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Factors Affecting the Adoption of Solar Energy Technology to Promote Sustainable Tourism: An Exploratory Study in the Makkah Region, Saudi Arabia

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ABSTRACT

Saudi Arabia has implemented substantial reforms to diversify its economy as part of its Vision 2030 strategic plan. Tourism is one of sectors the country seeks to promote. However, tourism relies significantly on fossil fuels for various applications, including cooling, lighting, and cleaning. The objective of this research is to analyze the factors influencing the adoption of solar energy technology within the tourism sector in the Makkah region of Saudi Arabia. This study provides the first empirical examination of barriers to solar energy technology adoption within the tourism sector in Saudi Arabia. Moreover, it considers a wide range of factors, including environmental concerns, awareness, cost, ease of use, government support, financial incentives, and the perceived image of solar energy utilization. The empirical analysis is based on primary data obtained from 332 owners/managers of hotels. The structural equation modelling was implemented to analyze the study hypotheses. The findings indicate that awareness, ease of use, government support, and financial incentives promote the adoption of solar energy. In contrast, the cost of solar energy has a negative impact. Finally, environmental concerns and the image of utilizing solar energy have no significant impacts on the willingness of hotel owners/managers to adopt solar energy technology.

1. INTRODUCTION

The consumption of fossil fuels, especially oil and natural gas, has increased in recent decades due to industrialization, economic growth and population. The rise in fossil fuel energy consumption has led to environmental degradation, which in turn has induced several health outcomes [1-3]. To reduce the detrimental ecological effects of fossil fuels and meet the increasing energy demand, many countries are shifting to renewable energy (RE) sources, including solar, wind, and hydropower [4, 5]. Driven by growing concerns about climate change and energy security, solar energy adoption has seen increased interest recently, with many countries demonstrating its benefits [6]. In addition to being an inexhaustible resource, solar energy has the advantages of being a clean energy source with no adverse environmental implications. Solar energy has many potential applications, including heating, water desalination, wastewater treatment, and electricity generation. Solar energy has emerged as a significant player in achieving Sustainable Development Goals, particularly SDG7, which refers to affordable and clean energy [7, 8]. Consequently, RE development, particularly the solar energy industry, has become a strategic priority in many developed and developing countries.

Given the importance of solar energy in fostering sustainable development, a growing body of literature has examined factors affecting household decisions to adopt it. Irfan et al. [9] revealed the importance of government financial support, awareness of global warming and climate change, and incentives for promoting solar energy adoption in China. In addition, Solangi et al. [10] concluded that the high cost of solar energy and the lack of knowledge about it represent the primary barriers hindering the adoption of solar energy in Malaysia. Patlitzianas and Flamos [11] revealed that the RE sector development in GCC countries is mainly linked to economic, technical, and many legal factors that regulate the RE industry. According to Alsabbagh [12], the high cost of capital and the lack of knowledge about the advantages of RE are the key causes inducing the shortage of solar energy adoption in Bahrain.

Earlier research on factors influencing RE adoption has mainly focused on the residential sector, as many countries have emphasized the use of such technology for power generating and water heating. Recent research has shifted to analyzing the drivers of solar energy adoption among firms across various sectors, including tourism. In this context, Mahachi et al. [13] examined factors influencing the adoption of RE in Botswana hotels. The authors showed that the availability of solar technology, political leadership, financial advantages, extensive environmental sustainability programs,

and environmental stewardship values are the main drivers of RE adoption. Additionally, Sardianou and Kostakis [14] identified barriers facing investments in RE by hotels in Crete, Greece. The findings show that the lack of financing, the risks associated with investing in new technologies, bureaucracy, and human resource barriers are the main barriers. For their part, Chan et al. [15] determined three types of barriers hindering the use of environmental technologies in hotels in Hong Kong, namely product-based barriers (lack of reliability, initial cost, technology maintenance), internal barriers (lack of initiative on behalf of owners, physical limitations of buildings and budget priorities) and external barriers (unpredictable weather conditions, negative effects of technologies on customer service). Chan et al. [16] corroborated these findings, concluding that the use of environmental technologies in Hong Kong's tourism sector is affected by the quality of after-sales service, human resources, customer experience, initial governmental support, financial performance, insufficient green knowledge, and environmental feasibility. Finally, Dhirasasna et al. [17] analyzed factors affecting the RE adoption in the hotel industry in Queensland, Australia and suggested the importance of incentive policies, perceptions of hotel owners/managers about RE, the behavior of tourists, technological progress, and electricity prices.

