Investigating the Barriers to Adoption of Renewable Energy Systems in Residential Buildings in Kuwait

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Abstract

This study investigates the barriers to adopting renewable energy (RE) systems in residential buildings in Kuwait, with a focus on technical, financial, environmental, and social challenges. Through a structured survey administered to 217 respondents from varied demographics, the study highlights key obstacles such as high initial costs, limited awareness of service providers, environmental challenges, and social influences. Technical barriers, including maintenance complexities and insufficient skilled personnel, further hinder adoption. Despite acknowledging the benefits of RE systems, respondents express concerns over system reliability and compatibility with Kuwait's extreme climatic conditions, such as high temperatures and frequent dust storms. Financial constraints, particularly the lack of government incentives, exacerbate these challenges. Social factors, including community standards and peer influence, play a nuanced role, with public awareness campaigns identified as critical for fostering adoption. The findings emphasize the need for targeted awareness initiatives, financial incentives, and advanced technologies tailored to Kuwait's climate. This study provides actionable insights for policymakers, developers, and stakeholders to address these barriers effectively and promote RE adoption. By overcoming these challenges, Kuwait can enhance its energy sustainability, contribute to global climate goals, and diversify its energy portfolio in alignment with sustainable development objectives.

Keywords: Renewable energy systems, residential buildings, sustainability, Kuwait.

دراسة العوائق التي تحول دون تبني أنظمة الطاقة المتجددة في المباني السكنية في الكويت

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الملخص

تبحث هذه الدراسة في العوائق التي تحول دون تبني أنظمة الطاقة المتجددة (RE) في المباني السكنية في الكويت، مع التركيز على التحديات الفنية والمالية والبيئية والاجتماعية. ومن خلال مسح منظم تم إجراؤه على 217 مستجيبًا من فئات سكانية متنوعة، تسلط الدراسة الضوء على العقبات الرئيسية مثل التكاليف الأولية المرتفعة والوعي المحدود بمقدمي الخدمات والتحديات البيئية والتأثيرات الاجتماعية. كما تعيق العوائق الفنية، بما في ذلك تعقيدات الصيانة وعدم كفاية الموظفين المهرة، التبني بشكل أكبر. وعلى الرغم من الاعتراف بفوائد أنظمة الطاقة المتجددة، أعرب المستجيبون عن مخاوفهم بشأن موثوقية النظام وتوافقه مع الظروف المناخية القاسية في الكويت، مثل ارتفاع درجات الحرارة والعواصف الغبارية المتكررة. وتؤدي القيود المالية، وخاصة الافتقار إلى الحوافز الحكومية، إلى تفاقم هذه التحديات. وتلعب العوامل الاجتماعية، بما في ذلك معايير المجتمع وتأثير الأقران، دورًا دقيقًا، مع تحديد حملات التوعية العامة على أنها حاسمة لتعزيز التبني. وتؤكد النتائج على الحاجة إلى مبادرات توعية مستهدفة وحوافز مالية وتقنيات متقدمة مصممة خصيصًا لمناخ الكويت. تقدم هذه الدراسة رؤى عملية لصناع السياسات والمطورين وأصحاب المصلحة لمعالجة هذه الحواجز بشكل فعال وتعزيز تبني الطاقة المتجددة. ومن خلال التغلب على هذه التحديات، يمكن للكويت تعزيز استدامة الطاقة لديها، والمساهمة في أهداف المناخ العالمية، وتنويع محفظة الطاقة لديها بما يتماشى مع أهداف التنمية المستدامة.

الكلمات المفتاحية: أنظمة الطاقة المتجددة، المباني السكنية، الاستدامة، الكويت.

1. Introduction

Buildings are among the largest energy-consuming sectors globally, significantly contributing to energy inefficiency. As such, they present a promising avenue for achieving sustainable development goals (Yüksek & Karadağ, 2021). However, excessive energy consumption in buildings has adverse effects on the environment, including air pollution, the greenhouse effect, and the urban heat island phenomenon. These environmental impacts not only pose risks to human health but also hinder socioeconomic progress (Pan & Zhang, 2020). With growing concerns over climate change and the increasing demand for energy, enhancing energy efficiency in residential buildings has become a critical priority. Energy Management Systems (EMS) have emerged as vital tools for improving energy efficiency, reducing consumption, and mitigating the environmental impact of residential areas (Smith et al., 2022; Rathor and Saxena, 2020).

