addition to the timescale.

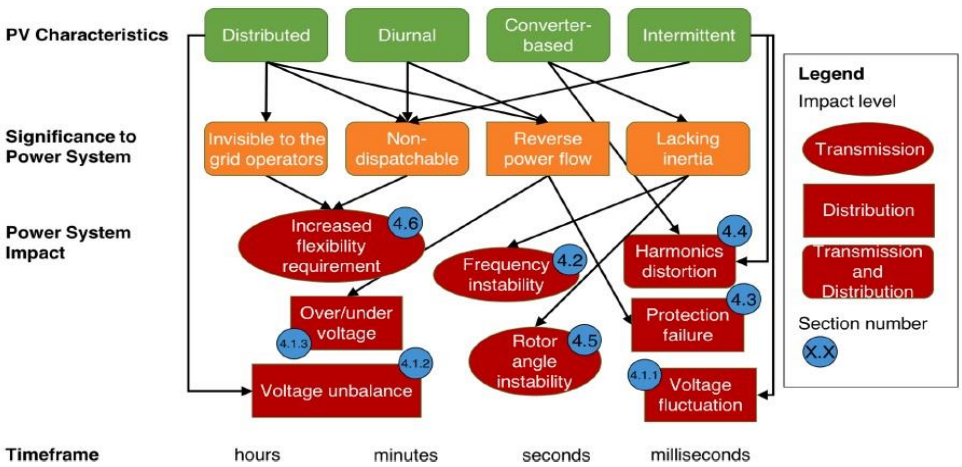


Figure 16. The integration of PV impacts on the power system (Gandhi et al. 2020)

4.1.2.2 None-Technical Factors

Surveyed literature confirmed numerous factors in the PVs path like, initial cost, acceptance, jobs creation, in addition to the technical limitations, were known as the significant barriers (Jahangoshai et al. 2019; Shim et al. 2018). There is no consensus on criteria or factors, for instance, in Ghana, Mahama et al. (2021) confirmed that the most critical challenging obstacles in the context of their study were identified as economic and financial factors, technical limitations, and the lack of necessary human skills. These obstacles were considered significant barriers that need to be tackled to achieve success in their research area. Numata et al (2020) in Myanmar have studied social/cultural in addition to the technical, regulatory, economic and financial for development of mini-grids. In Nepal, Ghimire et al. (2018) add geographic and administrative factors as a barriers of adopting renewable energy. Section 2 will explain more details of the factors.

4.1.3 Study objectives and questions

This study assumes that the exploitation of available spaces in the residential projects by installing PVs will support the stability of the energy system. While the current power system is unable to absorb additional capacities. Since solar energy is intermittent, enabling the energy system to exploit the outputs with consistency with available equipment and devices will be the key factor. In the Iraqi case, as explained in Chapter 3, the energy system is unstable, therefore it will be challenging for the government or the utility operator to expand with huge output projects. A key questions arise here;

Q3: What is the best grid connection type for PV penetration in the energy mix of the cities?

Q4: What are the influencing factors of PV integration into the power system of the residential projects towards sustainable cities in Iraq?

Up to our best knowledge, no similar study analyzing this issue with integrated perspectives in terms of technical, economic, and social factors was found in the literature. This study works to identify success factors to promote the energy transition, which in turn contributes to the formation of sustainable cities. It will also provide a new framework through the use of specialized experts to provide recommendations to the policymaker. It will be a base for future studies that deal with this problem in the developing countries which have both fossil fuel and renewable energy resources.

Second section will present the status of power sector in Iraq, then, section 3 will be the literature review. forth section will be the methodology which contain the implementation of a hybrid TES-AHP method for to select the best grid connection for the PVs in the residential projects in Iraq. The rest will be result and the policy implications.

4.2 Iraq Situation

In this regard, this study will investigate the Iraq situation after four decades of wars and international sanctions which depleted the infrastructure. Outages remain chronic issue in Iraq, the gap expanded between peak demand and supply of power. Although increasing the available supply, nevertheless, the low investment in infrastructure especially the transmission and distribution networks is widening the problem (Aziz et al. 2020; Istepanian 2018). The loss at the distribution and transmission level still around 20 percent of total energy produced, what considered the worst comparing with the neighbor countries

(IEA 2018). The security situation also has a direct impact on the national grid, the long path of 400KV and 132 KV transmission lines makes them easy prey for terrorist attacks (MOE 2021).

Solar energy is attractive according to the data records of Iraqi meteorological office, the mean of sunshine duration and solar radiation per month. Baghdad receives solar radiance more than 3000 hours per year (Al-Hamadani 2020). The steady falling costs of SPV industry not only reduce the cost of electricity, also the viability of NG resources. While also increasing export revenue opportunities for petroleum products in particular as an alternative opportunity instead of consuming them in the power generation (Malik et al. 2019; MOE 2021). The government initiatives for reforming the housing and energy sectors represents a challenge and opportunity to enhance the power services (Ersoy et al.2021; GSCOM 2021; NIC 2021). The government issued the order 67-2021 for install solar PV panels with capacity of 12 Gw till 2025, which represents about 31% of the total energy supplied. This policy ignores the residential projects, despite availability of free and wide spaces and load centers, which considered a waste of opportunity. However, these action coincided with previous orders in housing sector to accommodate the rapid population growth away from the city centers. One of these projects is the new city of Bismayah, which considered the largest housing project in the world (Hanwha 2022). It extends over 18,300 km2 and consists of eight towns in which 834 buildings are distributed. Each building containing 120 units, for a total of 100,080 units to accommodate 600,000 residents (NIC 2021) as shown in Figure 17.

Figure 17. Bismayah new city project

4.3 Literature review

4.3.1 Theoretical Background

Several studies addressed renewable energy issues through the MCDM theory, whether to identify the obstacles and their impact or to select the appropriate decision. Up to our best knowledge, there is no published study addressed the questions of this study or tackled its objectives. Therefore, the search for literature was theoretically to find closer studies to identifying the essential factors for the study model, in addition to standing on the models used in the solar PV context exclusively. Mastrocinque et al. (2020) provide TBL framework which based on social, economic and environmental aspects, AHP method for sustainable supply chain. Relying on three expert's opinions for criteria evaluation in seven countries does not be reliable, which also explains ignoring the techno-economic factors, for instance, the impact of solar radiation intensity variation in those countries, this factor can change the whole equation (Aryanfar et al. 2020; Kan et al. 2021).

Regarding the selecting suitable location for PV, the works of Anser et al. (2020) targeted selecting adequate locations of PV farms based on AHP-SWOT model validated to suggest different sites in Turkey. Which is to blame in this study, neglecting the infrastructure standard of the electricity system (Rediske et al. 2020), as well as the alternative opportunity for installing PV, as the installation of PV requires large areas, usually exploiting barren lands (Aryanfar et al. 2020). Similar works are proposed by Alizadeh et al. (2020), combining BOCR and ANP to overcome the pitfalls of past processes from an energy security perspective in Iran. However, limitations on the technical side were not given a detailed or great importance, technical limitations were so primitive. In Iran also, the works of Oryani et al. (2021) distinguishing the major obstacles to the development of the PV, wind, and biomass energy in Iran using AHP. Five dimensions have been identified, Economic, Social, Political, Technical, and Institutional. The technical criteria were limited to the lack of infrastructure, skilled personnel and absence of indiscriminate. pointed that neglect of important criteria in the Iranian situation, such as the potential of renewable energy or the security factor. The works of Ullah et al. (2021) present AHP framework for a 100% renewable energy in Pakistan including biomass, hydro, wind, and solar for selected rural area, the study conducted an hourly-based design optimization analysis of on-grid and off-grid electrification. The study considered various criteria, including reliability, economy, ecology, topography, and society. These criteria were taken into account to ensure the optimal design and implementation of electrification system. The results varied according to the alternatives and sub-criteria used, as the off-grid system provided relatively higher employment opportunities in addition to reducing emissions further, while the on-grid system reduced the area of land used.

The works of Rediske et al. (2020) propose a model to indicates the ideal place for install a large-scale PV plants. using AHP by the GIS-MCDM tools. point that potential locals may impact on the project and exclude protected areas as well as water bodies. C. N. Wang et al. (2021) proposed selecting the best locations in Taiwan by measuring the efficiency indicators through temperature, wind speed, humidity, precipitation, and air pressure, Data envelopment analysis and AHP models combined together. Khorshidi et al. (2022) in turkey, conducted an integration between hybrid fuzzy DEMATEL and MOORA to prioritize the regions for the PV plants, then fuzzy AHP conducted to do sensitive analysis. Almost the same outcomes but in deferent MCDM methods.

The works of Ke et al. (2022), Wei, (2021), and Wu et al. (2019) about the sustainability of PV poverty alleviation project to improve the rural poverty in China, the missing parts was analyzing the potentials with the technical and economical restrictions and addressing the project wastes. TBL-AHP model proposed by Mastrocinque et al. (2020) was significant in this point. Although the combination between AHP and TOPSIS provide an acceptable outcome, it also has confirmed demerits. Missing some Information or distortion in some phases of data collection in the projects, will not support to determining the numerical values to evaluate the alternative projects in terms of sustainability, uncertainty and ambiguity are also unavoidable in this kind of researches (Mousakhani et al. 2017). Aryanfar et al. (2020) submitted PV potential assessment using DM fuzzy logic. The authors argued that dust and humidity are considered as the technical indicators for PV potential assessment, while some studies like Kan et al. (2021) considered the climatic factors as techno-economic factors, several factors are examined like the agriculture and industry status and the transportation infra structures, they agreed with Rediske et al. (2020) in the importance of population factors. However, it ignored the power system infrastructure like the substations and the transmission lines and the security factor. There are some studies offer TOPSIS through quantitative and qualitative factors which impact on the manufacturing operation of PVS. Gazibey et al. (2012) use TOPSIS with quantitative approach depending on the level of PV efficiency to assess the technologies. The works of Wu et al. (2019) specified the conclusive risk factors and offer comprehensive framework for risk assessment of urban rooftop distributed PV policy in China. Firoozi et al. (2021) conducted an integrated DEMATEL and ANP method focus on exploring the risk factors affecting the sustainable development through low and medium SPV plants in Iran. Also Lin (2021) aimed to investigating current barriers to solar PV implementation. Through a meta-analysis, methodology was DEMATEL integrated with TOPSIS. Similarly with Alzahrany et al. (2022), the barriers of PV implementation in Saudi examined by using the DEMATEL and ISM to evaluate the driving and dependence power of the barriers, while Y. Wang et al. (2021) used DEMATEL and ISM to assess the accumulated funds of research and development and installed capacity of SPV. In electrical grids domain, Shetaya et al.

(2015) presents a new approach based on AHP to support the integration of concentrated PV in the smart grid by measuring the current grid flexibility and capability to operate grid securely. Detailed technical criteria were used for the first time; controllability, minimum power, ramp rate capability of generation and startup time. While the works of Omar et al. (2019) proposed flexible assessment using AHP to classify the energy management control algorithms of the residential buildings based on the cost, amount of energy and the discomfort index.

Among the variety of methods mentioned, it's clear that AHP utilized more among other approaches in the MCDM problems (Russo et al. 2015; Vaidya et al. 2006), in spite of the debates in some studies (Ishizaka et al. 2006; Norris et al. 1995; Omar et al. 2019). The main restriction of AHP is rank-reversal among the residual alternatives when delete or add an alternative. Some defenders of AHP like Norris et al. (1995); Pohekar et al. (2004); Saaty et al. (2006) confirmed that rank reversal is not an crucial demerit, this behavior has been pointed in the real-world DM issues. The measurements obtaining is relative, therefore, rank preservation in all situation is not true. However, we could not find in the literature any framework to assess PV integration into the power system in terms of grid type, or at least understand the priorities of grid connection for integrating PV into the grid. However, the literature has provided a comprehensive understanding variety of factors that can be considered influential in general. With reference to the need to add or modify some factors that have been neglected or underestimated as research requirements to achieve the goal of the current research and fill the gaps. Table 10 illustrates the summary of the previous studies comparing with this study.

Table 10: Summary of former studies

Study	Method	Country	Grid evaluation	Main Criteria Tech.	Eco.	Soc.
Mastrocinque et al. (2020)	AHP	Europe (7)			✓	✓
Anser et al. (2020)	AHP-F-VIKOR	Turkey			✓	✓
Alizadeh et al. (2020)	BOCR- ANP	Iran		✓	✓	✓
Oryani et al. (2021)	AHP	Iran		✓	✓	✓
Ullah et al. (2021)	AHP	Pakistan		✓	✓	✓
Rediske et al. (2020)	AHP-GIS	Brazil		✓		
Wang et al. (2021)	AHP- DEA	Taiwan		✓	✓	✓
Khorshidi et al. (2022)	DEMATEL-MOORA	Turkey		✓	✓	✓
Wei, (2021)	BOCR-AHP	China		✓	✓	✓
Wu et al. (2019)	DEMATEL	China		✓	✓	
Aryanfar et al. (2020)	DM fuzzy logic	Iran		✓	✓	✓
Gazibey and Çilingir. (2012)	TOPSIS	Turkey		✓	✓	✓
Wu et al.. (2019)	DEMATEL	China		✓	✓	
Firoozi et al. (2021)	DEMATEL-ANP	Iran		✓	✓	
Lin . (2021)	DEMATE-TOPSIS	Taiwan			✓	

Study	Method	Country	Grid evaluation	Main Criteria		
				Tech.	Eco.	Soc.
Alzahrany et al (2022),	DEMATE-ISM	Saudi Arabia		✓	✓	
Y. Wang et al. (2021)	DEMATE-ISM	China		✓	✓	
Shetaya et al. (2015)	AHP	Egypt		✓		
Omar et al. (2019)	AHP	USA		✓	✓	
Ghimire et al. (2018)	AHP	Nepal		✓	✓	✓
Numata, et al. (2020)	AHP	Myanmar		✓	✓	✓
Asante et al. (2020)	AHP	Ghana		✓	✓	✓
Mahama, Derkyi, and Nwabue. (2021)	AHP	Ghana		✓	✓	✓
This study	AHP	Iraq	✓	✓	✓	✓

4.3.2 Factors' identification

The main factors were identified in three steps explained in Figure 18. First step was preparing a list of factors from the former studies. In the second step, the last list was obtained through assembling the experts' opinion and updating the draft by adding some unconsidered factors and deleting some from the list. Finally, the last step was ranking the main factors of grid type selecting for PVs in the residential projects in Iraq.