The existing literature suggests that the decision to adopt solar energy may be affected by many economic, financial, institutional, technological, and environmental factors. This research contributes to this body of knowledge by concentrating on a strategic sector in Saudi Arabia, i.e., tourism. The research particularly investigates how to promote sustainable tourism through solar energy adoption in the Makkah region. More specifically, this research seeks to identify the factors affecting the decisions to adopt solar energy systems in the tourism sector in the Makkah region. The present study employs Structural Equation Modeling (SEM) to determine the factors influencing the adoption of solar energy, utilizing a dataset derived from a survey of 332 hotels located within the Makkah region (Appendix Table A). Saudi Arabia, particularly the Makkah region, offers an interesting context for analyzing factors affecting the adoption of solar energy. First, Saudi Arabia is dedicated to achieving net zero emissions by 2060 under the Circular Carbon Economy framework. It is, therefore, of upmost importance to shift towards a green economy by advancing clean energy sources in the different economic sectors, including tourism. Second, the present research topic is consistent with the objectives of the Saudi Vision 2030 strategic plan. Indeed, Saudi Arabia has sought to develop non-oil sectors since the adoption of Vision 2030. Among the promising sectors that Saudi Arabia seeks to develop is the tourism sector. The present research undertakes an investigation into the potential of solar energy adoption within the hotel sector of the Makkah region, positing it as a strategic initiative for the advancement of sustainable tourism practices. This initiative is consistent with the strategic objectives of the Saudi Vision 2030, specifically those pertaining to tourism sector development and the increase of renewable energy sources in the energy mix. It is worth noting that Saudi Arabia is currently engaged in the development of NEOM, a smart urban center designed to operate exclusively on renewable energy sources, thereby fostering the advancement of green tourism. Therefore, the strategic development of green and sustainable tourism modalities within different regions, such as Makkah, warrants careful consideration, considering its significance within religious tourism. This study contributes to achieving such objectives by offering fresh policy recommendations for enhancing the competitiveness of the tourism sector via the implementation of solar energy. Third, solar energy is consistently available in Saudi Arabia, with extended periods of solar brightness occurring throughout the year. It is therefore crucial to benefit from this natural resource by implementing solar energy technology within the tourism sector in the Makkah region, commencing with an initial phase. Then, this technology can be extended to the tourism sector in other regions. Fourth, the development of the tourism sector leads to a rise in electricity consumption. It is therefore essential to promote alternative energy sources, such as solar energy, for electricity generation in the tourism sector. This requires an exploration of factors influencing the decisions to adopt solar energy. Finally, recent research indicate that ecologically sustainable locations are more attractive to tourists. Consequently, the utilization of solar energy in the tourism sector within the Makkah region can enhance tourist flows and serves as an important factor in the supply function of tourism services.

Compared to prior investigations into the determinants of solar energy adoption within diverse economic sectors, encompassing both household and business domains, the current study presents three significant contributions. First, scholarly research into solar energy adoption intentions within the Gulf region is notably scarce, with existing studies predominantly focusing on the household sector [18-20]. However, to the authors' knowledge, no prior research has investigated the factors influencing solar energy adoption within economic sectors critical to the future development of Gulf economies. The current study, representing a pioneering contribution to the literature, addresses a significant research gap concerning solar energy adoption within the tourism industry of the Gulf region. In light of the sector's pivotal role in regional strategic visions, a comprehensive evaluation of sustainability factors, notably the implementation of solar energy technologies as an alternative to fossil fuel-based energy, is imperative for policy formulation. Second, studies examining solar energy adoption in the tourism sector outside the Gulf region have largely concentrated on assessing the impact of a restricted number of factors, including perceived ease of use, initial cost, technology maintenance requirements, after-sales support, workforce availability, government support, financial outcomes, and environmental awareness [13, 15, 16]. Unlike prior research, this study offers a comprehensive assessment of a wide range of factors influencing solar energy adoption within the tourism sector. Specifically, the empirical investigation examines the role of seven dimensions: environmental concerns, awareness, cost, ease of use, government support, financial incentives, and the perceived image of solar energy use. As a result, this research provides a thorough analysis of the key factors driving solar energy adoption in the tourism industry. Third, while existing scholarly work on factors affecting solar energy adoption within the tourism sector has relied upon established econometric and statistical techniques, this research advances the body of knowledge through the application of Structural Equation Modeling. This methodology, demonstrating proven efficacy in the identification and classification of determinants of intention, as applied to solar energy adoption in our case, may offer a comprehensive analytical framework and provide more accurate policy implications.