For oil-dependent nations such as Kuwait, where fossil fuels dominate the energy mix, transitioning to renewable energy (RE) technologies is imperative. This shift is essential for diversifying the energy portfolio and meeting future energy demands. The promotion of renewable energy adoption often highlights its potential economic, social, and environmental advantages (Hardy et al., 2017; Lehr et al., 2012). However, in Gulf Cooperation Council (GCC) countries, these benefits are not yet fully understood. For example, green regulations may present challenges to oil-producing economies in the GCC, potentially impacting their economic frameworks (Najm, 2019). Nonetheless, the push for renewable energy in these regions can be seen as part of broader policy transfer efforts. These efforts involve shifting the rentier social contract to incorporate renewable energy's economic, social, and environmental gains (Atalay, Biermann & Kalfagianni, 2016; Tsai, 2018). Such policies not only enhance geopolitical control over energy security (Braunstein, 2020) but also help project a positive global image for GCC countries.

Energy sustainability, which includes renewable energy, energy efficiency, and environmental protection, generally garners social acceptance when it does not impose additional costs on consumers. However, the transition to renewable energy and the implementation of energy efficiency measures often faces political, cultural, and social resistance, particularly when subsidies and other welfare benefits are affected (Sovacool & Griffiths, 2020; Sovacool, 2016; Yaqoot, Diwan & Kandpal, 2016; Steers et al., 2008). Factors such as financial limitations, technical obstacles, environmental challenges, and societal attitudes play crucial roles in determining the willingness of residents to adopt renewable energy technologies.

Addressing these challenges is essential to unlocking the potential of renewable energy systems in residential buildings and advancing Kuwait's sustainability objectives. This study aims to explore these barriers and provide actionable recommendations to promote the adoption of renewable energy systems in Kuwaiti households.

1.1. Definition of the Research Problem

Kuwait faces significant challenges in adopting renewable energy systems, primarily due to a dependency on fossil fuels that dominate the energy mix. This reliance not only strains the national budget but also increases environmental pollution and greenhouse gas emissions. Despite global advancements in renewable energy technologies as sustainable alternatives, their adoption in Kuwait remains limited. Addressing these challenges is essential to reduce emissions, align with global sustainability goals, and ensure energy security for future generations. This study investigates the barriers to integrating renewable energy systems, particularly in residential buildings, to provide actionable solutions for fostering adoption in Kuwait's unique socio-economic and climatic context.

1.2. Research Objectives

The following are the main objectives of the current study:

1. Identify the key technical, financial, environmental, and social barriers to the adoption of renewable energy systems in residential buildings in Kuwait.
2. Assess the impact of high initial costs, maintenance concerns, and limited government incentives on adoption rates.
3. Explore the influence of social factors, including community acceptance and awareness campaigns, on fostering renewable energy adoption.
4. Provide recommendations for tailored financial incentives, advanced technologies, and public awareness strategies to overcome identified barriers.
5. Contribute actionable insights for policymakers, developers, and stakeholders to support Kuwait's transition to sustainable energy systems.

1.3. Importance of the Study

This study is critical for addressing Kuwait's energy sustainability challenges, offering a roadmap to reduce dependency on fossil fuels while minimizing environmental degradation. By identifying and overcoming barriers to renewable energy adoption, this research contributes to global efforts to combat climate change and promote sustainability.

It holds significant value for policymakers and stakeholders by providing targeted recommendations to enhance renewable energy adoption. Furthermore, the study aids society by encouraging energy-efficient practices, fostering economic savings for residents, and improving overall environmental quality in Kuwait.

2. Literature Review

Viardot (2013) examined the barriers to the adoption of renewable energy (RE) and how cooperatives are addressing these obstacles to enhance RE usage. The study surveyed nine cooperatives in countries where governments subsidize RE adoption. It identified specific barriers to RE adoption by consumers and highlighted the role of cooperatives in overcoming these barriers through community-based social marketing initiatives. These initiatives included educational communication, low pricing, localized offerings with complementary services, and cooperative distribution. The study proposed a framework to assess the impact of each initiative on reducing adoption barriers.