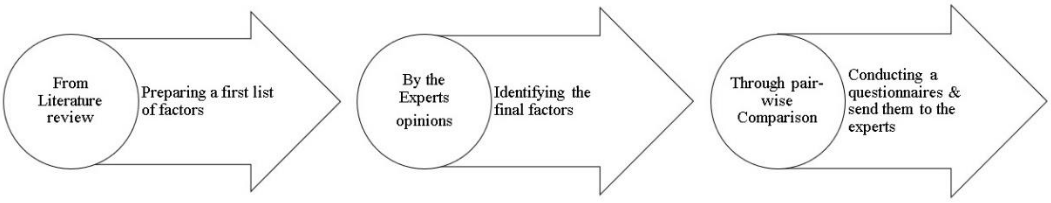


Figure 18. Steps of identification the factors in Iraq

The extracted list was submitted to the experts again. at the end.10 factors were identified and categorized into three main dimensions. Table 11 explain the summary of the ultimate factors list and their references.

Table 11: Summary of the ultimate factors

Criteria	Sub-criteria	References
Technical (T)	Infrastructure (T1)	Jahangoshai et al. (2019), Asante et al. (2020), Oryani et al. (2021), Ghimire et al. (2018), Firoozi et al. (2021), Alizadeh et al. (2020)
	Grid stability (T2)	Shetaya et al, (2015), Gazibey et al. (2012), Ullah et al. (2021), Mahama et al. (2021), Numata et al. (2020)
	Generation capacity (T3)	Ullah et al. (2021), Ghimire et al. (2018), Firoozi et al. (2021), Lin . (2021) & experts
	Staff experience (T4)	Jahangoshai et ali. (2019), Asante et al. (2020), Oryani et al. (2021), Ghimire et al. (2018), Firoozi et al. (2021), Wu et al. (2019) &experts
Economic (E)	O&M (E1)	Asante et al. (2020), Mahama dt al. (2021), Numata et al. (2020), Wang et al. (2021), Wu et al. (2019), Alizadeh et al. (2020)
	Cost (E2)	Omar et al (2019), Jahangoshai et al. (2019), Mahama et al. (2021), Oryani et al. (2021), Ghimire et al. (2018), Wang et al. (2021), Alzahrany et al. (2022), Alizadeh et al. (2020)
	Subsidy (E3)	Ghimire et al. (2018), Wang et al. (2021), Alzahrany et al. (2022), Wu et al. (2019) & experts

Criteria	Sub-criteria	References
Social (S)	Jobs (S1)	Ullah et al. (2021), Khorshidi et al. (2022), Alizadeh et al. (2020), Mastrocinque et al. (2020) & experts
	Acceptance (S2)	Jahangoshai et al. (2019), Asante et al. (2020), Mahamaet al. (2021), Oryani et al. (2021), Numata et al. (2020), Ghimire et al. (2018), Wang et al. (2021), Mastrocinque et al. (2020)
	Security (S3)	Firoozi et al. (2021), (Lin et al. 2018) & experts

4.3.2.1 Technical sub criteria

Jahangoshai et al. (2019) highlighted that the lack of required infrastructure, both weak and non-existent, is a significant obstacle in the energy transition of developing countries like Iraq. This deficiency in infrastructure poses a significant challenge in the implementation and advancement of sustainable energy systems, hindering the progress towards a more sustainable and efficient energy sector. Infrastructure includes switching stations and transmission lines for the transport sector, in addition to sub-stations, transformers and it may sometimes include smart meters and various sensors for the distribution sector. For the off-grid systems, infrastructure is also necessary to transfer surplus energy to the grid, which reduces investment costs in this case the consumer will be prosumer (Gandhi et al. 2020).

The grid stability factor in this study was developed through the literature and expert opinions, as it was explained in the introduction, the effect of PV integration in the grid has a significant impact on its stability in terms of service quality, network flexibility and voltage balance and fluctuation (Ahmed et al. 2015). Since the source of generation is PV panels in all grid options, the generation capacity is considered constant, but the net power is an important measure according to experts' opinion. In the main Grid, various types of losses occur, while in off-grid case the net power will be in the maximum, as we indicated in the introduction section (Jurasz et al. 2022). In the literature, we couldn't find a similar factor, for this reason we developed it as a criterion. The previous studies in the field of solar energy referred to the important role of skilled engineers and technicians (Wu et al. 2019). In our study, this factor is crucial because of the emerging penetration of advanced technology in the country. The role of technical expertise will be a key factor in success, according to experts as well (Jahangoshai et al. 2019). The impact of this factor includes all alternatives, especially in performing the necessary maintenance to sustain the grid of solar energy systems and their integration with the grid.

4.3.2.2 Economic sub criteria

Economic factors are the most crucial barriers to hinder the energy transition evolving in the developing countries such as Iraq (Alizadeh et al. 2020), with a reminder that energy transition policies in general falter due to the economic factors impact on consumer's preferences, it is clearly noted in the decision to have an EVs in the developed economic countries (Choi and Koo 2019). It represents the most influenced factor in the MCDM related to PV through the literature. However, the operation and maintenance cost is significant in selecting the type of grid (Numata et al. 2020). As we mentioned in the previous section, in case of off-grid, the main cost will be on the storage devices like batteries. while in on-grid distributed, it will be more complicated due to the overhead charges. The cost of grid type constructions is not the PVs initial cost because its equal in all alternatives, according to the expert's opinions, it impacts on the grid type will be essential to decide the right choice economically. For subsidy, the government incentives and subsidy represents significant motivation in RE generally (Ghimire et al. 2018), in our study, the positive impacts of subsidy will effect on the grid type feasibility.

4.3.2.3 Social sub criteria

The energy transition has faced public resistance especially in the countries who has cheap fossil fuel price like Iraq (Oryani et al. 2021). It could be labelled by the defect of public awareness and social acceptance. Public acceptance may go beyond the sense of interest behind the power system improvement, as many of public and researchers together believe that exploitation of rooftops of residential buildings may be more beneficial through mitigating the heat island effect by creating a rooftop gardens to reduce high temperature or improve the environmental condition and landscape (J. Kim, Lee, and Kang 2020).

However, at the same time, there is a sweeping local desire to get rid of the electricity crisis that has been intractable for decades as we mentioned in the previous sections. After deliberation with experts, this factor is considered necessary in adopting renewable energy in general and its accessories such as the type of grid (Mastrocinque et al. 2020). The grid type has an important impact on creating or eliminating jobs (Ullah et al. 2021). Through the literature we can find so many studies relied on this factor as a barrier (Khorshidi et al. 2022). Security concerns in a country like Iraq will be a main issue for any project related to the energy. as we explained in the section 2. we develop this factor after negotiation with the experts and some related literature (Lin et al. 2018).

4.4 Methodology

4.4.1 Analytic Hierarchy Process method

In this section, the methodology used will be addressed by MCDM framework based on AHP model to assess the readiness of SPVS integration with the power system. MCDM represents an accurate technique which provides reasonable decision among complex criteria with deferent scales. currently, a wide range of studies has been carried out on the theoretical and application aspects of MCDM. From the literature on the energy sector, it has been seen that AHP and ANP are widely used due to the ease of use and the software available. AHP is a valuable tool for effectively managing interdependencies among criteria. Introduced by Saaty et al. (2006), as one of the MCDM techniques, the AHP model enables the evaluation of priority scales without assuming specific relationships between elements. It utilizes a network of criteria to establish a comprehensive scale that remains consistent under the identity transformation, with values ranging from 1 to 9 (Saaty 1987).

Software packages such as Super-Decisions and Expert Choice facilitate the implementation of the AHP in decision-making processes, offering users a quick and efficient means of utilizing the AHP methodology (Alizadeh et al. 2020). Through pairwise comparisons, experts subjectively assess the relative importance of one factor over another concerning a third factor. This judgment-based approach is crucial for determining the relative significance of different factors within the decision-making framework. The identification of the framework is a crucial initial step in the AHP process. Once established, selected experts compare strategic dimensions against each other, allowing for informed judgments and evaluations to be made in order to determine the relative importance and priorities among the different factors. According to (Saaty 1987), we have to raise the matrix to a large power then summing up the matrix along the rows then finally dividing each by the sum of all the rows in order to normalize the weights. In case of consistent judgement, the total weights of the alternatives are determined by multiplying the priorities by the priorities of the sub-criteria and dimensions. At the end, gathering the resulted values for the alternatives. Figure 19 shows the conceptual framework for the whole procedures to prioritize the grid connection alternatives and to reformulate policies on improving technical, social and economic importance by focusing more on the technical factors. First examine the criteria through the literature and review them with the experts, then selecting the final list. The experts invited to submit them judgement of the TES dimensions according to Saati's scale. The alternatives will be examined in the same way by give the judgement of criteria according to the alternatives. After that creates the super matrix for the model, then each expert result will be calculated. Finally, geometric mean conducted for all the experts results before using the Super decision software to obtain the best alternative.

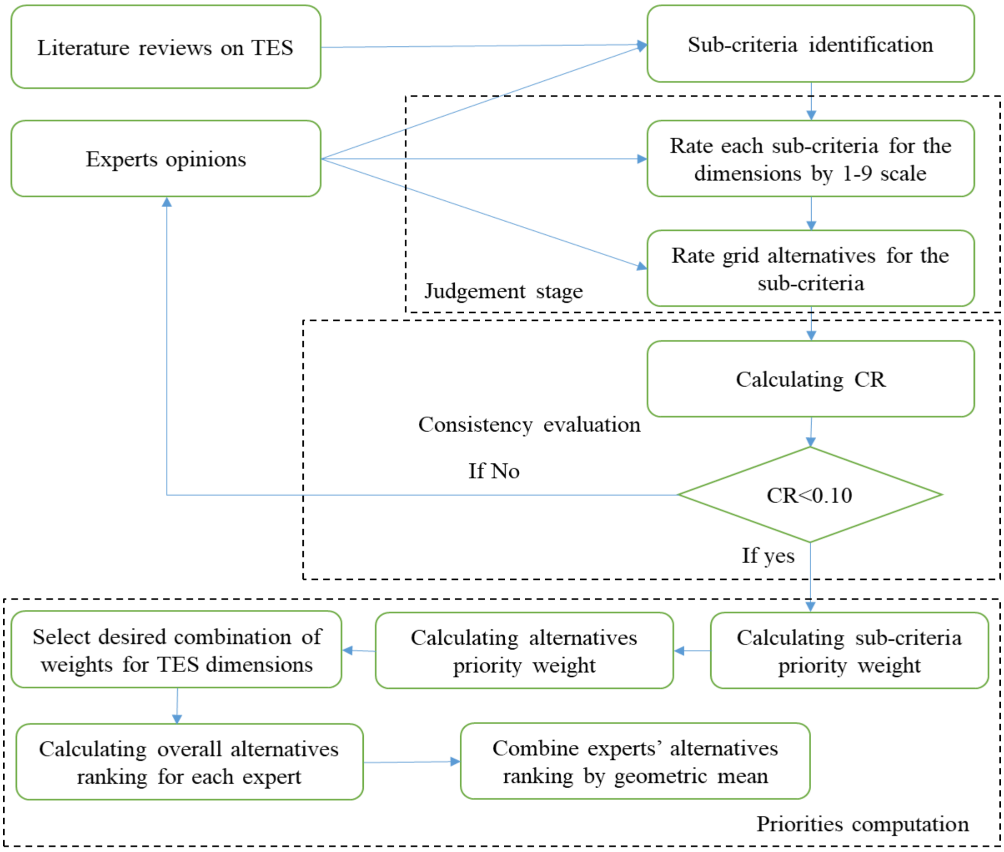


Figure 19. The proposed grid connection evaluation methodology

4.5 Results

4.5.1 The expert team formation

In order to test the framework and model, 50 independent experts in the electricity sector were approached, 37 respondents approved. Three experts are former ministers of electricity. Recently one of them work as an advisor with Siemens Group. The second former minister has experience in the energy economics in the UK and Iraq, in addition to establish the Iraqi energy forum. The rest are senior's researcher, one of them is from Scopus evaluated team. They work as managers in the RE department and IT center in the ministry of electricity. Among them some minister deputies, director's general and assistant in the training and development directorate, RE department, economic directorate etc. Initially, by the literature review, experts' opinions refined the model and consider the factors more appropriate to the PV panels connection within the grid. The experts were assigned to implement the steps mentioned above. The qualifications of them were conducting according to the academic records, background of experience and recent field of work.

4.5.2 Determining the structure

The goal will be the head of level 1, the strategic criteria (TES) will be in the level 2, sub-network and criteria will be in level 3. Level 4 will be the alternatives. Figure 20 shows the proposed model contents. Level 1 of the structure is prioritizing the three grid connection alternatives of SPVS in the power system of Iraq. According to the former studies and the experts, the main criteria defined as follows: Technology (T) consists of four factors, Economy (E) consists of three factors, Social (S) consists of three factors. Through testing the model, the relationship of its clusters and elements will give us the final results.

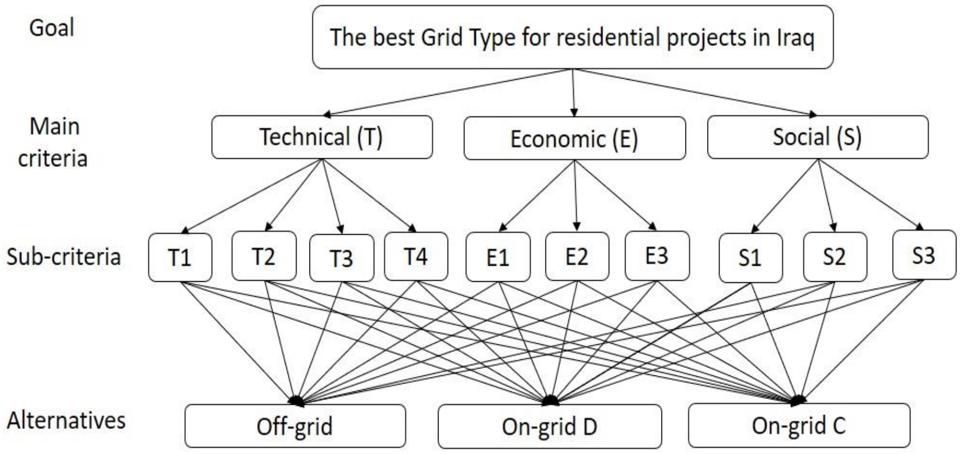


Figure 20. The proposed model

4.5.3 The strategic criteria weights

In the process of prioritizing the best grid connection, the experts will compare the TES criteria by using a pairwise comparison matrix. They will use Saaty's 1-9 scales to rank the importance of one criterion against another. To ensure the consistency and logic of the comparisons, the super decision software will be employed to calculate the inconsistency rate (IR), which helps identify any errors or inconsistencies in the judgments. After assessing the pairwise comparisons and ensuring consistency, the next step involves determining the weights of the TES factors. Then, evaluating the weights of the three elements of the TES. This evaluation will allow for the determination of the relative importance and contribution of each factor in achieving the objective of ranking the best grid connection

4.5.4 Categories results

The results of three main categories factors hierarchy were explained in Figure 21.