The rest of the paper is structured as follows. In Section 2,

we review the existing literature on factors influencing the adoption of solar energy within the tourism sector and present the relevant hypotheses. Section 3 develops the conceptual model, while Section 4 is reserved for the empirical methodology, mainly the questionnaire and measurement scales. In Sections 5 and 6, we discuss the empirical findings, conclude the paper and provide policy recommendations.

2. LITERATURE REVIEW AND HYPOTHESES DEVELOPMENT

The tourism industry heavily depends on traditional fossil fuel energy for various operations, including cooling, lighting, heating swimming pools, cooking, and cleaning [17, 21]. These energy sources emit greenhouse gases (GHG) into the atmosphere, adversely impacting environmental quality [5, 22]. The use of fossil fuel energy also influences the competitiveness of the tourism sector. Regarding this issue, researchers noted that hotels that do not comply with environmental regulations could risk losing potential guests to environmentally conscious hotel [23, 24]. Furthermore, there has been a rise in the number of reservations made by environmentally conscious guests at green hotels and other ecologically friendly sites. The existing literature suggests that hotels can reduce their carbon emissions by switching to RE sources and decreasing their reliance on fossil fuels [22, 25]. The adoption of RE also contributes to the propagation of a positive brand image among customers, who are increasingly sensitive to green hotels and ecotourism [23]. Some authors have shown a keen interest in this subject by examining the determinants and challenges to the adoption of RE within the tourism sector [26-28]. Prior studies regarding the adoption of RE within the tourism sector have highlighted many potential factors that affect the decision to utilize solar energy. These encompass environmental concerns, costs, ease of use, governmental regulations, financial incentives, and public perceptions on RE use.

2.1 Environmental concerns

Fossil fuel energy sources provide detrimental environmental impacts, notably greenhouse gas emissions that exacerbate climate change. Conversely, RE is proposed as a sustainable alternative to fossil fuel sources that protect the environment. Irfan et al. [9] defined environmental concerns as the level to which individuals are concerned about resolving environmental issues. Environmental concerns have been identified as driving the shift toward RE sources. Empirical research indicate that environmental compassion and awareness increase the likelihood of individuals adopting and utilizing RE sources. Some works concluded in this context that environmental awareness affects the decision to adopt RE. For instance, Khalid et al. [29] revealed that environmental concerns significantly affect the adoption of RE in Poland. According to Abuzaid et al. [19], public opinion on RE is heavily influenced by environmental concerns in the United Arab Emirates. Using structural equation modelling, Lin and Syrgabayeva [30] identified the factors explaining the intention to use RE in Kazakhstan. Their findings indicate that individuals with deep concerns about environmental issues tend to maintain a positive attitude towards solar energy adoption. These outcomes have been confirmed by Irfan et al. [31], who suggested that environmental concerns influence the decision to invest in RE technology. Recently, Qamar et al. [32] revealed that SMEs with environmental concerns in Punjab, Pakistan, are more likely to invest in solar energy technologies. Given these findings, it is essential to take into account the environmental aspect while examining the drivers of solar energy adoption, which leads to the following hypothesis.

H1. *Environmental concerns significantly and positively affect the decision to adopt solar energy in the tourism sector.*