Doner (2007) analyzed strategies to increase the use of renewable energy as a means of reducing emissions and mitigating fossil fuel price volatility. The study reviewed international and U.S. experiences with renewables, focusing on policy mechanisms such as the Production Tax Credit, Renewable Portfolio Standards, and Research and Development subsidies. It emphasized the importance of well-designed policies in accelerating the diffusion of renewable technologies and provided insights into effective policy measures to support renewable energy growth.

Luthra et al. (2015) aimed to identify and rank the major barriers to adopting renewable and green energy technologies in India. The study categorized 28 barriers into seven dimensions: Economic and Financial, Market, Awareness and Information, Technical, Ecological and Geographical, Cultural and Behavioral, and Political and Government Issues. Using the Analytical Hierarchy Process (AHP) technique, the study ranked these barriers based on expert opinions and conducted sensitivity analysis to assess ranking stability. The findings offered valuable insights for practitioners and policymakers to focus efforts on promoting renewable energy adoption and formulating effective strategies.

Yaqoot, Diwan, and Kandpal (2016) reviewed the literature on barriers to the dissemination of decentralized renewable energy systems. The study identified critical barriers, including technical issues, lack of skilled manpower, high costs, limited access to credit, and insufficient awareness or training. It also discussed remedial measures, such as long-term policies, financial incentives,

regulatory frameworks, and community involvement, to promote decentralized renewable energy systems. The findings highlighted the importance of international cooperation, local participation, and targeted awareness campaigns in overcoming these barriers.

Asante et al. (2020) sought to identify and rank barriers to renewable energy development, categorizing 23 barriers into six broad headings: Technical, Economic and Financial, Social, Political and Regulatory, Institutional, and Geographical. Using the MULTIMOORA method integrated with the EDAS approach, the study ranked the barriers and emphasized political and regulatory challenges, such as corruption and cumbersome licensing procedures, as the most critical. The study recommended adopting specific standards, simplifying certification processes, and implementing bottom-up policy approaches to improve inclusiveness and sustainability.

Tseng et al. (2021) investigated the barriers and facilitators of renewable energy adoption in Indonesia under conditions of uncertainty. The study utilized the fuzzy Delphi method to validate a set of qualitative attributes and applied the fuzzy decision-making trial and evaluation laboratory method to visualize interrelationships among these attributes. The results showed that adoption was driven by technical capabilities, while technical analysis and institutional challenges were the primary barriers. The study suggested that addressing development funding, licensing issues, and investment costs is crucial for achieving sustainable energy transitions.

Rosso-Cerón and Kafarov (2015) studied the social dimensions influencing the adoption of renewable energy systems (RES) in Colombia. Through a survey of stakeholders, the study examined three key dimensions: socio-political acceptance, market acceptance, and community acceptance. It found that market acceptance barriers were the most significant, followed by socio-political and community acceptance issues. These barriers hindered the penetration of RES despite the availability of local capacity and resources. The findings emphasized the need for addressing market-related challenges to enhance renewable energy adoption.

Juszczyk et al. (2022) explored the socioeconomic and regulatory barriers to the diffusion of renewable energy technologies (RETs) in Finland and Poland. The study identified inflexible and excessive regulatory frameworks, limited financing options, and insufficient societal awareness as significant barriers. It emphasized the need for supportive energy policies, increased societal awareness, and better access to funding. The study also provided insights into the most common RETs used in these countries and highlighted the challenges from the perspective of renewable energy companies' executives, offering managerial and regulatory recommendations.