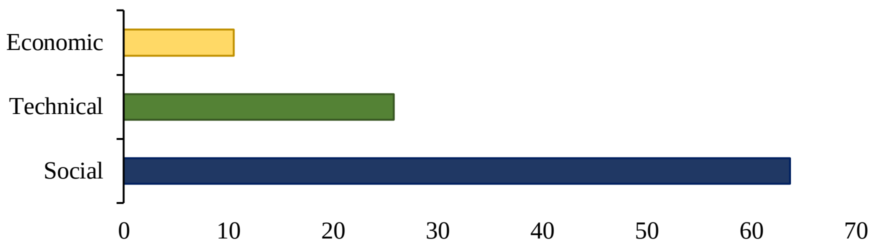


Figure 21. Synthesize of the main criteria and prioritization

4.5.5 Ranking of factors

The judgement will set the importance of the alternatives with respect to each factor in the TES. The acceptance factor has the first priority among social criterion with 65.9%, the second was the jobs with 18.5% and the last rank was the security with 15.6%. On the technical side, staff experience factor was significantly distinguished with 57.8%, the second factor was the infrastructure with 22%, grid stability and grid stability 11% and generation 9.2%. For the economic side, operating and maintenance factor was 60% in the first rank, cost and subsidy factors have the same position with 20%. The overall ranking of factors was demonstrated in Figure 22.

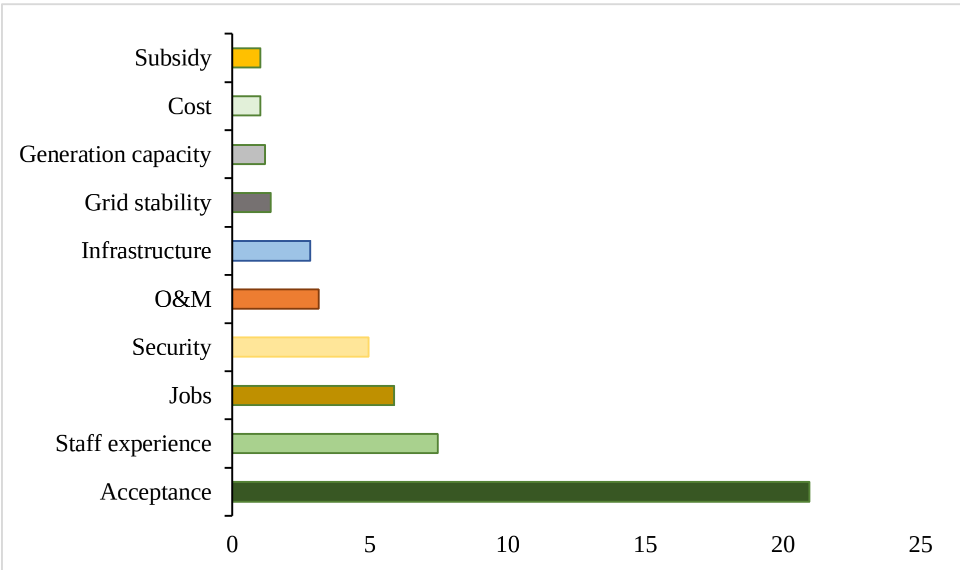


Figure 22. The overall ranking of the factors

Furthermore, by combining the weights within the hierarchy, the relative importance or composite priorities of the alternatives based on the factors were settled. This process involves combining the weights assigned to each factor at different levels of the hierarchy to arrive at an overall assessment of the alternatives. The aggregation of weights allows for a comprehensive evaluation and comparison of the alternatives, taking into account the relative significance of each factor in achieving the desired goal or objective. However, aggregated group results for identifying factors in Figure 23.

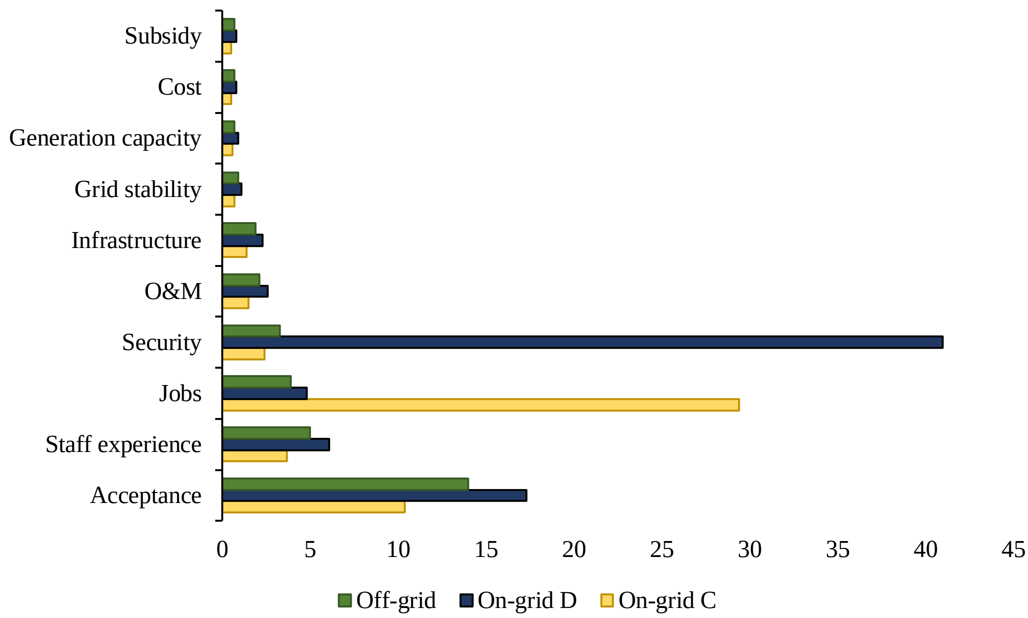


Figure 23. Aggregated group results

As demonstrated in Figure 23 and 24, the top three factors among the main dimensions of the grid type selection from three inspected alternatives were listed as the acceptance, staff, and O&M see Figure 24 and 25.

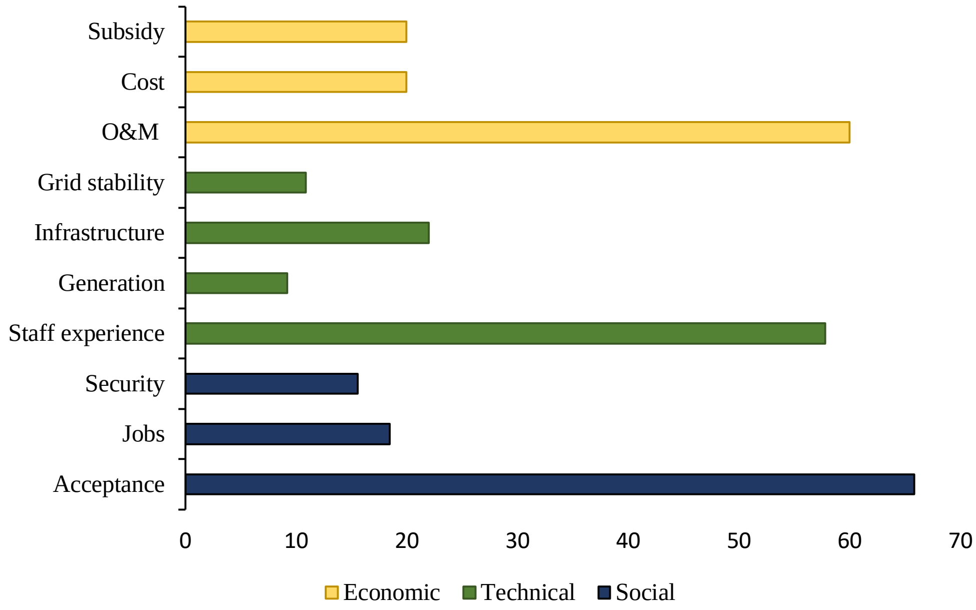


Figure 24. Top three factors of grid type selection

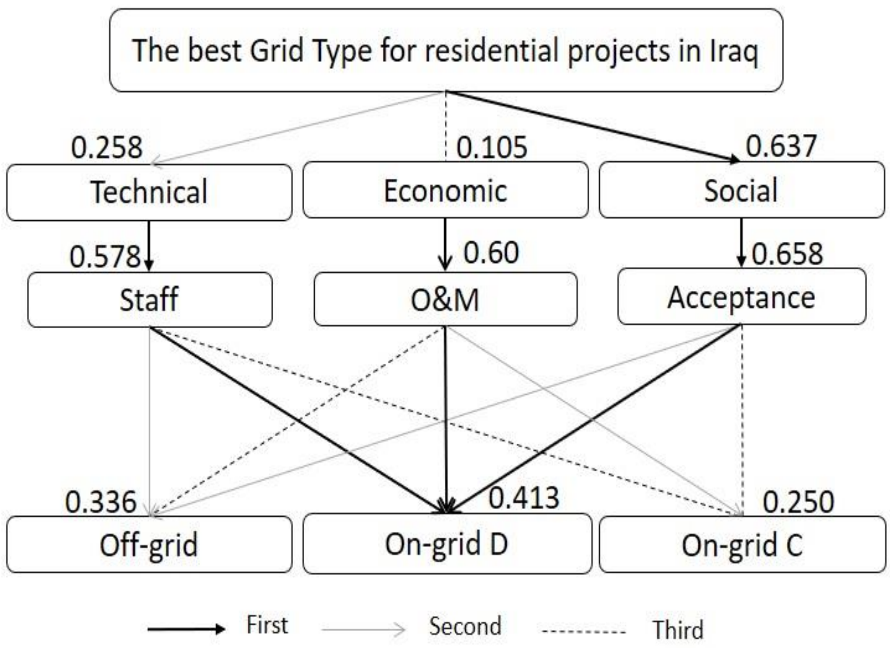


Figure 25. Top three factors of grid type selection

Finally, the synthesized results of alternatives regarding the goal were explained in Figure 26.

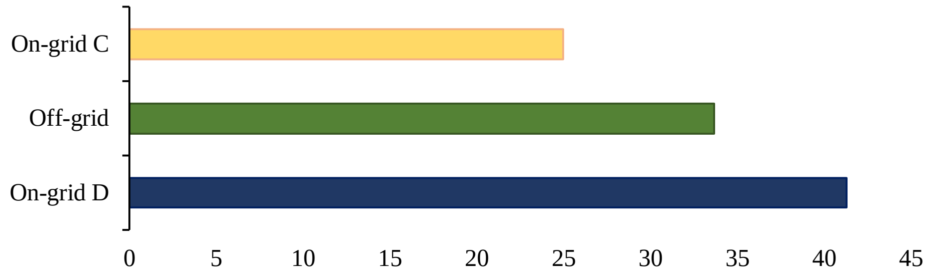


Figure 26. Ranking of alternatives

Figure 26 shows the fewer factors to the on-grid centralized (0.25), followed by an off-grid (0.336), and on-grid distributed (0.413). This finding indicated that the on-grid distributed should be the best option for accommodate the PVs in the residential projects followed by off-grid and on-grid distributed by the Government and the policymakers in Iraq.

4.6 Policy implications

Comparing the results with figure 15, Its noted that the on-grid distributed and off-grid outperformed the on-grid central, which proves that developing countries situation is different from developed countries and they need to invest more in modernizing the energy system. DES represents a key-factor to improve the power system in the residential projects, and pushes to enhance the PV contribution within the energy system in particular. Exploitation of free spaces in the residential projects for PV panels installation will minimize the investments cost and maximize the usefulness due to the free spaces and eliminate the transmission losses. In our study we can say that to achieve this target in Iraq, the policy-maker have to put in mind that social acceptance will be crucial before going ahead in in upgrading the energy systems in the residential projects. Since the government lunched several initiatives, a comprehensive awareness campaign should be launched to publicize the benefits and challenges of this new technology.

In the same perspective, the specialized staff must be at a high level of dealing with this technology, and therefore training will be an important factor in raising technical capabilities in the matter of operation and maintenance. The operation and maintenance aspect is an important matter in the sustainability of the work of PV panels, therefore the government must provide appropriate budget and increase spending on this aspect. The issue of job opportunities may affect a decision of this kind, as the results have proven that the central network option contributes to the creation and stability of jobs more than other options, especially since Iraq is known for a large job slack in the government sector and that the private sector is very weak. Therefore, it is necessary to restructure the government sector and try to enhance job opportunities by involving the energy private sector.

The security issues in Iraq represent a big challenge, the distributed energy systems may be the key-factor for decrease the attack on the transmission lines, the huge PV farms will be dangerous investment, comparing with middle scale in the cities. It can be say that failure of previous initiatives was due to the ignorance of these points proven by our study. The process of achieving the energy transition goes beyond growing the capacity of renewable energy within the energy system to the advanced usage of technology, upgrading the power system is of the utmost importance that must be worked on. In a more precise sense that distributed energy applications like smart grid and smart meters are the main key to success in the governmental initiatives of reforming the power sector and residential projects through the integration of sectors.

It can be concluded that the expansion PV farms and dispatch the energy produced through transmission lines is not the only solution to increase the efficiency of energy systems. Residential projects represent free land for affordable energy that must be invested. The findings proved that experts were more concerned with the social and technical factors in Iraq. Also, it can be explained experts believe that Iraq's energy transition plan will be enhanced in the best way if these factors are given maximum attention. Where success in energy transition of residential projects will encourage to achieving the sustainability, therefore the implementation of sustainable smart city projects will be applicable according to the renewable energy potential were presented in chapter 3, in addition to the grid connection through DES in which energy is produced and consumed in the same location. Although the model has been calibrated for the Iraqi situation, nevertheless, the study model can be used in another country faces the same conditions.

4.7 Contribution

On the academic level, this study contributes to the present literature by focusing on the analysis of grid connection in the energy transition regard. In developing countries, the criteria for energy transition are different compared to developed countries due to the presence of both renewable and traditional energy resources. Furthermore, socio-technical factors have a significant influence on energy transition technology, surpassing the impact of economic factors. This emphasizes the importance of considering social and technical aspects when implementing and adopting new energy technologies. On the professional level, the study revealed that infrastructure upgrading must address security concerns, investigate public acceptance, and enhance staff capabilities. Utilizing residential projects for PV requires upgrading the energy system to distributed energy systems (DES). Table 12 shows the summarized contribution.

Table 12: Categories of the study contribution

Professional level International, Governmental, Stakeholders	Academic level Innovative methodological research approaches, novel theoretical frameworks & original findings
1- Infrastructure upgrading cannot be done without addressing the security concerns and investigate the public acceptance and develop the staff ability. 2- To utilize the residential projects for PV, energy system has to upgraded into DES.	1- Contributions to literature and theoretical debates of expanding the DM to examine the grid connection. 2- The developing countries is different than developed countries in the research criteria of energy transition because it has both renewable and traditional energy resources. 3- Socio-technical factors impacts the technology related to the energy transition more than economic.

4.8 Limitations

This study encountered several limitations during. One of them was finding appropriate literature due to the uniqueness of the topic. In addition to hardship of having a consensus on some factors due to the multi background of the experts, which lead to delete or change some of them.