2.2 Awareness

Awareness and knowledge of RE are among the key factors affecting solar energy adoption. Alam et al. [33] characterized awareness as the degree to which users understand new technology, including its advantages and disadvantages, and their ability to remain informed about updates related to such technologies. In addition, Irfan et al. [31, 34] indicated that awareness encompasses many factors relevant to the knowledge of renewable energies that can influence costs and efficiency. Many studies have emphasized the importance of awareness in decision-making about using RE. For example, Alam et al. [33] employed a multiple regression analysis and concluded that awareness affects the intention to adopt RE in Malaysia, while Vand et al. [35] showed that awareness is related to consumer intention in China. Using structural equation modelling, Irfan et al. [31] showed that awareness has a positive impact on the intention to adopt RE in Pakistan. These conclusions were corroborated by Irfan et al. [9], indicating that the limited adoption of RE technology in China is primarily due to a lack of awareness regarding these energy sources. Furthermore, Adepoju and Akinwale [36] suggested that awareness and knowledge of RE are significant factors affecting the adoption of such energy sources by small and micro-enterprises in Lagos State. According to Wang et al. [37], a negative attitude toward environmental protection and energy conservation has a detrimental impact on the intention to adopt RE. The previous investigation confirms that a lack of knowledge about RE technology reduces awareness of its advantages. Therefore, enhancing the spread of knowledge about the advantages of RE may foster its acceptance. Based on these outcomes, one could design the following hypothesis:

H2. *The awareness of renewable energy significantly and positively affects the decision to adopt solar energy in the tourism sector.*

2.3 Cost

Solar energy adoption in the tourism industry is significantly influenced by the cost of solar energy. The cost includes the initial investment to implement the technology and the maintenance expenses [33]. Irfan et al. [38] indicated that RE projects entail significant costs because of their substantial capital requirements. Despite a substantial reduction in the cost of RE technology over the last decade, it remains more costly than fossil fuels. Moreover, the high cost of RE leads investors to adopt a wait-and-see behavior. Some empirical studies concluded that rising costs contribute to a decrease in the demand for RE technology. For instance, Luthra et al. [39] investigated factors impacting RE adoption in India and revealed a significant inverse association between investment cost and the demand for RE. This result has been further confirmed by Ghosh and Ghosh [40], who noticed that

the cost represents the main obstacle to adopting RE. Moreover, Alsabbagh [12] stated that the acquisition and installation costs represent a significant barrier to expanding solar energy in Bahrain. In addition, Sardianou and Kostakis [14] assessed obstacles to RE adoption in the Cretan hotel industry and suggested that high initial investment costs negatively affect the adoption of RE technology. Overall, empirical research looking at solar energy adoption concludes that there is a negative linkage between the cost of RE and the intention to utilize it, which leads to the formulation of the following hypothesis:

H3. *The cost of solar energy significantly and negatively affects the decision to adopt solar energy in the tourism sector.*

2.4 Ease of use

According to the Technology Acceptance Model (TAM) suggested by Davis [41], perceived ease of use is a key factor in adopting a new technology. Indeed, the perceived ease of use is defined as the degree to which a user believes that utilizing a particular technology will require no effort. According to Ajzen [42], ease of use means that users easily understand, operate, and maintain new technology. Adjakloe et al. [43] defined ease of use in renewable energy technology as the easy access to energy and its components, as well as the simplicity of installation and maintenance procedures. Empirical studies, including [44], indicated that the introduction of user-friendly RE technology enhances the intention to utilize it. Nevertheless, the implementation of solar energy presents some technological obstacles for new users and may necessitate particular expertise [45, 46]. Public acceptance of solar energy improves when the installation of solar energy systems is simple, and their usage and maintenance are easy to comprehend. Empirically, the ease of use of technology is considered a critical factor influencing the acceptance of solar energy. Overall, there is consensus in the literature on the importance of ease of use as a determinant of solar energy adoption. Based on the discussion above, one can develop the following hypothesis:

H4. *The ease of use of the technology significantly and positively affects the decision to adopt solar energy in the tourism sector.*

2.5 Government support

The role of government support in promoting RE across economic sectors has become the subject of increasing research. Policy design, energy information dissemination, subsidies, and financial support are all examples of government policies that Gillingham and Sweeney [47] believed may lead to adopting RE. The relationship between sustainable tourism regulations and RE in Peru was examined by Calderón-Vargas et al. [48]. The analysis revealed that most regulations promoting sustainable tourism do not directly support RE sources, including solar energy. Furthermore, the quantitative research showed that clear legislation, policies, and programs supporting RE use in the tourism sector are required. Moreover, Ntanos et al. [49] employed a logit model to conduct an empirical study on the public perception of adopting renewable energies in Greece. It has been proven that the role of governments in providing energy subsidies and disseminating information positively affects the adoption of RE. Focusing on the case of Jordan, Abu-Rumman et al. [50] stated that government incentives, regulatory support and tax exemptions for solar energy enhance the adoption of solar photovoltaic projects. Alnaser and Alnaser [51] emphasized the significance of new university programs and courses in solar and other renewable technologies, along with the establishment of a long-term partnership between universities in GCC countries and international institutions, as further governmental support for the development of RE. Finally, Shahzad et al. [52] highlighted that the legal and regulatory system is among the most significant drivers for developing renewable energies in Pakistan. From this discussion, we can formulate the hypothesis concerning the significance of government policies in solar energy adoption within the tourism sector as follows:

H5. *Government support significantly and positively affects the decision to adopt solar energy in the tourism sector.*

2.6 Financial incentives

The government may employ financial incentives as an effective financial tool to promote the utilization of RE. Fowler and Breen [53] defined financial incentives as any action to lessen the financial burden of acquiring or installing RE technology. Financial incentives can be broadly defined as all forms of affordable and effective financial access for financing RE installation projects. The government may provide financial incentives through subsidies, lending programs, and quota systems to RE users. The existing empirical literature suggests that financial incentives for adopting RE boost the demand for RE. The analysis conducted by Crago and Chernyakhovskiy [54] in the United States concluded that financial incentives that reduce the initial cost of adopting the technology allows increasing the demand for solar energy. Moreover, Khalid et al. [29] stated that financial incentives promote RE investments. It is worth noting that the high cost associated with procuring solar energy technologies may hinder its widespread implementation. Consequently, financial incentives from the government aimed at lowering the initial expenditure may promote the adoption of RE. Based on the discussion above, one can develop the following hypothesis:

H6. *Financial incentives significantly and positively affect the decision to adopt solar energy in the tourism sector.*

2.7 Image of utilizing solar energy

Some recent studies highlighted the role of green marketing in increasing the market share [32]. According to this viewpoint, promoting environmentally friendly products has the potential to attract new consumers and increase client loyalty. Indeed, firms that prioritize environmental sustainability improve their reputation among environmentally conscious consumers, thereby increasing their competitiveness and market share. In the same vein, Qamar et al. [32] concluded that the adoption of solar energy by Pakistani firms is influenced by green marketing and the pursuit of a RE image. In the tourism sector, Calderón-Vargas et al. [48] revealed that environmentally friendly regions are most attractive to tourists. Using solar energy in the tourism sector can increase the number of tourists. The authors indicated that solar energy adoption is becoming an important factor in the supply function of tourism products.

Consequently, implementing green marketing policies and constructing an eco-friendly firm image can be considered a stimulus factor for adopting solar energy in the tourism sector. Based on the previous discussion, the following hypothesis can be formulated:

H7. *The image of utilizing solar energy significantly and positively affects the decision to adopt solar energy in the tourism sector.*

3. CONCEPTUAL MODEL

Previous empirical research on factors affecting the acceptance of solar energy in the tourism sector suggests that many factors can impact the decision to adopt solar energy. Indeed, the solar energy adoption in the tourism sector is contingent upon a complex interplay of economic, technical, and environmental considerations and the influence of government support policies and incentives. In order to analyze the adoption of solar energy by tourism firms in Makkah region, a conceptual model that can effectively identify the different factors affecting decisions to invest in RE technology is developed. To examine how the dependent variable (solar energy adoption) reacts to the various potential factors affecting solar energy adoption in the tourism sector, we propose the conceptual model in Figure 1. As shown, the conceptual model suggests that the decision to adopt solar energy in the tourism sector of the Makkah region is influenced by seven factors: environmental concerns, awareness, cost, ease of use, financial incentives, government support, and image of utilizing solar energy.