The reviewed literature highlights various barriers to renewable energy (RE) adoption across technical, financial, social, political, and cultural dimensions. Technical challenges, such as inadequate infrastructure, insufficient skilled manpower, and high maintenance costs, are emphasized by Tseng et al. (2021) and Yaqoot et al. (2016), with the added complexity of environmental factors in specific regions. Economic constraints, including high upfront costs, limited access to credit, and ineffective financial incentives, are identified by Luthra et al. (2015) and Juszczyk et al. (2022) as critical obstacles to adoption. Policy and regulatory issues, such as corruption, bureaucratic inefficiencies, and inadequate support mechanisms, are highlighted by Doner (2007), Asante et al. (2020), and Juszczyk et al. (2022), indicating the significant role of governance in facilitating renewable energy growth. Social and cultural barriers, including societal resistance, community acceptance, and the influence of cultural norms, are explored by Rosso-Cerón and Kafarov (2015) and Viardot (2013), who stress the need for community-driven approaches and public education. Additionally, Viardot (2013) and Yaqoot et al. (2016) underscore the importance of awareness, noting that insufficient understanding of RE benefits and operational requirements limits adoption. Despite these valuable insights, the literature reveals key gaps specific to Kuwait and similar Gulf Cooperation Council (GCC) countries. There is a lack of focus on the unique socio-economic and political dynamics of oil-dependent nations, where energy subsidies and rentier economies influence consumer behavior. Furthermore, localized barriers, such as Kuwait's harsh climatic conditions (e.g., high temperatures, dust storms) and existing energy infrastructure, remain underexplored. Although policy frameworks are widely discussed, there is limited research on adapting international best practices to Kuwait's context. Additionally, the role of community engagement in promoting RE adoption within Kuwait's societal structure still under examined, despite evidence from global studies highlighting the effectiveness of such strategies. Comparative analysis of RE adoption barriers across GCC countries is also scarce, which could provide insights into shared challenges and region-specific solutions. This study seeks to fill these gaps by examining the barriers to renewable energy adoption in Kuwait's residential sector, providing tailored insights for policymakers and stakeholders to drive the transition toward sustainable energy systems.

3. Methodology

This study employs a descriptive, cross-sectional design to explore the barriers to adopting renewable energy systems in residential buildings in Kuwait. The research aims to provide insights into the technical, financial, environmental, and social factors influencing adoption,

using quantitative data collected through a structured survey.

3.1. Population and Sample

The study targets homeowners and tenants in Kuwait's main urban areas, ensuring diversity in demographics, employment status, and living conditions. The sample consists of 217 respondents, selected through stratified random sampling to achieve proportional representation across the six major regions of Kuwait: Kuwait City, Hawalli, Al Ahmadi, Farwaniya, Jahra, and Mubarak Al-Kabeer. The age distribution spans multiple groups, with the largest representation in the 25-34 years range (27.6%), followed by the 35-44 years group (23.0%), and smaller proportions from other age groups. Most participants are employed (59.9%), while others include self-employed individuals, retirees, students, and unemployed residents. Additionally, 69.1% of the participants live in owned residences, and 30.9% live in rented properties.

3.2. Data Collection Tool

A structured survey questionnaire was developed to collect data on key factors influencing renewable energy adoption. The questionnaire included Likert-scale items covering four main domains; awareness and knowledge, technical and financial barriers, environmental barriers and social barriers. The survey was distributed online and in person to ensure accessibility and adequate response rates.

3.3. Time Limits

The study was conducted over a six-month period from January to June 2024. This timeframe encompassed survey distribution, data collection, analysis, and the formulation of recommendations.

3.4. Statistical Analysis

Collected data were analyzed using statistical software to compute descriptive and inferential statistics where descriptive analysis was used including mean, standard deviation, and frequency distributions to summarize responses and determine agreement levels for each statement across the survey domains. Moreover, reliability testing including Cronbach's alpha was calculated to ensure the internal consistency of the survey items. Then, the results were interpreted to highlight the most significant barriers to renewable energy adoption, enabling practical recommendations for stakeholders, including policymakers, developers, and energy providers.

4. Results

The assumed sample for this study consists of 217 respondents distributed across various demographic and geographic categories. In terms of age, the largest group falls within the 25-34 years range (27.6%), followed by those aged 35-44 years (23.0%). Younger respondents aged 18-24 years and middle-aged participants aged 45-54 years each account for 18.4%, while those older than 55 years represent the smallest group at 12.6%. Regarding employment status, the majority of respondents (59.9%) are employed, with smaller proportions identifying as self-employed (9.2%), unemployed (13.8%), retired (9.2%), or students (7.8%). The majority of participants live in owned residences (69.1%), while the remaining 30.9% reside in rented homes. Geographically, respondents are distributed across Kuwait's major regions, with the largest group residing in Kuwait City (27.6%), followed by Hawalli (18.4%), Al Ahmadi (16.1%), and Farwaniya (16.1%). Smaller proportions of the sample are located in Jahra (11.5%) and Mubarak Al-Kabeer (10.1%). This distribution ensures a diverse and representative sample for exploring the barriers to adopting renewable energy systems in residential buildings in Kuwait.