Chapter 5. Staff specialist's perspective of distributed energy systems adoption in Iraq: perceptions and policy implications

5.1 Introduction

Energy transition led to a radical change in the energy consumption policies, as it depends not only on renewable energy within the energy mix, it improves the ability to deal with fluctuations caused by the diversity of energy sources through distributed energy systems (DES) (Henderson et al. 2021; Rakhshani et al. 2019). Through advanced ICT applications, the smart grid enables distributed systems to control appliances at consumption centers to save energy and cost and prove grid reliability (Shi et al. 2020). Smart grid works closely with human performance; it also needs a specialized intelligent technical staff who is trained, qualified, and ready to carry out the operations and respond immediately to notifications, in addition to carrying out the necessary maintenance for the sustainability of the work of this complicated system (Mohammadian etl. 2020). The research on the smart grid domain witnessed a boom due to the decline of renewable energy costs, which motivated governments to adopt and invest in this technology (Haidar et al. 2015). In 2021, a 6% increase in the power grid investment done by the developed countries, according to the IEA, includes upgrading the system to accommodate renewable resources and electrification of buildings. Figure 27 shows that investment in installing smart meters and smart grid infrastructure continues to increase, with an investment of USD 43.7 billion in 2021 (IEA 2022).

The Iraqi government has launched several initiatives to reform the energy sector. However, the results were remarkably disappointing due to low investment in transmission and distribution networks, mismanagement and planning, poor training and staff development curricula, and social and economic crises such as unstable security and a high corruption rate (Vanegas 2020). In this regard, several studies have referred to the significance of surrounding social conditions and identifying the elements that affect the adoption of renewable technologies and DES in developed countries such as Throndsen et al (2015) in Norway and (Park et al. 2014) in Korea . Nevertheless, few of them have been looking at the adoption motivation in the developing or low-income countries such as in the Middle East. Perhaps the most prominent gap identified in the literature on clean energy and smart technology adoption is its confinement to the consumer's perspective and the absence of studies that attempted to explain the adoption behavior of specialists in the energy sector. Thus, this study will address this gap by examining Iraq's ambitious approach to reforming the energy sector.

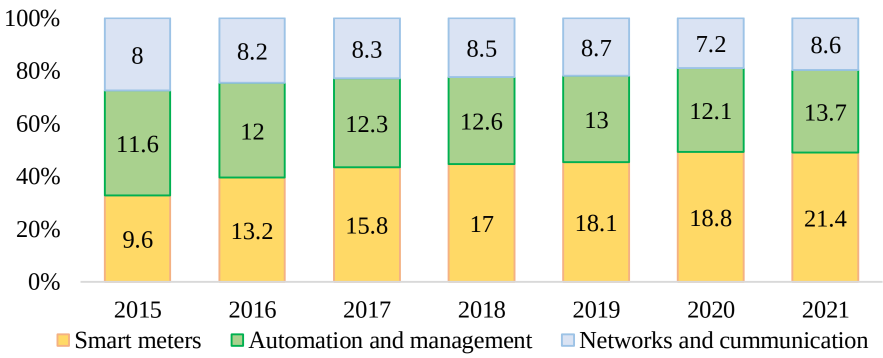


Figure 27. Global investment in the electrical grids in billion USD (IEA 2022)

Considering people's attitudes, beliefs, and behaviors, Venkatesh et al. (2003) proposed the UTAUT, a developed version of TAM. It was noted that many studies that took UTAUT as a framework could inspect the influencing factors of consumer behavior due to the feature that allows adding different constructs within the basic model. Regarding social acceptance of smart meters, an updated model of UTAUT was used to study the cognitive background and environmental awareness among consumers in Malaysia; the study confirms the significant increase in explaining the variance in acceptance of smart meters (Alkawsi et al 2020). The attitude part was not a part of the original UTAUT approach; however, it was recognized as a significant factor for behavior anticipation in the literature. It has been proven to be an essential predictor of behavioral intention (Ajzen et al. 2000). Moreover, the motivations of power sector staff specialist (PSS) attitude, intention, and acceptance toward DES adoption have been largely overlooked. To address this gap, we follow the PSS's specialist by examining the factors that affect the adoption of DES applications. This study targets to recognize the motivation of PSS's perceptions of DES adoption to synthesize rational policy and managerial measures that boost DES acceptance. The research questions raised here are as follows:

Q5: Will the perception of Power staff specialists (PSS) towards distributed energy systems (DES) affect the implementation of distributed energy systems (DES) in the smart cities projects?

Q6: What are the influenced factors of PSS's perception on DES implementation?

Q7: What are the relationships among these factors? What are the impacts?

This study offers an inclusive model integrating PSS specialists' attitudes, awareness, and security concerns constructs regarding DES into the original UTAUT model. The results show that this model can predict and analyze the behavior of DES implementation and underscore the importance of integrating the proposed model constructs. The study finds that PSS' attitude and behavioral intention significantly impact DES implementation, while their awareness level predicts their attitude toward DES. However, their performance expectancy negatively affects their attitude and behavioral intention. Additionally, security concerns greatly influence their behavioral intention regarding DES implementation. This research identifies the influential factors that motivate PSS to implement and adopt DES and highlights the significant role of their attitudes in DES adoption. Since this technology has not yet been applied on a large scale in Iraq, the perceptions of the power sector specialized staff whose work on distributed energy systems will be a key reason for policymakers to develop plans that guarantee success. The research structure comprises a review of previous studies and theoretical background in section 2, the hypotheses explanation will be in section 3, while section 4 will present the study methodology. Section 5 will be the results and discussion. Section 6 will show the policy implications and conclusion, and finally, the limitations will be discussed in section 7.

5.2 Literature review and theoretical background

The literature of the last decade indicates that various factors, including physical and moral considerations, influence the adoption of renewable and smart energy technology.

Throndsen et al. (2015) found citizens coolly accepting the notion of GHG emissions, while they were dissatisfied with the current narrow range of engagement in Norway. Ratner et al. (2022) found that Russians were not aware of smart grid technology details; however, they believed it could help reduce energy consumption. Smart grids are touted as a solution for energy consumption and climate change, but this claim may be an attempt to sugarcoat reality (Chawla et al. 2020). This study emphasizes that the success of DES (distributed energy systems) depends not only on technological advancements but also on social and governmental networks. The processes that create, sustain, limit, or hinder DES are complex and multi-layered. Electricity sector leaders prefer incremental changes to avoid destabilizing the system and increasing consumer anxiety; in addition to their belief that the success of DES implementation depends on customer readiness (Druic 2022; Düştegör et al. 2018; K. J. Kim, Lee, and Koo 2020) and their willingness to pay for new services (Shim et al. 2018). The Technology Acceptance Models had been extensively conducted in previous studies. TAM and UTAUT have shown a significant level of accuracy in predicting use behavior compared to other theories, such as the Theory of Reasoned Action (TRA) and the Theory of Planned Behavior (TPB)(Davis 1989).

Chou et al. (2015) proposed a new model to compare smart meter adoption in developed countries (Korea and Taiwan) and developing countries (Indonesia and Vietnam) using the TAM. They found that social, cultural, and economic factors contribute to the differences in adoption rates between these countries. In their survey of consumers in Norway and Switzerland, Broman et al. (2014) emphasized private consumers' acceptance of smart grids in Denmark, Norway, and Switzerland through a mutual framework of the Norm Activation Model (RAM) and TAM. The result confirmed the significance of adding the personal norms as independent constructs to the TAM model through increasing consumer acceptance variance. Similarly, C. fei Chen et al. (2017) investigated sustainable energy by applying the TAM and surveying the people who do not own smart meters in the USA. They concluded that environmental awareness positively impacted energy-saving measures and supported government regulations and the perceived usefulness of using smart meters or smart grid applications (Broman et al. 2014). On the contrary, Perri et al. (2020) found that environmental sustainability does not affect the adoption process through an attempt to understand the behavioral change processes of Italian consumers by the TBL model; it was confirmed that experts' participation in smart energy technologies initiatives is more effective compared with the consumers. Grandhiet al. (2021) Conduct a Security-UTAUT to survey the smart city acceptance in Australia by adding the attitude construct to the core model.

Although Venkatesh et al. (2003) had put forward the UTAUT and UTAUT2 models, which rely on modifying the perceived ease of use determinants through innovative constructs, To date, no study has surveyed energy professionals regarding smart energy systems, nor have there been studies conducted in low-income or developing countries with small-scale renewable energy projects and smart grid technology. The vast majority of previous studies revealed the intentions and behavior of the consumer, especially on smart meters. Alkawsi et al. (2020), combined energy-saving awareness and environmental realization and underlined the effect of users' behavioral intention on users' use behavior in Malaysia through the UTAUT2 model; the results confirmed a remarkable rise in the described variance of the integrated model. In contrast, Shuhaiber (2018) added the perceived control and the perceived enjoyment constructs to the main body of the UTAUT model to survey the Jordanian consumers' intention of smart meter adoption; the results revealed significant variance in the integrated model. Gumz et al. (2022) proposed the UTAUT model to survey the smart meters adoption in Brazil. The findings indicated that social influences greatly affect adoption, while performance expectancy has no impact.

Given that most of these countries suffer from economic and security crises, especially in the Middle East, such as Iraq, this study attempts to uncover the important constructs that were overlooked in previous studies, such as the effects of the security aspect on the adoption and implementation of DES. This study recognizes the need to examine the factors that affect the perceptions of PSSs in the electricity sector regarding DES implementation. Through the literature, UTAUT is widely used to examine the citizens' new technology adoption. Moreover, UTAUT was used to discover the employees' opinion in the information system domain (Bu et al. 2021), but in our case, this is the first study to examine the PSS' perception toward DES implementation. The UTAUT successfully explains 70% of the variance in the intention to use in addition to its significant explanatory power and suitable structure. According to Venkatesh et al. (2003) UTAUT can accept the modification by adding new research variables and will offer wider knowledge for technology acceptance.

Based on the above, this study includes attitude, awareness, and security concerns in the original model. We are attempting to discover more practical factors affecting the adoption of DES by PSS. According to (Ajzen et al. 2000), attitude is the positive or negative propensity toward a particular idea or event under an individual's subjective evaluation. Within the field of behavior prediction, many studies have shown that attitude is a reliable and powerful factor for proving behavioral intention to adopt a particular technology (Bu et al. 2021; Haque et al. 2016; Perri et al. 2020). Therefore, our study conducts the attitude factor as a main construct to discover the insights of the DES adoption among staff specialists in the power sector. Table 13 represents a comparison between previous studies close to this study.

Table 13: Comparison between previous studies and this study

Study	Theory	Field of study	Professionals survey	DES related	Construct used		
					Attitude	Awareness	Security
(Chawla et al. 2020)	Innovation diffusion	Energy		✓		✓	
Druic et al. (2022)	RITAM	Energy		✓			
(Düştegör et al. 2018)	TPB	Energy		✓	✓	✓	
Chou et al. (2015)	TAM	Energy		✓	✓		
Broman Toft et al. (2014)	TAM	Energy		✓	✓		
C. fei Chen	TAM	Energy		✓			

Study	Theory	Field of study	Professionals survey	DES related	Construct used		
					Attitude	Awareness	Security
et al. (2017)							
Perri et al. (2020)	TPB	Energy		✓	✓		
Grandhi et al. (2021)	UTAUT	Smart city			✓		
Alkawsi et al. (2020)	UTAUT2	Energy		✓		✓	
Shuhaiber (2018)	TAM	Energy		✓			
Gumz et al. (2022)	UTAUT2	Energy		✓		✓	
(Bu et al. 2021)	UTAUT	IT	✓		✓	✓	
Park et al. (2014)	TAM	Energy		✓			
Patil et al. (2020)	UTAUT	E-pay			✓		
Alam et al. (2020)	UTAUT	Health care					
(Chen et al. 2017)	TAM	Energy		✓			
(Safari et al. 2018)	TPB	Enviro nment	✓		✓	✓	
(Foroudi et al. 2018)	TBP	Smart Tech.				✓	
Melorose et al. 2015	TAM	E-trade					
Shuhaiber	TAM	Energy		✓			

Study	Theory	Field of study	Professionals survey	DES related	Construct used		
					Attitude	Awareness	Security
(2021)							
Jain et al. 2022	UTAUT	EVs				✓	
This study	UTAUT	Energy	✓	✓	✓	✓	✓

5.3 Hypothesis development

Since this research studies the Iraq case, re-examining the influence of some constructs in the former studies on intention to use will be irrelevant, especially for some cases such as the DES adoption in the developing countries. For instance, according to (Vencatesh) facilitating conditions refer to the existing infrastructure already developed in the developing countries. Therefore, there are more compelling constructs that were not addressed in the previous models and theories, and they need direct examination in terms of DES adoption. This study will add attitude, awareness, and security constructs to the original UTAUT model. This research examined the impact of these new constructs on the intention to adopt DES in Iraq and specified which perceived dimension had a considerable effect on the PSS view and the importance of the impact. Based on the above, this study developed seven constructs. Finally, we proposed an expanded conceptual model where the hypotheses were formulated as in Figure 28.

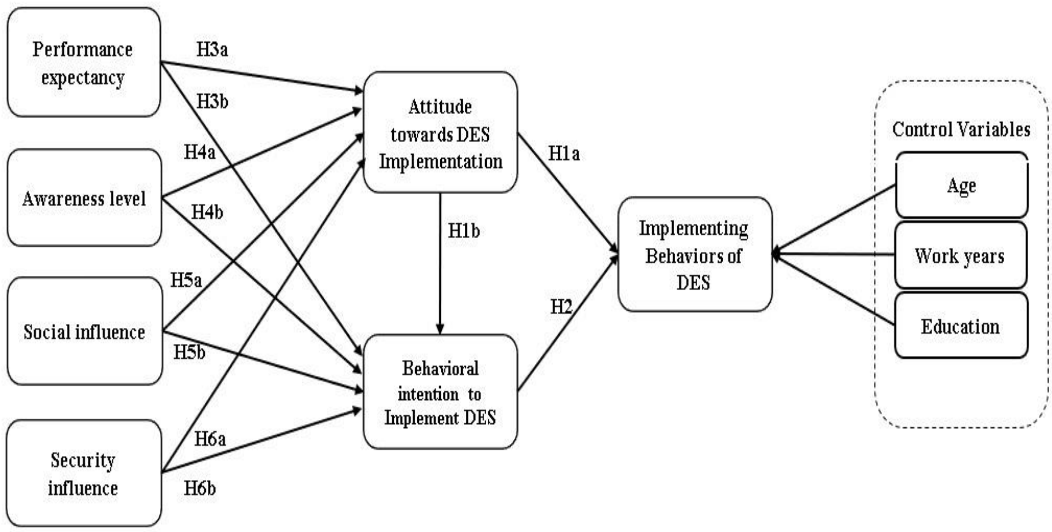


Figure 28. Integrated model

5.3.1 Attitude of PSS towards DES implementation (ATT)

Ajzen et al. (2000) defined attitude as a person's tendency to feel a certain way (emotion) toward a particular behavior or action. Understanding people's attitudes toward new technologies can be a useful tool for predicting and promoting their adoption. In this regard, several theoretical frameworks have been widely used, such as the Theory of Planned Behavior (TPB),(Ajzen et al. 2000). Technology Acceptance Model (TAM) (Davis 1989; Park et al. 2014), and Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh et al. 2003) to investigate how employees' attitudes affect their willingness to adopt new technologies. This study examines the influence of power sector staff specialists' perceptions on adopting renewable energy and smart grid technologies. The researchers define employees' attitudes toward adopting DES as their overall feeling or opinion about implementing DES into their work Bednar et al. (2020) studied privacy protection integration in products in the information system technology field. The study discovered that employees' positive protection behavior is influenced by their perception of privacy. The implementing behavior of DES (IBD) is described as PSS' tangible behaviors related to adopting DES in their job. It is supposed that their attitude toward DES adoption links to their behavior toward DES implementation,

H1a

PSS's attitude toward DES implementation (ATT) will positively influence their implementing behaviors of DES (IBD).