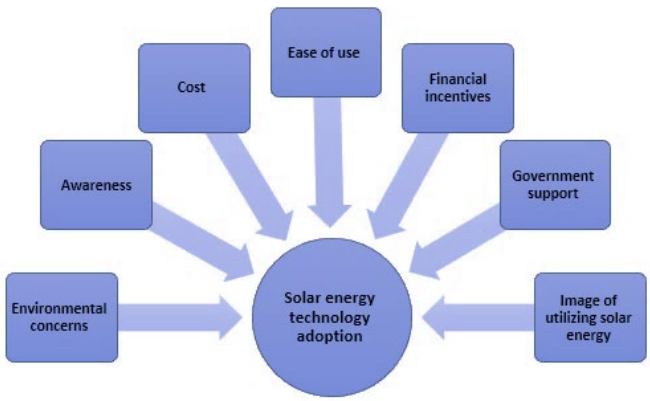

Figure 1. Conceptual framework

Drawing upon prior research and the study hypotheses, this conceptual framework summarizes the potential impacts of factors affecting the decision to use solar energy in the tourism sector within the Makkah region. Specifically, environmental concerns (ENV), awareness (AWR), ease of use (EAS), government support (GOV), financial incentives (FIN), and image of utilizing solar energy (IMG) are expected to positively influence solar energy adoption intentions, while cost (CST) is expected to have a negative impact.

4. DATA COLLECTION, SCALE ITEM MEASUREMENT, AND SAMPLE CHARACTERISTICS

The questionnaire carried out for this study consists of three sections. The first includes questions about the hotel and its manager, such as age, educational background, and the number of hotel rooms. The second section comprises questions associated with the dependent variable, which is the intention to adopt solar energy in the hotel (SEA). The third section contains seven axes representing the different dimensions influencing the decision to adopt solar energy in the tourism sector. These dimensions are as follows: ENV, AWR, CST, EAS, GOV, FIN, and IMG. The items related to independent and dependent variables are measured on a Likert scale ranging from 1 to 5, defined as follows: 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, and 5 = strongly agree. Different sources have been employed to select the measurement scales. The study of Qamar et al. [32] served as the basis for our measurement of the dependent variable (intention to adopt solar energy). Moreover, we used the different items from Irfan et al. [31] to measure the ENV, Alam et al. [33] to measure AWR, Jabeen et al. [55] to measure the cost, Ahmad et al. [56] to measure EAS of solar energy technology, Abuzaid et al. [19] to measure the GOV, Khalid et al. [29] to measure financial incentives and Qamar et al. [32] to measure the image of utilizing solar energy.

The questionnaire was conducted in the Makkah region of Saudi Arabia, specifically targeting hotel owners/managers. The purpose was to collect information about the intentions of owners/managers about the implementation of solar energy in their hotels. A preliminary check was conducted to enhance the clarity and comprehensibility of the questionnaire. At this stage, the questionnaire was disseminated to specialists in RE and statisticians to acquire their feedback.

Table 1. Sample characteristics

Demographic Features	Items	Frequency	Share (%)
Gender	Male	308	92.77
	Female	24	7.23
Age	< 30	179	53.92
	30-50	146	43.98
	> 50	7	2.1
Education level	Primary and intermediate education	11	3.32
	Secondary education	81	24.4
	Bachelor	171	51.5
	Master or higher	69	20.78
Number of rooms	< 50 rooms	106	31.93
	50-100 rooms	131	39.46
	> 100 rooms	95	28.61
Number of stars	1	98	29.52
	2	80	24.09
	3	124	37.35
	4	13	3.92
	5	17	5.12

Following the incorporation of minor changes suggested by participants in the pilot study, the final version of the questionnaire, reported in the Appendix, was distributed to a sample of hotels in the Makkah region. From a practical standpoint, the questionnaire was transformed into an electronic format and distributed by eight individuals experienced in data collection. The average duration for completing the questionnaire with the hotel manager/owners ranged from 15 to 25 minutes. The concept and content of the questionnaires were properly presented and explained to the

respondents to get the most reliable information. Once the questionnaire was distributed, we collected data from 332 responders. Table 1 presents information on the interviewed individuals and the characteristics of hotels included in the sample. The table shows that the male respondents account for 92.77%, whereas the female respondents represent only 7.23%. When considering age, the largest proportion of respondents fell into the age group under 30 years, specifically 53.92% of the surveyed population. This was followed by the age group spanning from 30 to 50 years, which accounted for 43.98%. Finally, individuals above 50 years represented only 2.1%. In terms of education, most of the interviewed population attained a university degree (Bachelor's, Master's, or higher), accounting for 72.28%. In comparison, those with a secondary educational level represented 24.4%, and finally, those with an intermediate or primary education represented only 3.32%. The analysis of hotel characteristics reveals that 31.93% of hotels have fewer than 50 rooms, whilst 39.46% have a room count ranging from 50 to 100. Finally, 28.61% of hotels have more than 100 rooms.