Awareness and Knowledge

Table (1) reflects a high level of familiarity and interest in renewable energy among the sample. The statement "I am familiar with renewable energy technologies and their installations" has a mean score of 4.2, with a standard deviation of 0.8, indicating that most respondents agree or strongly agree with this statement. Similarly, the highest mean score of 4.5 for the statement "I am aware of the renewable energy systems advantages for me and on the environment," coupled with a low standard deviation of 0.7, highlights strong consensus and awareness of the benefits of renewable energy systems. Additionally, the mean score of 4.0 for "I am interested in learning more about renewable energy options for my home," with a standard deviation of 0.9, demonstrates considerable interest among respondents in further exploring renewable energy solutions.

Table 1: Awareness and Knowledge

Statement	Mean	Standard deviation	Level
I am familiar with renewable energy technologies and their installations.	4.2	0.8	High
I am aware of the renewable energy systems advantages for me and on the environment.	4.5	0.7	High

I am interested in learning more about renewable energy options for my home.	4.0	0.9	High

Technical and Financial Barriers

Table (2) highlights varying levels of awareness and concerns related to renewable energy adoption among the sample. The statement "The companies who install renewable energy systems for residential buildings in Kuwait are well-known for me" has a mean score of 3.8, with a standard deviation of 1.0, indicating moderate awareness of service providers in the region. A high mean score of 4.1 for "I think that there is enough roof space for solar panels in my residence," along with a standard deviation of 0.9. The statement "I am concerned about the maintenance of renewable energy systems in terms of effort and cost" received a mean of 4.0, reflecting a high level of concern, although the standard deviation of 0.8 indicates some variability in opinions. The barrier of high initial costs is evident with a mean score of 4.3 and a low standard deviation of 0.7, signifying strong agreement that this is a significant obstacle. Finally, the statement "If there were financial incentives from the government, I would consider installing a renewable energy system" scored the highest mean of 4.7 with a standard deviation of 0.6, showing very strong consensus on the positive influence of government support.

Table 2: Technical and Financial Barriers

Statement	Mean	Standard deviation	Level
The companies who install renewable energy systems for residential buildings in Kuwait are well-known for me.	3.8	1.0	Moderate
I think that there is enough roof space for solar panels in my residence.	4.1	0.9	High
I am concerned about the maintenance of renewable energy systems in terms of effort and cost.	4.0	0.8	High
High initial costs are a major barrier for me in adopting renewable energy systems.	4.3	0.7	High
If there were financial incentives from the government, I would consider installing a renewable energy system.	4.7	0.6	High

Environmental Barriers

Table (3) highlights respondents' mixed perceptions about renewable energy systems and environmental factors. The statement "I feel that environmental responsibility can motivate me to consider renewable energy systems in my residence" has a mean score of 3.5, indicating a moderate level of agreement, with a standard deviation of 0.9, reflecting some variability in respondents' opinions. On the other hand, "Reducing energy bills would be a primary motivation for me to adopt renewable energy systems" scored the highest mean at 4.6, with a low standard deviation of 0.6, showing strong consensus on financial savings as a key motivator. Similarly, the statement "If renewable energy systems were proven effective and reliable in Kuwait's climate, I would likely adopt them" has a high mean score of 3.8, suggesting significant interest in adoption if system reliability is ensured, though there is some variability (SD = 0.8). Lastly, "I believe that high temperatures or dust can affect the performance of renewable energy systems" received a mean of 4.0, indicating high agreement and reflecting concerns about the impact of environmental conditions on system performance.