Dwivedi et al. (2017) assessed the technology acceptance models (TAM, TPB, and UTAUT) and started a noteworthy relationship between attitude and behavioral intention. The study suggested that augmenting UTAUT with the attitude construct enhances the whole model performance. Similarly, Grandhi et al. (2021) incorporated attitude into the primary UTAUT to investigate the adoption of smart cities, and the results indicated a positive impact on adoption in Australia. It can be hypothesized that if staff members in the power sector possess a favorable attitude toward distributed energy systems (DES) and believe that it would positively impact all aspects of organizational performance, they are more expected to use DES:

H1b

PSS's attitude toward DES implementation (ATT) will positively influence their behavioral intention to implement DES (BIN).

5.3.2 Behavioral intention towards DES implementation

Behavioral intention refers to the degree to which someone intends or plans to engage in a particular behavior. It is a psychological state that exists before the actual behavior occurs. In other words, it represents the level of motivation or commitment that a person has toward performing a certain behavior (Ajzen et al. 2000; Perri et al. 2020). Previous research in various fields, including technology adoption, has shown that behavioral intention robustly predicts tangible behavior. This means that if someone strongly intends to adopt a new technology, they are more likely to actually adopt it (Patil et al. 2020). prove that behavioral intention is the key predictor of adoption behavior in UTAUT of information technology acceptance. This study identified PSS intention to implement DES as the extent of their readiness to execute DES implementation. The intention of PSS to implement distributed energy systems (DES) refers to the extent of their readiness and willingness to carry out DES adoption:

H2

PSS's Behavioral intention to DES implementation (BIN) will positively influence their DES implementing behavior (IBD).

5.3.3 Performance expectancy concerning DES implementation (PED)

One of the key constructs in UTAUT is the expectation of increased use, which denotes the scope to which individuals consider that operating a specific technology will increase their productivity. This construct parallels the perceived usefulness construct in the TAM Perceived usefulness. If people observe that a technology will bring benefits, they are more likely to use it (Bu et al. 2021; Venkatesh et al. 2003). Patil et al. (2020) used UTAUT to study mobile payment acceptance in India; it was observed that performance expectation directly affects attitude. Performance expectancy in this study is described as the level to which the PSS expects that implementation of DES can motivate them to improve DES performance.

H3a

PSS's performance expectancy concerning implementing DES (PED) will positively influence their attitude towards DES implementation (ATT).

Prior studies have shown that performance expectancy significantly shapes behavioral intentions toward adopting technology, particularly in information systems research.(Bu et al. 2021; Patil et al. 2020; Venkatesh et al. 2003). All these studies revealed that performance expectancy strongly influences the intention to adopt new technologies. Similarly, with health services studies, Alam et al. (2020) investigated the factors that affect the adoption of e-health technologies. They found that performance expectancy positively influenced the intention to adopt e-health technologies. Performance expectancy can influence people's attitudes toward technology adoption and shape their intentions to adopt it. Therefore, technology developers and policymakers must identify and promote the benefits of new technologies to encourage their adoption and use:

H3b

PSS's performance expectancy related to DES implementation (PED) will positively influence their behavioral intention to implement DES (BIN).

5.3.4 Awareness level concerning DES implementation (AWR)

Awareness can be defined as the state of being conscious about something. Awareness can be subjective, as it depends on one's perception and interpretation of information, and it can vary across different populations and contexts (Schmeichel et al. 2009). It can inform policy and intervention strategies to promote positive societal changes. The awareness of the PSS about the implementation of DES in this study is the extent of their knowledge of the principles, requirements, and goals of the implementation of DES. Refusing the technology is usually judged through the knowledge background and experience of the effects resulting from the use and the level of sense of responsibility in addition to personal preferences by the users(Ajzen et al. 2000). Since attitude is affected by emotional reactions and personal impression based on prior knowledge through experience and emerging awareness toward use, it was noted that the positions in favor of environmental protection policies could be strengthened by focusing on increasing the level of awareness among people (Safari et al. 2018). Therefore, the assumption of PSS attitude toward DES implementation will be significant if the level of awareness increases among them:

H4a

PSS's Awareness (AWR) will positively influence their attitude toward DES implementation (ATT)

Safari et al. (2018) highlighted that the level of awareness and environmental knowledge significantly impact individuals' intention to engage in green behaviors. Similarly, studies by Abdmouleh et al. (2018) and Park et al. (2014) affirmed that awareness was imperative in influencing individual behavior. As a result, the lack of awareness about DES can affect the intention of PSS to implement DES since it is still a relatively unfamiliar concept for many people in the power sector.

H4b

PSS's Awareness (AWR) will positively influence their behavioral intention to implement DES (BIN).

5.3.5 Social influence concerning implementing DES (SIP)

The perceived social influence of PSS in implementing DES is identified as the influence of the work environment and social climate on technology usage, including the influences of colleagues and managers on the attitudes and behavioral intentions of the SS in implementing DES. Venkatesh et al. (2003) developed the social influence construct from the subjective norm in prior related TRA, TAM2, and TPB theories. Therefore, it can be concluded that the attitudes of others around the work environment are likely to affect the attitude and intention of adoption, especially if they have a personal influence through the job position or personal relationship, which constitutes an additional motivation toward adoption.

H5a

PSS's perceived social influence concerning implementing DES (SID) will positively influence their behavioral intention to implement DES (BIN).

Several researchers have concluded that individuals tend to acquire social identity through identification with the active actors of their surroundings Doll et al. (1992). perceived social impact has been confirmed in the technology acceptance through the UTAUT on the behavioral intention of adoption Bu et al. (2021) indicated that Information technology engineers would be intent to utilize privacy by design when they think that others expect them to utilize it. As a result of social connection, social intent, and connections with peers, potential customers turn to their purchases from socializing about the buying experience (Foroudi et al. 2018).

H5b

PSS's perceived social influence concerning implementing DES (SID) will positively influence their attitude toward DES implementation (ATT).

5.3.6 Security concerns of DES implementation (SEC)

Security denotes the perception of safety and reduced risk related to the use of technology, particularly in unstable or risky environments. When individuals feel unsafe or perceive a high level of risk associated with using technology, they may be less likely to accept new technologies (Melorose et al. 2015). For example, the threat of attacks on power transmission lines in Iraq and other countries could increase the willingness of employees to adopt smart grid and renewable energy technologies to feel more secure. The impact of security on technology adoption has been examined in various contexts. This construct developed after consulting the opinions of the team of specialists who are mentioned in the introduction section.

H6a

PSS's perceived security concerns of DES implementation (SEC) will positively influence the PSS's behavioral intention to implement DES (BIN).

In Jordan, the works of Shuhaiber (2021) confirmed that security can impact employees' behavioral intention to technology acceptance. If employees perceive new technologies as insecure or unreliable, they may be less likely to adopt them and resist using them. On the other hand, if employees feel that their organization has taken adequate measures to ensure the security of new technologies, they may be more willing to adopt and use them. This can aid in promoting a more positive attitude toward technology acceptance and inspire greater adoption of new technologies.

H6b

PSS's perceived security concerns of DES implementation (SEC) will positively influence the PSS's behavioral intention to implement DES (BIN).

5.3.7 Control Variables

The basic UTAUT used the age, gender, and experience to the user's acceptance. However, the specialist staff's work is highly differentiated and modular and needs to emphasize the core model constructs in this research; thus, the moderations are dropped, and we conduct the control variables, age, experience, and academic qualification to control the independent variables. Moreover, we dropped the gender variable because all the workers in this field are male, according to the official data from Iraq.

5.4 Methodology

5.4.1 Research items

The quantitative method was selected to inspect the hypotheses that were improved through eight constructs. Each construct is measured on 5 or 6 items using a 5-point Likert scale, from “strongly disagree” to “strongly agree”. The context of the energy sector and the characteristics of DES were seriously considered in improving all measurements. We also invited eight specialists from the energy distribution sector, who come from different functional areas, such as the control center and the transportation sector, to participate in the process of developing measurements and creating security constructs, in addition to their suggestions in the semantic description to ensure the quality of the questionnaire.

5.4.2 Data collection and sampling

Given that the study targets to examine the factors influencing the DES implementation by energy sector PSS, particularly in sites where DES serves as the pilot projects, professionals in renewable energy, power distribution, and transmission fields, in addition to operation, control centers, and project departments were selected as respondents for the survey questionnaire. To guarantee the survey questionnaire’s effective design, five experts from the Ministry of Electricity in Iraq were selected to discuss the key subjects relevant to the study's question. From a group of 70 questions sourced from several published papers over the past three years, the experts finalized a list of 40 items. The questionnaire was conducted directly at different stages during one month. All respondents were interviewed in five locations across Baghdad. With a team of four skilled employees conducting the interviews during official working hours. Initially, a brief explanation of the DES concept was provided to prevent ambiguity in the answers, while the specific topic and purpose of the questionnaire were kept undisclosed to prevent any bias. The answer collection proceeded smoothly without encountering any obstacles.

5.4.3 Data analysis

Out of 245 questionnaires were collected after excluding 12 invalid questionnaires at the survey stage. PLS-SEM is more suitable for dealing with small samples than CB-SEM (Henseler, Ringle, and Sarstedt 2015). Bu et al. (2021) indicated that analysis results in PLS-SEM are not affected by a sample size ranging from 200 to 500. PLS-SEM is frequently used in examining technology acceptance models. The logic singularity between PLS-SEM and CB-SEM can be straightforward through the research objectives, whether theory testing or prediction. CB-SEM is preferred in theory testing or confirmation, while PLS-SEM is better in prediction or theory development. For this reason, PLS-SEM was selected to conduct the data examination in this research.

5.5 Results

5.5.1 Demographic data of respondents

Table 14 explains the respondent's demographic description in detail. The majority of respondents were aged between 26 and 35. Only three respondents aged 45 or above were there in the list. 61.3% of them have a bachelor's degree. The majority have five to ten years of experience.

Table 14: Demographic data

Variables	Frequency	Percentage (%)
Age		
Less than 25	39	15.9
26–35	144	58.8
36–45	59	24.0
Above 45	3	1.22
Education		
Lower than Bachelor	4	1.6
Bachelor and diploma	173	61.5
Master and PhD	68	9.5
Working Year		
Under 5 years	36	14.7
5 to 10 years	156	63.7
Above 10 years	53	21.6

5.5.2 Descriptive statistics

The PAC test was done using the SPSS Statistics version 22 to understand the data normalization, then Smart-PLS version 4.0 software was selected to test the model and the developed hypothesis. The detailed descriptive statistics are shown in Table 15. All construct's mean values are above 3.4. There is no consensus among the academic community about the threshold of an acceptable Cronbach-α value, but the majority tend to have it higher than 0.5 and less than 0.95 (Ursachi et al. 2015). In our model most variables' α scores were between 0.902 and 0.698. Therefore, our model results show convinced reliability.

Table 15: descriptive statistics results

Construct	Cronbach's Alpha	Items	Mean	SD
Attitude towards implementation (ATT)	**0.785**	**ATT1**	**3.49**	**1.098**
		ATT2	**3.506**	**1.071**
		ATT3	3.657	0.971
		ATT4	3.722	1.083
		ATT5	3.486	0.984
		ATT6	**3.506**	**1.048**
Behavioral intention (BIN)	**0.91**	**BIN1**	**3.78**	**1.114**
		BIN2	3.706	1.082
		BIN3	**3.751**	**1.095**
		BIN4	3.78	1.073
		BIN5	3.759	1.024
		BIN6	**3.894**	**1.068**
Implementing behaviors (IBD)	**0.902**	**IBD1**	**3.461**	**1.123**
		IBD2	3.51	1.056
		IBD3	**3.494**	**1.138**
		IBD4	**3.494**	**1.083**
		IBD5	3.506	1.06
		IBD6	3.51	1.064
Performance expectancy (PED)	**0.698**	PED1	3.682	0.967
		PED2	**3.624**	**0.984**
		PED3	**3.731**	**1.011**
		PED4	**3.673**	**0.973**
		PED5	3.624	0.989

Construct	Cronbach's Alpha	Items	Mean	SD
Awareness (AWR)	**0.811**	**PED6**	**3.62**	**0.972**
		AWR1	**3.306**	**1.022**
		AWR2	**3.412**	**1.045**
		AWR3	3.416	1.049
		AWR4	**3.637**	1.085
		AWR5	**3.335**	**1.015**
Social influence (SIP)	**0.84**	**SIP1**	**3.682**	**0.879**
		SIP2	**3.71**	**0.886**
		SIP3	3.71	0.9
		SIP4	**3.747**	**0.94**
		SIP5	**3.845**	**0.926**
		SIP6	3.755	0.92
Security (SED)	**0.816**	**SED1**	**3.535**	**1.004**
		SED2	**3.608**	**1.043**
		SED3	3.612	1.073
		SED4	**3.6**	**1.051**
		SED5	**3.608**	**1.015**

5.5.3 Measurement model evaluation

We applied a bootstrapping calculation with 5000 resamples to assess the importance of the path coefficient and hypothesis. Cronbach's α, Factor-loading, Average-Variance-Extracted (AVE) value, Cross-loading, Composite-Reliability (CR), and Rho-A were computed to measure the research reliability and validity. The result shows that Cronbach's α, rho-A, composite reliability, and AVE for all constructs were between 0.682 and below 0.943, as shown in Table 16, which is considered in line with the advised threshold for convergent validity (Bagozzi et al. 1988). The results also show satisfied internal consistency reliability based on the recommendation of F. Hair Jr et al. (2014). Based on above mentioned results, this study has convincing reliability.