5. EMPIRICAL RESULTS

Data analysis is divided into three stages. The first stage is reserved for analyzing the different tests of the measurement model. The second stage is dedicated to estimating the structural model and testing the various hypotheses, while the third stage focuses on discussing the findings.

5.1 Testing the measurement model

The evaluation of the measurement model consists of verifying the internal reliability and the convergent and discriminant validity of the model. This study used Cronbach's alpha and composite reliability (CR) to examine the internal reliability. The Cronbach's alpha (a) and CR values must be greater than 0.70 to ensure satisfactory internal reliability. Furthermore, two indicators are employed to confirm convergent validity, namely loading values and the average variance extracted (AVE). Table 2 summarizes the outcomes of the different internal reliability and convergent validity indicators.

In order to assess convergent validity, we initially analyze the loading values of the various items and only retain those with values exceeding 0.5. Next, we check the AVE index, which should exceed 0.5. The results in Table 3 indicate that the loading values of the different items and the AVE index are greater than the recommended thresholds. Therefore, the constructs of our study model satisfy the requirement for convergent validity. Finally, the discriminant validity is assessed following the guidelines proposed by Fornell and Larcker [57]. In order to assess its validity, we compare the square root of AVE for each latent variable with the correlation between the factors in pairs. Discriminant validity is confirmed when the square root of the AVE exceeds the correlations between the factors. Table 3 presents the results relating to discriminant validity. It shows that the square roots of the AVE, presented in bold on the diagonal of Table 3, are higher than the other correlation coefficients.

Table 2. Results of the measurement model

Constructs	Items	Loadings	Cronbach's α	CR	AVE
	ENV				
ENVI	I am anxious about pollution	0.959	0.924	0.929	0.770
ENV2	I am anxious about climate change	0.963			
ENV3	I am anxious about environmental problems	0.853			
ENV4	Utilization of solar energy can improve the environment	0.709			
	AWR				
AWR1	I can recall what types of energy are renewable	0.815	0.870	0.912	0.723
AWR2	I am aware of solar energy	0.865			
AWR3	I can easily recognize solar energy	0.861			
AWR4	I do not have any difficulties in imagining solar energy	0.859			
	CST				
CST1	Buying solar energy incurs high implementation costs	0.893	0.778	0.874	0.702
CST2	Using solar energy incurs high costs in terms of maintenance and repair	0.910			
CST3	Switching to solar energy is not a cost-effective option	0.693			
	EAS				
EAS1	Easy to install solar energy materials	0.797	0.867	0.913	0.724
EAS1	Easily understandable manuals	0.844			
EAS1	Easy to operate	0.870			
EAS4	Easy to master on operating the machine	0.890			
	FIN				
FIN1	Loans are available to require solar energy	0.942	0.877	0.964	0.898
FIN2	Grants are available to acquire solar energy technology	0.963			
FIN3	Government subsidies renewable solar energy	0.938			
	GS				
GOV1	There are regulations and laws motivating the use of solar energy	0.868	0.893	0.927	0.759
GOV2	There are incentive tax exemptions for the use of solar energy	0.885			
GOV3	There are academic programs that provide specialized competencies in the use of solar energy	0.886			
GOV4	There is support and encouragement from the state for the solar energy sector	0.846			
	IMG				
IMG1	solar energy is good for the image of the business	0.924	0.925	0.953	0.872
IMG2	The use of solar energy attracts customers because of loyalty to the environment.	0.947			
IMG3	Image of utilizing solar energy promotes the business revenues	0.930			
	SEA				

SEA1	I wish to utilize solar energy	0.814			
SEA2	I am ready to utilize solar energy	0.904			
SEA3	I have the ability to utilize solar energy	0.882	0.908	0.931	0.731
SEA4	I have the ability to make decisions on whether to utilize solar energy	0.868			
SEA5	I will keep on using solar energy in the long-term future	0.803			