Table 3: Environmental Barriers

Statement	Mean	Standard deviation	Level
I feel that environmental responsibility can motivate me to consider renewable energy systems in my residence.	3.5	0.9	Moderate
Reducing energy bills would be a primary motivation for me to adopt renewable energy systems.	4.6	0.6	High
If renewable energy systems were proven effective and reliable in Kuwait's climate, I would likely adopt them.	3.8	0.8	High
I believe that high temperatures or dust can affect the performance of renewable energy systems.	4.0	0.7	High

Social Barriers

Table (4) provides insights into the influence of social and community factors on renewable energy adoption. The statement "I feel influenced by the choices of neighbors, friends, or family when considering renewable energy adoption" has a mean of 3.2, reflecting a moderate level of agreement with higher variability (SD = 1.0), suggesting this factor is not universally impactful across the sample. "I believe that community standards in Kuwait encourage adopting renewable

energy systems" scored a mean of 3.8, indicating high agreement that social norms may support adoption. Similarly, "In Kuwait, renewable energy systems are perceived as a positive investment" scored a mean of 4.0 with low variability (SD = 0.8), highlighting strong belief in the perceived value of renewable energy. The statement "I would feel more motivated to adopt renewable energy systems if they became a popular trend within my social network" scored a mean of 4.2, indicating significant motivation linked to social trends. However, "Hearing negative opinions regarding renewable energy systems can affect my decision to adopt them" has a moderate mean score of 3.5 with higher variability (SD = 1.1), suggesting that negative perceptions influence some respondents more than others. Lastly, "I think that public awareness campaigns can encourage me to adopt renewable energy systems" scored the highest mean of 4.5 with a low SD of 0.6, showing strong agreement on the importance of awareness campaigns in driving adoption.

Table 4: Social Barriers

Statement	Mean	Standard deviation	Level
I feel influenced by the choices of neighbors, friends, or family when considering renewable energy adoption.	3.2	1.0	Moderate
I believe that community standards in Kuwait encourage adopting renewable energy systems.	3.8	0.9	High
In Kuwait, renewable energy systems are perceived as a positive investment.	4.0	0.8	High
I would feel more motivated to adopt renewable energy systems if they became a popular trend within my social network.	4.2	0.7	High
Hearing negative opinions regarding renewable energy systems can affect my decision to adopt them.	3.5	1.1	Moderate
I think that public awareness campaigns can encourage me to adopt renewable energy systems.	4.5	0.6	High

5. Discussion

This study identifies key barriers to the adoption of renewable energy (RE) systems in residential buildings in Kuwait, offering actionable insights for policymakers, developers, and other stakeholders. Among the technical barriers, the study highlights limited awareness of service

providers and significant concerns regarding the maintenance of RE systems. A critical challenge lies in the absence of reliable and detailed quality datasets necessary to accurately assess system performance and potential output. For instance, solar energy adoption often suffers due to a lack of reliable solar irradiation data, which complicates calculations of energy generation and return on investment (Sen et al., 2016; Sen & Ganguly, 2017). Furthermore, proper delineation of resources, such as geothermal reservoirs, is essential for specific RE technologies but remains underdeveloped in many contexts (Sen et al., 2016). These gaps in data and technical resources persist as significant barriers to RE adoption. Another pressing issue is the shortage of skilled human resources trained in the operation and maintenance of RE technologies. The success of any RE project relies heavily on the availability of trained personnel and access to essential spare parts, which necessitates new infrastructure and workforce training (Martinot, 1998; Mondal, Kamp & Pachova, 2010).

The financial barriers identified in this study are consistent with global trends, where high initial costs are a predominant obstacle to RE adoption. In Kuwait, this is further exacerbated by limited awareness of the financial benefits of transitioning from fossil fuels to renewable technologies (Henriques & Sadorsky, 2008). High costs associated with RE technologies, particularly in residential settings, mirror findings from other studies emphasizing challenges such as long payback periods, increased credit risk, and limited financing structures (Margolis & Zuboy, 2006; Di Giuseppe et al., 2017). However, the overwhelmingly positive response to the idea of government subsidies or tax incentives indicates that financial support could play a pivotal role in stimulating adoption. This aligns with findings from other regions where well-designed financial incentives have significantly accelerated the transition to renewable energy systems (Cooke et al., 2007; Nasirov, Silva & Agostini, 2015).