Table 16: Constructs reliability and validity

Constructs	Cronbach's Alpha	Rho-A	Composite Reliability	Average Variance Extracted (AVE)
ATT	0.785	0.808	0.877	0.707
AWR	0.811	0.815	0.888	0.727
BIN	0.91	0.91	0.943	0.847
IBD	0.902	0.902	0.938	0.836
PED	0.698	0.75	0.806	0.515
SED	0.816	0.821	0.891	0.732
SIP	0.84	0.889	0.894	0.682

Moreover, factor-loading, cross-loading, and VIF for each construct were measured. For inner and outer VIF values were lower than 5; thus, these results have enough discriminant validity, according to Fornell et al. (2016).

5.5.4 The analysis of structural model

PLS estimation showed adequate results (Astrachan et al. 2014); therefore, the present study conducted PLS estimation through the Smart-PLS version 4.0 software package. Tables 17 and 18 explain the results. Age, education, and work years were the control variables for DES implementation in our model. The results in Table 17 show that control variables have no significant effect on staff specialist DES implementing behaviors.

Table 17: Control variables results

Control variables	Dependent variables	Path coefficients	t-value	result
Age	IBD	0.03	0.316	No influence
Experience	IBD	-0.018	0.214	No influence
qualification	IBD	-0.054	0.800	No influence

The model confirmed its effectiveness in explaining 14.5% of the variation in behaviors related to implementing distributed energy systems (DES) and 19% in the intention construct. Additionally, 53.1% of the proposed model variance was explained in PSS's attitude toward DES implementation. As a result, the research model's ability to predict outcomes is considered to be dependable. This finding aligns with the views of F. Hair Jr et al. (2014) who asserted that the predictive capability of a model is a crucial criterion for evaluating its quality. The graphical representation of these findings is presented in Figure 29.

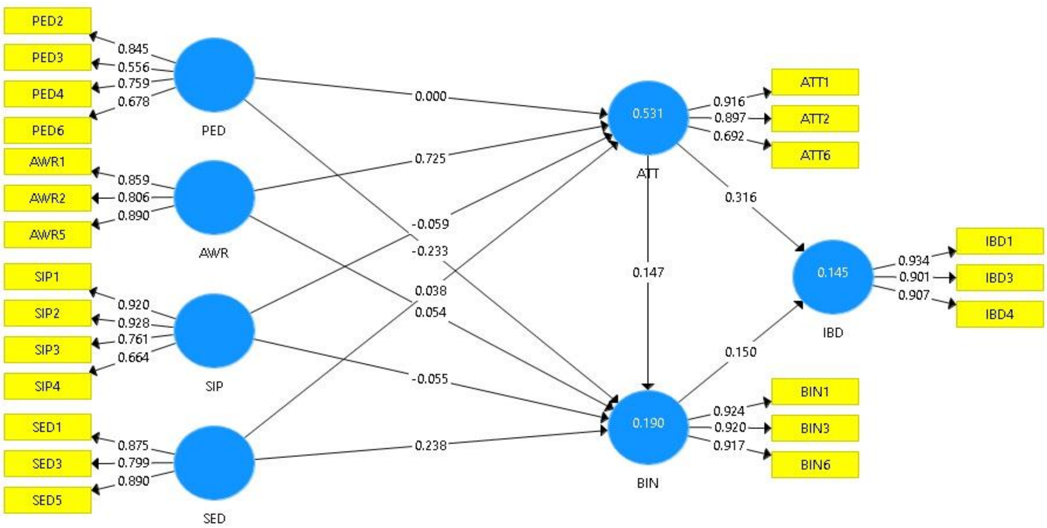


Figure 29. Results of the main effects.

The findings indicate that PSS's attitude toward implementing distributed energy systems (DES) significantly impacts their DES implementation behaviors. Additionally, their behavioral intention to implement DES significantly impacts their implementation behaviors. The level of awareness about DES significantly affects the attitude toward its implementation. Furthermore, security concerns significantly affect the behavioral intention to implement DES. These results support hypotheses H1a, H2, H4a, and H6b. The total results are demonstrated in Figure 30 and Table 18.

Table 18: Hypothesis test results

Hypotheses	Independent Construct	Dependent Construct	Path Coefficients	t value	P value	Decision
H1a	ATT	IBD	0.316	5.265	0	Supported
H1b	ATT	BIN	0.147	1.536	0.125	not supported
H2	BIN	IBD	0.15	2.502	0.012	Supported
H3a	PED	ATT	0	0.011	0.991	not supported
H3b	PED	BIN	-0.233	4.234	0	not supported
H4a	AWR	ATT	0.725	20.337	0	Supported
H4b	AWR	BIN	0.054	0.558	0.577	not supported
H5a	SIP	ATT	-0.059	3.54	0.224	not supported
H5b	SIP	BIN	-0.055	1.215	0.322	not supported
H6a	SED	ATT	0.038	0.991	0.392	not supported
H6b	SED	BIN	0.238	3.978	0	Supported

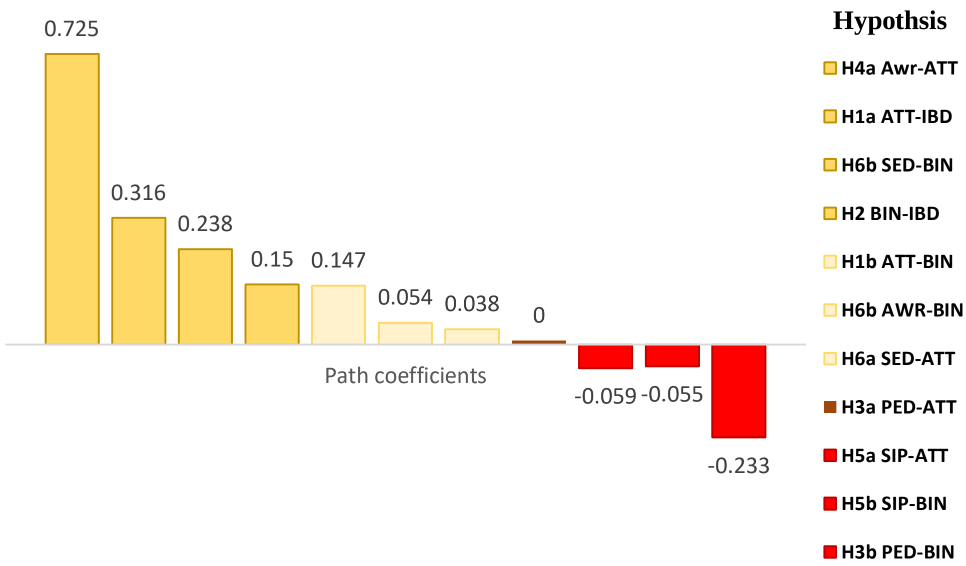


Figure 30. Path coefficient results

5.6 Discussion

The first finding is that the PSS's DES implementation is directly influenced by attitude and behavioral intention constructs. The result is compatible with the earlier studies (Bu et al. 2021; Venkatesh et al. 2016). The proposed model showed a predictive ability in the implementation behavior of DES by interpreting 14.5% of the variance, in addition to explaining 19% variance of the behavioral intention regarding DES implementation, in addition to 53.1% variance of the attitude toward DES implementation. It is clear that adding the attitude construct was coherent with earlier studies by Bu et al.(2021).

Secondly, PSS's performance expectancy negatively influences behavioral intention, and it differs from prior studies that have argued that users' performance expectation positively affects their intention to use (Venkatesh et al. 2012; Venkatesh et al. 2016). Meanwhile, it also differs from the result of Gumz et al. (2022) who found no impact on the performance expectancy in their model. Another finding is that attitude mediates the effects of the awareness level on DES implementation behaviors. Given that DES is a new concept of energy transition vision to most PSS, an understanding of DES is gradually being established.

Thirdly, attitude toward DES implementation can be predicted by Awareness level directly, which means that the PSS have a high level of knowledge that represents an essential base to the DES implementation.

Finally, a novel finding here is that security concerns significantly influence behavioral intention. Given that the unstable security situation in Iraq negatively impacts the PSS, the highly skilled staff will choose to work on DES to avoid the risk since the DES sites are located in the cities.

5.7 Contribution

This study examines the implementation of distributed energy systems (DES) as a viable option to increase renewable energy penetration in smart cities. The research investigates the perceptions of power sector staff specialists (PSS) towards DES using an extended UTAUT model with an added attitude construct. The significance of PSS attitude in DES implementation is emphasized, and a new conceptual model is developed to improve previous research. The results revealed the importance of considering attitude towards DES adoption for better clarifications and anticipation. This study is the first to address the critical role of PSS attitude in DES projects. Additionally, it expands the theoretical investigation of attitude factors in technology adoption studies. The findings demonstrate that awareness significantly affects specialist attitude towards DES adoption. This study highlights the motivating factors for specialists to adopt DES and broadens the scope of theoretical research in renewable energy, smart grid, and smart meters.

5.8 Policy implications and conclusion

This study explores how cognitive and organizational factors influence the adoption of distributed energy systems (DES) by power sector staff (PSS). The research identifies awareness, attitude, and security predictors, which can assist governments and organizations in expanding DES projects. The findings emphasize the insignificance of effort forecasting and social impact while providing practical guidance for policymakers.

First, given the importance of the PSS's attitude toward DES implementation in terms of its positive impact on the behavioral intent of the implementation, decision-makers in the Iraqi government should focus on factors that strengthen the PSS attitude toward the future projects of DES.

Second, the negative relation between the performance expectancy and the attitude and behavioral intention to implement DES indicates that the PSS urgently needs to enhance confidence in the feasibility of working in DES sites. The government should study the reasons for the psychological state that led to these perceptions, especially since the government intends to adopt promising projects of smart grids and smart meters, as well as the large expansion of solar PV. The decisive role of PSS will contribute to the success of these projects.

Third, the level of awareness of power sector staff specialists (PSS) toward distributed energy systems (DES) is essential for improving their perception of attitude and intention toward DES implementation. The study found that PSS have adequate background and knowledge about the importance of energy transition and its requirements. The government can utilize this finding to expand DES projects and provide special training to improve the PSS potential, which will increase their awareness of DES projects. This action can effectively enhance the adoption of DES by PSS.

Fourth, the social impact on attitudes and behavioral intentions toward adopting distributed energy systems (DES) technology is limited. Therefore, the government should establish a DES climate and culture by promoting and encouraging DES adoption. Managers should focus on the target of DES implementation and understand the significance of DES in future projects. Policymakers can use this information to create policies encouraging DES adoption and promoting a DES culture. They can incentivize businesses and individuals who adopt DES technology, educate the public on the benefits of DES, and collaborate with stakeholders to create a supportive environment for DES implementation.

Fifth, the security concerns of power sector staff (PSS) were a significant motivation for adopting distributed energy systems (DES). The results suggest that PSS may migrate toward DES sites to feel safe, which challenges DES implementation. Additionally, these security concerns can explain the negative impact of performance expectancy on the attitude and intention of DES implementation. Policymakers in the government have to address security concerns by establishing secure working environments and promoting equal opportunities for work in all locations. The government can create policies that provide secure work environments for PSS, encourage DES adoption, and promote equal job opportunities in all regions.

Finally, the study model can be applied and informative to all countries, regardless of their economic status (i.e., high- or low-income economies). However, some minor modifications may be required to the constructs and their relationships to suit each country's research requirements and surrounding conditions. To apply the research model in other countries, it is recommended to first identify any specific factors or conditions that may impact the adoption of distributed energy systems (DES). This can help in modifying the constructs and relationships of this model accordingly. Moreover, engaging with local stakeholders and professionals in the energy field and sustainable development is crucial to gain insights into the local context and identify potential barriers or facilitators for DES adoption. It is important to mention that such research findings can guide policy and decision-making toward promoting the adoption of DES and achieving a sustainable energy future.

5.9 Limitations and Future studies

The study encountered several restrictions; finding appropriate literature due to the originality of the topic and the inadequate studies addressing it was one of them, in addition to the challenges of increasing the sample size while revealing the perceptions of energy professionals. The workers of renewable energy and smart grids are still limited and distributed in faraway places, and their knowledge background is different, which may affect the study results. Future studies may consider establishing a communication network among workers in this field to exchange experiences and information. Future research may also include conducting CB.SEM and/or PLS.SEM to verify the results of the technology acceptance model theoretically.

Chapter 6. Discussion and Conclusion

6.1 Summary

The rapid growth of urbanization and energy consumption has led to positive economic growth but also negative effects on the environment. Consequently, the scientific community has proposed the concept of sustainable development, which includes sub-concepts such as energy transition and smart cities. This research highlights the importance of sustainable development in supporting urbanization, and emphasizes the need for smart cities to prioritize sustainability in order to provide better services while also addressing the urgent climate change concerns. The transition to clean energy and sustainable practices is essential to alleviate the negative influences of urbanization on the environment and support economic growth while preserving the planet's natural resources. According to this context, the current research catches the main reason of the considerable environmental degradation, which is the traditional energy system. this research focus on energy transition as a convergence to smart city concept. Furthermore, the traditional energy system considered a main motivation to improve the cities as center on of urban growth.

The initial objective of this research commenced in Chapter 2, where utilizing a systematic literature review on the energy transition from a social sciences perspective. The focus was on identifying the determinants and challenges associated with the energy transition, as well as understanding the direction that researchers have taken in addressing these issues. The review analyzed 39 high-quality research papers published in the last ten years and categorized them into three areas: decision-making, socio-technical systems, and social acceptance. The findings revealed 41 determinants that have been addressed in the literature, with varying levels of focus on developed and developing countries. The study identified gaps in the literature, which subsequent studies have attempted to address. The authors provide recommendations and implications for future research in this area. By examining the literature from a social sciences perspective, this research offers valuable insights into the complex issues surrounding the energy transition. Policymakers, industry leaders, and scholars can utilize the findings to design effective strategies and policies that address the socio-technical and social aspects of the energy transition. This research funds to the growing body of understanding in the field and highlights the need for continued research into this critical area.

The energy transition requires cutting the use of fossil fuel and accelerating the use of renewable energy resources in the energy mix to decrease carbon emissions. Chapter 3, the second study in this research focused on examining the potential of renewable energy in developing and low income countries, with Iraq as a specific case study. By analyzing the consumption of a modern housing project in Baghdad and simulating solar energy generation, the study found that the share of solar energy could reach 29.8% of the energy mix. These findings suggest that renewable energy has the potential to transform cities into sustainable and smart cities. It is imperative to leverage renewable energy sources to reduce the carbon footprint of urban areas and promote sustainable urbanization. Policymakers and urban planners can utilize the findings of this study to design effective strategies and policies that encourage the adoption of renewable energy sources and promote sustainable development.

Based on the outputs of the two previous studies, it was necessary to expand the research on how to support the penetration of solar energy within the energy mix in residential projects. Solar energy is characterized by intermittence and weather-dependent factors, which causes technical confusion in how to absorb the energy produced from solar panels and distribute it for consumption. Therefore, the third study in Chapter 4 focused on finding the appropriate option for grid connection to support the penetration of solar energy within the energy mix in residential projects. The study utilized the theory of multi-criteria decision-making and the AHP model to adopt the criteria identified in the previous literature, including technical, social, and economic dimensions, to select an alternative from within the central on-grid, stand-alone system, and on-grid distributed systems.

The study relied on the opinions of distinguished experts specialized in the field of energy to evaluate the selected criteria and rank the alternatives. The results indicate that the on-grid distributed systems are the best alternative for increasing the penetration of solar energy into the energy mix in cities. The security factor, technology acceptance, and experience of technical personnel were identified as the most important determinants to consider when initiating similar projects. These findings provide valuable insights into the selection of appropriate grid connection options for residential projects seeking to integrates solar energy into their energy mix. The adoption of distributed systems can promote the utilization of renewable energy sources and contribute to reducing carbon emissions. Policymakers and urban planners can utilize the results of this study to design effective strategies and policies that encourage the adoption of distributed solar energy systems and promote sustainable urbanization.

The fourth study in this research was in Chapter 5, highlights the importance of social acceptance in implementing distributed energy systems (DES) in residential projects. The study presents a hybrid model of social acceptance inspired by the UTAUT model, which considers the viewpoint of professionals instead of consumers. The study focuses on the factors influencing adoption of DES with new constructs to the UTAUT model consistent with the Iraqi case. The results show that awareness and security have the biggest impact on the attitude and intention towards implementation of DES. This finding is different from many previous studies that emphasized the role of performance expectancy in adoption. The study suggests that the adoption of advanced technology like DES in developing countries, particularly Iraq, requires a deeper understanding of the cultural, social, and security aspects of the local context. The hybrid model of social acceptance presented in this study can provide a useful framework for future research and policy-making in the area of sustainable smart cities. Overall, the findings of this study back up the importance of social acceptance as a key factor in achieving the energy transition towards renewable sources and realizing the vision of sustainable smart cities.

6.2 Implications

This research covers a diverse range of topics and addresses various questions with a high level of rigor, strengthening the reliability of the findings. The implications significantly impact various stakeholders, highlighting the importance of sustainable urban development. The implications synthesized from the research are robust enough to provide guidance and recommendations to policymakers and practitioners involved in urban planning, as well as to researchers and consumers seeking to understand the complexities of urban growth. Moreover, the roadmap laid out in this research can serve as a valuable resource for governments and organizations aiming to implement effective measures for addressing the challenges of urbanization, especially in the context of energy transition and the adoption of smart city initiatives. It can be categorized into international and governmental levels as follows:

First, reviewing the current energy transition policies is important to ensure a sustainable energy supply. In Chapter 2, sections 2.7 and 2.8, the findings and implications of the SLR indicate that governmental and regional efforts toward energy transition must be combined. In line with climate change mitigation, developed countries have an advantage in investing in energy transition and smart city infrastructure. While developing countries, particularly those with great potential in solar energy, should be supported in their shift toward renewable energy. Technology transfer and financial aid through international grants and loans can aid sustainable development in these countries facing economic and security challenges. It is noted the successful reflection of some European

Union projects in North Africa, where it is possible for countries that export crude oil and natural gas to Europe to become exporters of clean energy. This matter is fully reflected in Iraq. Reviewing policies must be a priority for the government. Based on the results of Chapter 3, section 3.5, the focus is on exploiting the promising potential of renewable energy to fill the energy supply shortage and expanding to export opportunities because of Iraq's distinguished geographical location.

Second, the significance of government reforming and encouraging participation in energy transition, as indicated in Chapter 2, sections 2.7 and 2.8, the findings and the implications resulted from the SLR. Drafting laws and regulations to support consumers in moving toward clean energy to reduce bureaucratic obstacles that hinder the transition is a priority. Furthermore, governments can incentivize individuals, organizations, and communities to participate in the energy transition through tax credits, grants, subsidies, and other financial incentives. The findings of Chapter 4, section 4.6, indicate the importance of social acceptance of energy transition applications. Moreover, in Chapter 5, section 5.8, the implications confirmed the importance of increasing social awareness about technology related to energy transition applications. Governments should invest in public education and awareness campaigns to promote the use of renewable energy and highlight the significance of a sustainable energy supply. In the context of Iraq, policymakers must prioritize social acceptance before upgrading energy systems in residential projects. While the government has launched various initiatives, a comprehensive awareness campaign is necessary to communicate the benefits and challenges of this new technology to the public.

Furthermore, in Chapter 2, sections 2.7 and 2.8, the findings and the implications resulting from the SLR highlight the importance of addressing decision-making, and governments should promote transparency and stakeholder engagement in decision-making processes to guarantee project success. The implications of Chapter 4, section 4.6, indicate that the expert's direction differs from the government policy when the result proves that installing PV panels in the residential project is more useful than PV farms through distributed energy systems. In this regard, the stakeholders should be well-defined. Non-government organizations, employee experts, and the public must engage in the decision-making.

Third, modernizing energy infrastructure is important to ensure high-quality energy transition and increase clean energy's penetration in urban energy mixes. As indicated in Chapter 2, sections 2.7 and 2.8, the findings and implications of the SLR indicate that developing countries' governments must prioritize budget allocations for the energy sector and invest in infrastructure development. Based on the results of Chapter 3, section 3.5, the contribution of renewable energy to the city's energy system is attractive and requires an advanced infrastructure. Furthermore, the findings of Chapter 4, section 4.6, indicate that a distributed energy system will be the best option for solar PV output. The right option will be initiating large housing projects that can convert energy consumers into prosumers. This approach will utilize available space and reduce land acquisition costs, primarily for renewable energy projects such as solar energy. Exploiting free spaces in residential projects for PV installation can minimize investment costs and maximize usefulness due to the available space, eliminating transmission losses. Thus, increasing budget allocations for the energy sector and investing in infrastructure development, combined with large housing projects, can effectively promote renewable energy use while reducing energy costs.

Fourth, Human Resources, the importance of developing power sector specialized staff training and intensive training programs. As indicated in Chapter 2, sections 2.7 and 2.8, the findings and the implications resulting from the SLR, the specialized technical staff should be trained, and their awareness of the importance of transitioning to sustainable energy systems should be raised. Moreover, Chapter 4, section 4.6, results indicate that staff experience has priority among the technical criteria and has the second rank after public acceptance. Thus, incentives should also be provided to encourage staff to continue working in this sector. These measures will help to promote a more skilled workforce and ensure the successful implementation of energy transition projects. Furthermore, Chapter 5, section 5.8, refers to the impact of staff specialist perception on the DES implementation and adoption; therefore, the government should pay more attention to the influencing factors that improve staff productivity.

Fifth, Chapter 2, section 2.8, indicates the growth of research in the Middle East and China, while most developing countries such as Iraq are still lagging. Therefore, it is essential to conduct further research to address the challenges and determinants of energy transition. Governments must provide funding for research and development in renewable energy and related fields to identify new approaches and effective solutions to the problems associated with ensuring a stable and environmentally friendly energy supply. Encouraging local researchers to increase innovation in these fields can lead to developing new solutions to aid in advancing energy transition. To support this, universities and development centers should have adequate resources and funding to promote research in these areas. This can help to create new fields of study related to energy and smart cities.

Seventh, International Cooperation, as indicated in Chapter 2, sections 2.7 and 2.8, the findings and implications of the SLR crises, wars, and conflicts of geopolitical interests pose significant challenges to developing renewable energy and energy transition, particularly in developing countries. Such challenges often lead to disruptions in the energy supply chain and hinder the growth of renewable energy investments as the focus shifts to addressing security concerns. The situation is further exacerbated by the lack of job opportunities, especially in new fields, due to the weak security situation in these countries such as Iraq. The results of Chapter 5, section 5.8, indicate that security concerns influenced the behavioral intention toward DES adoption. Activating international cooperation committees in various regional organizations and groupings is crucial to control these crises and prevent their escalation. These committees can help create stability and peace in conflict-prone regions, offering an advantageous environment for developing renewable energy and energy transition projects. Figure 31 explains the summary of the implications. The first ring is divided into the international and governmental levels; the second ring represents the economic, technical, and policy dimensions; and the third ring refers to the recommendations and procedures.

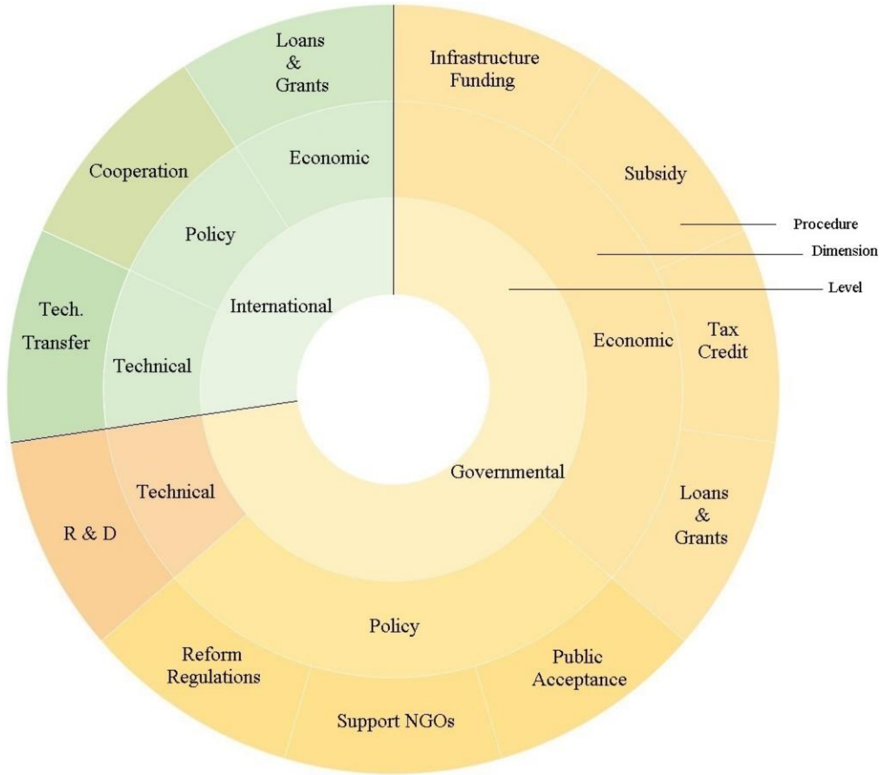


Figure 31. Summary of the governmental and international implications.

6.3 Contribution

The research has made a significant contribution to the previous studies on energy transition of smart cities. This was achieved through the diverse range of four studies that accurately answered the main research question. The review of the literature conducted as part of this research found a limited research of SLRs on energy transition, and there was a lack of systematic literature reviews on the topic related to smart cities. Thus, this research provides an advanced step for future researchers in this area. Many scholars have directed out the significance of originality and novelty in the research. Within energy-social science domain, Sovacoo et al., (2018), indicated the significance of advancing science and achieving social benefits, figure 32 shows the position of this research according to the social benefits and advancing science.

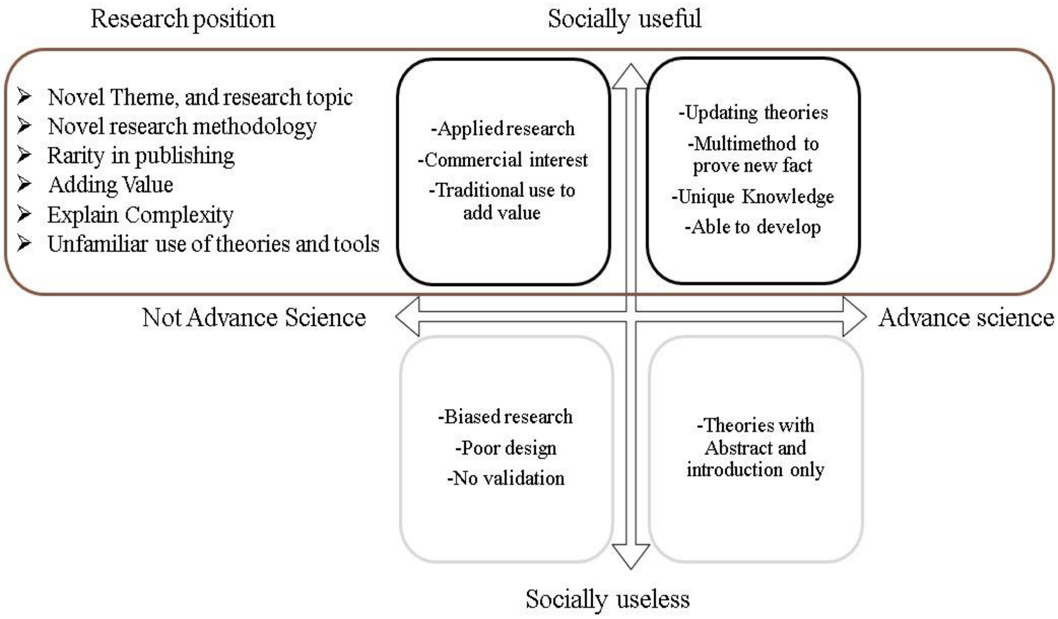


Figure 32: Research position

One of the unique contributions was the utilizing a documented data of the pattern of energy consumption in residential cities for large numbers of consumers, using official government data. This provided a valuable insight into the share of solar energy contribution in cities, which is a critical aspect of sustainable smart city applications. Additionally, the study presented an extended model for decision-making regarding selecting the appropriate grid connection for solar energy in residential city projects. The security criterion was adopted as a decisive factor of grid prioritization for selecting the appropriate grid based on technical, economic, and social dimensions. This extended model can be further expanded to suit the nature of future studies. Furthermore, we expanded the technology acceptance theory model UTAUT in the field of distributed energy systems from the perspective of power sector staff specialists. The model included the attitude construct derived by theory of planned behavior theory, awareness, and security constructs for a first time. The accuracy of the extended model was proven through its predictive and explanatory strength, and the variance in the results.

In summary, this study has provided valuable qualitative contributions to the literature by utilizing diverse interrelated theories to answer the research questions and provide implications and recommendations for various stakeholders concerned. The research conducted in this study provides a valuable foundation for future studies in this area. Table 19 illustrates the originality of research and Knowledge extracted were categorized into professional and academic levels.

Table 19: Categories of research contribution

	Professional level International, Governmental, Stakeholders	Academic level Innovative methodological research approaches, novel theoretical frameworks & original findings
Study 1	1- The social dimension is more important than others in the developing countries in particular. 2- Energy transition and sustainable smart city are crucial to achieve 4 of SDGs.	1- PRISMA was powerful to interpret the trend of the publications. 2- Contributions to literature and theoretical debates for the Socio-technical impacts of energy transition. 3- Understanding the barriers of energy transition.