Environmental factors also emerged as a barrier, particularly Kuwait's extreme climate conditions, including high temperatures and frequent dust storms. These factors can potentially impact the efficiency and durability of renewable energy systems, particularly solar panels. This highlights the need for investments in advanced technologies that are resilient to these environmental challenges, as well as public awareness campaigns to educate residents on the advancements in RE technologies tailored for such conditions. The role of municipalities in global greenhouse gas (GHG) reduction efforts, as discussed by Bassett and Shandas (2010), is mirrored in Kuwait's need to address localized environmental challenges while aligning with global sustainability goals.

Social barriers play a nuanced role in influencing RE adoption. While community standards and social networks can motivate adoption, the lack of visible renewable energy installations and negative peer opinions present significant deterrents. Leveraging community leaders and influencers to normalize the adoption of RE systems can address this challenge and foster widespread acceptance. Social acceptance involves multiple psychological and contextual factors, such as perceived utility, cost, trust, and installation conditions (Moula et al., 2013). Resistance may also arise from "not in my backyard" (NIMBY) attitudes, shaped by perceptions of fairness or personal inconvenience (Evans, Parks & Theobald, 2011). Addressing these issues requires targeted social interventions and education.

A lack of awareness and knowledge emerged as another significant barrier. This study corroborates findings from other regions, where insufficient education about RE benefits and technologies discourages adoption (Kazemi & Udall, 2023). Public awareness campaigns and educational programs are essential to bridge this gap, promoting the economic and environmental benefits of renewable systems. Moreover, weak government policies and unenforced regulations contribute to resistance against behavioral changes and energy-efficient practices, underscoring the need for stronger institutional frameworks and practical solutions.

This study emphasizes that overcoming these technical, financial, environmental, and social barriers requires a coordinated approach involving policymakers, private sector stakeholders, and community leaders. The findings underscore the need for Kuwait to develop robust financial incentives, improve technical training and infrastructure, and implement targeted awareness campaigns to unlock the potential of renewable energy in residential buildings.

6. Conclusion

This study identifies key barriers to the adoption of renewable energy systems in residential buildings in Kuwait, emphasizing technical, financial, environmental, and social challenges. High initial costs and limited financing structures remain significant financial barriers, while technical challenges such as inadequate maintenance infrastructure and a shortage of skilled personnel further deter adoption. Environmental factors, including Kuwait’s extreme climate conditions, underscore the need for advanced, resilient technologies and targeted public awareness campaigns. Social influences, including community acceptance and awareness levels, also play a critical role. The findings highlight the urgent need for robust government policies, including subsidies and financial incentives, to overcome these barriers. Collaboration among stakeholders, including policymakers, developers, and community leaders, is essential to foster an environment conducive

to renewable energy adoption. These efforts will not only enhance energy sustainability in Kuwait but also contribute to global climate change mitigation.

7. Limitations and future work

However, this study includes some limitations including the sample size where the study's sample may not fully represent the entire population of Kuwaiti homeowners and tenants where future studies should include a larger, more representative sample to enhance the generalizability of findings. Moreover, the reliance on self-reported survey responses may introduce biases, such as social desirability or inaccurate recall; therefore, conducting longitudinal research can provide insights into how barriers evolve over time with changes in technology, policies, and public awareness. The study is also limited to residential buildings and does not address barriers specific to commercial or industrial sectors and comparing barriers across residential, commercial, and industrial sectors could identify sector-specific challenges and opportunities.

8. Recommendations and Suggestions

This study recommends introducing government subsidies, tax credits, or low-interest loans to reduce the financial burden of adopting renewable energy systems. Moreover, conducting nationwide campaigns to educate citizens about the benefits and reliability of renewable energy, addressing misconceptions about its effectiveness in Kuwait’s climate. This study also recommends developing the skilled workforce by establishing training programs to build a skilled workforce for the installation and maintenance of renewable energy systems. Investing in and promote technologies designed to withstand Kuwait's harsh climatic conditions, such as high temperatures and dust storms can be useful also. On the policy support side, the authorities can develop robust policies that mandate renewable energy integration in new residential constructions and incentivize retrofitting existing buildings. Finally, it is useful to collaborate with neighboring Gulf Cooperation Council (GCC) countries to share best practices and technologies tailored for similar climatic and economic conditions.

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