	Professional level International, Governmental, Stakeholders	Academic level Innovative methodological research approaches, novel theoretical frameworks & original findings
	3- Iraqi educational institutes has to update the systems and consolidate new centers for energy R&D	4- Quantitative analysis of the energy transition publication trend globally.
Study 2	1- Update the renewable energy potential to support government plans, the private sector investment and public participation. 2- Confirm that utilizing the residential projects is useful more than PV farms to decrease the initial cost.	1- Contributions to literature by addressing the gap of the hybrid residential energy system. 2- Real consumption data analysis and provide a PV contribution in a whole city from developing countries. 3- Quantitative analysis of PV adoption rates and pattern.
Study 3	1- Infrastructure upgrading cannot be done without addressing the security concerns and investigate the public acceptance and develop the staff ability. 2- To utilize the residential projects for PV, energy system has to upgraded into DES.	1- Contributions to literature and theoretical debates of expanding the DM to examine the grid connection. 2- The developing countries is different than developed countries in the research criteria of energy transition because it has both renewable and traditional energy resources. 3- Socio-technical factors impacts the technology related to the energy transition more than economic.
Study 4	1- Enhancing the staff specialist's thoughts and increase their awareness about the importance of DES and energy transition in their work will be	1-Contributions to literature and theoretical debates of technology acceptance models, the traditional constructs should be updated according to the social features of the country.

	Professional level International, Governmental, Stakeholders	Academic level Innovative methodological research approaches, novel theoretical frameworks & original findings
	the key factor of the new project success. 2- The staff in the developing countries (Iraq) has deferent motivation, performance expectancy as example. 3- This study represents a valid base and motivation for further research in developing countries that are endowed with fossil fuel resources and renewable energy capacity for reaching the SDGs	2- Extending the UTAUT by adding attitude, awareness and security factors, improved by predicted power. 3- Performance expectancy has a negative impact on the intention behavioral to adopt technology. 4- Social influence has no impact on the adoption, which differs than the studies in developed countries.

6.4 Limitations and future research

This dissertation encountered some restrictions during a various stages of the study. One of the significant challenges was finding appropriate literature due to the uniqueness of the research subject and the inadequate studies addressing it. In the first study (chapter 2), the lack of systematic literature reviews of energy transition from the perspective of smart cities hindered the review process. Future research should conduct more comprehensive reviews to identify relevant future research directions. Additionally, finding specialists in the field of smart cities in developing countries was challenging, as the concept is emerging and new. This represents an opportunity to expand smart city research, particularly through universities and research centers in these countries. In the second study (chapter 3) Another limitation was the random power consumption bills, which enforced to predict some monthly consumer's data in few cases. In the third study (chapter 4), having a consensus on some factors was one of the limitations, due to multi background of the experts.

In the fourth study (Chapter 5), the research also faced challenges in increasing the sample size while revealing the perceptions of energy professionals. Workers in the renewables field and smart grids are still limited and distributed in faraway places, and their knowledge background is different, which may affect the study results. Future studies may consider establishing a communication network among workers in this field for the purpose of exchanging experiences and information. Future research may also include conducting CB.SEM and/or PLS.SEM to verify the results of the technology acceptance model theoretically. Additionally, surveying public acceptance to widen the perception of smart city adoption in developing countries could be beneficial. Finally, as one of the SLR findings, the unequal access to renewable energy, social inequities, and its impact on developing communities will be promising areas for further studies.

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Appendix 1: AHP Survey Questionnaire

This survey is intended to prioritize the types of grid connection with respect to their importance to support the solar PV penetration to achieve energy transition in the residential projects. This research will help to provide the necessary recommendations to the policy makers to achieving the maximum benefit from solar PV. This study is for a research purpose and the confidentiality of information and data will be preserved for all respondents.

Questions

Based on the scale given from 1-9, select the relative importance of the factor over the other by coloring your choice. Please see the example below.

Example 1: Technical factors are 'Much more important' than the Economic.

Technical	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Economic

1: Equal, 3: Slightly more Important, 5: More Important, 7: Much More Important, 9: Absolutely Important

Example 2: Social factors are 'More important' than the Economic.

Economic	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Social

1: Equal, 3: Slightly more Important, 5: More Important, 7: Much More Important, 9: Absolutely Important

Pair-wise Comparison (Level-1)

1- What is the more important among the following factors that contributes to choosing the best grid connection?

Technical	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Economic
Technical	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Social
Economic	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Social

1: Equal, 3: Slightly more Important, 5: More Important, 7: Much More Important, 9: Absolutely Important

Pair-wise Comparison (Level-2)

1- What is more important among the following technical factors that contribute to choosing the best grid connection?

Infrastructure	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Grid stability
Infrastructure	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Generation
Infrastructure	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Staff
Grid stability	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Generation
Grid stability	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Staff
Grid stability	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Staff

1: Equal, 3: Slightly more Important, 5: More Important, 7: Much More Important, 9: Absolutely Important

2- What is more important among the following economic factors that contribute to choosing the best grid connection?

O&M	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Cost
O&M	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Subsidy
Cost	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Subsidy

1: Equal, 3: Slightly more Important, 5: More Important, 7: Much More Important, 9: Absolutely Important

3- What is more important among the following Social factors that contribute to choosing the best grid connection?

Job	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Security
Job	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Acceptance
Security	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Acceptance

1: Equal, 3: Slightly more Important, 5: More Important, 7: Much More Important, 9: Absolutely Important

Pair-wise Comparison (Level-3)

Please rank the Alternatives importance according to the following technical factors

1- In terms of infrastructure requirements, what is more important among the following alternatives?

Off-grid	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	On-grid D
Off-grid	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	On-grid C
On-grid D	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	On-grid C

1: Equal, 3: Slightly more Important, 5: More Important, 7: Much More Important, 9: Absolutely Important

2- In terms of grid stability requirements, what is more important among the following alternatives?

Off-grid	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	On-grid D
Off-grid	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	On-grid C
On-grid D	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	On-grid C

1: Equal, 3: Slightly more Important, 5: More Important, 7: Much More Important, 9: Absolutely Important

3- In terms of generation, what is more important among the following alternatives?

Off-grid	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	On-grid D
Off-grid	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	On-grid C
On-grid D	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	On-grid C

1: Equal, 3: Slightly more Important, 5: More Important, 7: Much More Important, 9: Absolutely Important

4- In terms of staff experience, what is more important among the following alternatives?

Off-grid	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	On-grid D
Off-grid	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	On-grid C
On-grid D	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	On-grid C

1: Equal, 3: Slightly more Important, 5: More Important, 7: Much More Important, 9: Absolutely Important

Please rank the Alternatives important according to the following economic factors

1- In terms of O&M, what is more important among the following alternatives?

Off-grid	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	On-grid D
Off-grid	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	On-grid C
On-grid D	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	On-grid C

1: Equal, 3: Slightly more Important, 5: More Important, 7: Much More Important, 9: Absolutely Important

2- In terms of cost, what is more important among the following alternatives?

Off-grid	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	On-grid D
Off-grid	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	On-grid C
On-grid D	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	On-grid C

1: Equal, 3: Slightly more Important, 5: More Important, 7: Much More Important, 9: Absolutely Important

3- In terms of subsidy, what is more important among the following alternatives?

Off-grid	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	On-grid D
Off-grid	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	On-grid C
On-grid D	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	On-grid C

1: Equal, 3: Slightly more Important, 5: More Important, 7: Much More Important, 9: Absolutely Important

Please rank the Alternatives important according to the following Social factors

1- In terms of Jobs, what is more important among the following alternatives?

Off-grid	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	On-grid D
Off-grid	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	On-grid C
On-grid D	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	On-grid C

1: Equal, 3: Slightly more Important, 5: More Important, 7: Much More Important, 9: Absolutely Important

2- In terms of Security, what is more important among the following alternatives?

Off-grid	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	On-grid D
Off-grid	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	On-grid C
On-grid D	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	On-grid C

1: Equal, 3: Slightly more Important, 5: More Important, 7: Much More Important, 9: Absolutely Important

3- In terms of Acceptance, what is more important among the following alternatives?

Off-grid	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	On-grid D
Off-grid	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	On-grid C
On-grid D	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	On-grid C

1: Equal, 3: Slightly more Important, 5: More Important, 7: Much More Important, 9: Absolutely Important

Appendix 2: Smart-PLS analysis / Factor-loading

	ATT	AWR	BIN	IBD	PED	SED	SIP
ATT1	0.916						
ATT2	0.897						
ATT6	0.692						
AWR1		0.859					
AWR2		0.806					
AWR5		0.89					
BIN1			0.924				
BIN3			0.92				
BIN6			0.917				
IBD1				0.934			
IBD3				0.901			
IBD4				0.907			
PED2					0.845		
PED3					0.556		
PED4					0.759		
PED6					0.678		
SED1						0.875	
SED3						0.799	
SED5						0.89	
SIP1							0.92
SIP2							0.928
SIP3							0.761
SIP4							0.664

Appendix 3: Smart-PLS analysis / Cross-Loading

	ATT	AWR	BIN	IBD	PED	SED	SIP
ATT1	**0.916**	0.67	0.207	0.317	-0.065	0.141	-0.043
ATT2	**0.897**	0.629	0.244	0.275	-0.04	0.137	-0.001
ATT6	**0.692**	0.52	0.127	0.299	-0.084	0.007	0.016
AWR1	0.649	**0.859**	0.167	0.317	-0.036	0.119	0.072
AWR2	0.577	**0.806**	0.156	0.391	-0.069	0.028	-0.038
AWR5	0.626	**0.89**	0.187	0.31	-0.096	0.106	0.137
BIN1	0.223	0.176	**0.924**	0.206	-0.254	0.27	-0.147
BIN3	0.212	0.2	**0.92**	0.211	-0.287	0.252	-0.127
BIN6	0.208	0.175	**0.917**	0.201	-0.25	0.297	-0.107
IBD1	0.321	0.344	0.212	**0.934**	-0.106	0.047	-0.037
IBD3	0.338	0.364	0.166	**0.901**	-0.021	0.018	-0.059
IBD4	0.304	0.378	0.236	**0.907**	-0.088	0.047	-0.072
PED2	-0.06	-0.085	-0.271	-0.133	**0.845**	-0.101	0.113
PED3	-0.046	0.002	-0.135	0.025	**0.556**	-0.071	0.205
PED4	-0.096	-0.141	-0.23	-0.042	**0.759**	-0.085	0.17
PED6	0.037	0.107	-0.132	-0.017	**0.678**	-0.069	0.178
SED1	0.159	0.149	0.257	0.03	-0.075	**0.875**	-0.12
SED3	0.055	0.023	0.277	0.036	-0.091	**0.799**	-0.156
SED5	0.085	0.082	0.221	0.039	-0.137	**0.89**	-0.106
SIP1	-0.013	0.07	-0.144	-0.103	0.173	-0.145	**0.92**
SIP2	-0.016	0.079	-0.111	-0.071	0.2	-0.108	**0.928**
SIP3	-0.018	0.012	-0.11	0.032	0.237	-0.185	**0.761**
SIP4	0.007	0.076	-0.077	-0.044	0.069	-0.032	**0.664**

Appendix 4: Smart-PLS analysis / Survey questionnaire

<table>
<tr><td colspan="2">This research attempts to find out the motivation and the influencing factors of specialist's staff to work on DES. Through the experience in the departments related to the energy sector, especially DES, please help us to complete this research, which is completely devoted for academic purposes. We would also like to inform you that neither the identities of the respondents nor their exact locations of work will be disclosed to anyone.</td></tr>
<tr><td colspan="2">Please insert your age in the as a number on the left and circle the right number of your rank for the experience and the qualification</td></tr>
<tr><td colspan="2">Demographic Information</td></tr>
<tr><td>Age</td><td></td></tr>
<tr><td>Experience</td><td>1- Under 5
2- Between 5 and 10
3- above 10</td></tr>
<tr><td>Qualification</td><td>1- Under Bachelor
2- Bachelor and Diploma
3- Master and PhD</td></tr>
<tr><td colspan="2">Please state your answer for all the items by inserting numbers from 1 to 5 as indicated below:
1- Strongly disagree 2- Disagree 3- Neutral 4- Agree 5- Disagree</td></tr>
<tr><td>Survey Items</td><td>Constructs</td></tr>
<tr><td>PE1. DES implementation improves the power system situation.</td><td rowspan="3">Performance expectancy regarding DES implementation</td></tr>
<tr><td>PE2. DES implementation enables me to do my works faster.</td></tr>
<tr><td>PE3. DES implementation enables me to do my work safer.</td></tr>
</table>

PE4. It is easy to become skillful by working on DES applications.	
PE5. By training it will be easy to develop my work.	
PE6. I do have enough training to work on DES applications.	
SI1. My colleagues and leaders would believe that I should adopt DES into my work	Social influence of DES implémentation
SI2. People who are important to me would think that I should adopting DES into my work.	
SI3. My friends would believe that I should adopt DES into my work.	
SI4. People who influence my behavior would think I should adopt DES into my work.	
SI5. The global development in the energy transition push me to work on DES.	
SI6. I have to work on DES according to the governmental trend to reform the energy situation.	
AC1. I know the rules prescribed by the DES implementation.	Awareness concerns to implement DES
AC2. I understand the rules prescribed by the DES implementation.	
AC3. I know my responsibilities as prescribed in the DES implementation are enhancing my work in the organization.	
AC 4. I have to work on DES to improve the security situation.	

AC5. Adopting DES will push the government to reform the security conditions.	
SED1 I do believe working on DES will secure my life.	Security concerns regarding DES implementation
SED2 DES sites will be more secure.	
SED3 I will change my job if the security improved in my former job.	
SED4 I will work on DES sites out of the capital center.	
SED5 I will change my job when I feel unsafe.	
AT1: To adopt DES into my work is a good idea.	Attitude towards DES implementation
AT2: I think the work on DES is a wise idea.	
AT3: I like the idea of adopting DES into my work.	
AT4: To adopt DES into my work would be improve my skills.	
AT5. Adopting DES will enhance and fix the relations among the technicians and workers.	
AT6. Working on DES will increase the competitiveness among the employees	
BI1. I intend to continue work on DES in the future.	Behavioral intention to DES implementation
BI2. I will always try to work on DES in my work routine.	
BI3. I plan to work on DES frequently.	
BI4. I will develop my skills to meet the DES requirements.	
BI5. I will do my best to participate in the DES projects.	

BI6. I will participate in all training courses related to the DES.	
IS1. I do work on DES applications in my work.	Implementation DES
IS2. I do work on Renewable energy related jobs.	
IS3. I do work on energy storage equipment.	
IS4. I do work on control software and application related to DES.	
IS5. I do check the online energy related platforms.	
IS6. I do submit recommendations to develop the procedures related to DES.	

국문초록

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이 논문은 에너지 전환이 스마트 시티의 개념에 미치는 영향을 탐구하고 개발도상국, 특히 이라크가 이러한 계획을 실행하는 과정에서 직면한 과제를 진단합니다. PRISMA 분석을 사용하여 에너지 변환에 대한 문헌을 검토하여 의사 결정 메커니즘 및 사회적, 기술적 영향과 관련된 41개의 결정 요인을 식

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주요어 : 에너지 전환, 스마트 시티, 태양광, 분산 에너지 시스템.
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