Table 3. Discriminant validity

	REA	ENV	AWR	CST	EAS	FIN	GOV	IMG
REA	**0.855**							
ENV	0.156	**0.877**						
AWR	0.390	0.142	**0.850**					
CST	0.223	0.094	0.066	**0.838**				
EAS	0.471	0.125	0.393	0.063	**0.851**			
FIN	0.427	0.357	0.290	0.239	0.504	**0.984**		
GOV	0.334	0.327	0.134	0.264	0.394	0.736	**0.871**	
IMG	0.567	0.276	0.217	0.330	0.329	0.416	0.406	**0.934**

The bold values represent the square root of AVE

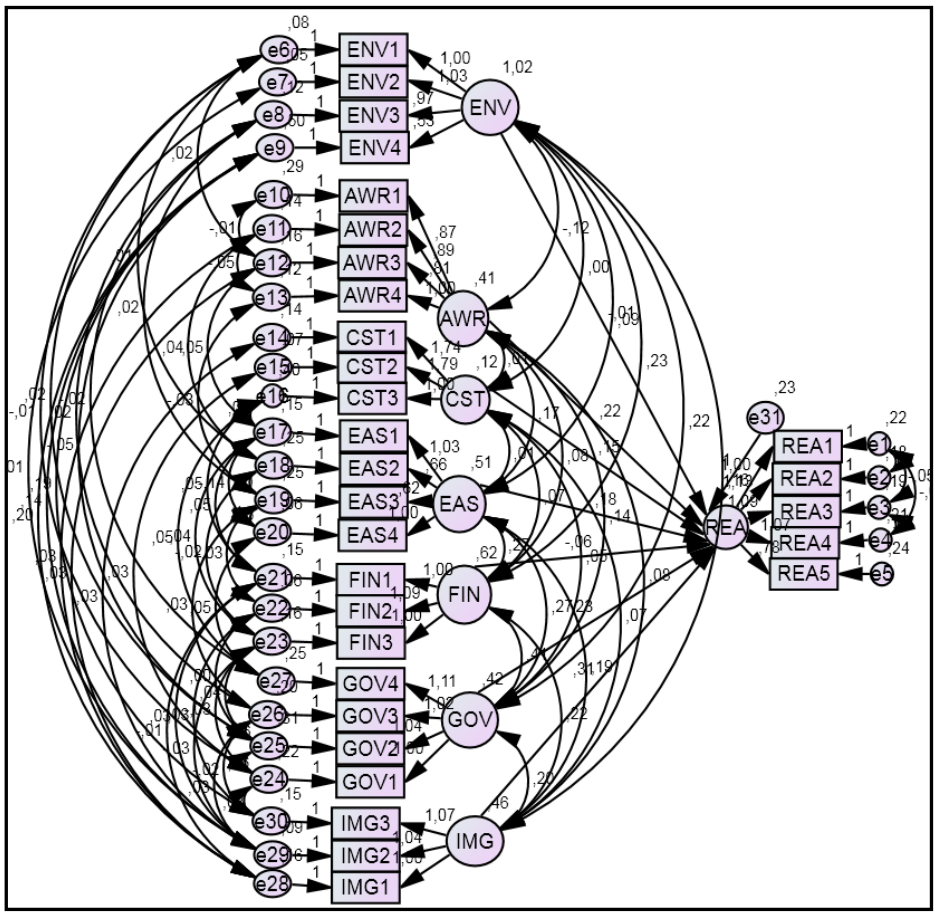

Figure 2. Measurement model

Overall, the various tests used to evaluate the measurement model, such as internal reliability, convergent validity, and discriminant validity, demonstrate the model's relevance. Based on these findings, we conclude that all variables are sufficiently robust to conduct the empirical analysis, which involves identifying the factors explaining the intention to adopt solar energy technology in the tourism sector. These outcomes validate the significance of the factors selected based on the literature review.

5.2 Estimation of the structural equation model

In order to examine the influence of the different factors, including ENV, AWR, cost, EAS, GOV, financial incentives and image of utilizing solar energy, on the intention to adopt solar energy in the tourism sector in Makkah region, we built the following initial structural model in Figure 2.

The structural model is estimated using the AMOS 28 software. As required in structural modelling and to ensure the quality of the adjustment of the structural model, we provide in Table 4 the different indices measuring the goodness-of-fit of the structural model. As shown, the values of all goodness-of-fit indices (CFI, IFI, GFI, NFI, and TLI) reported in Table 4 exceed the suggested values, while the RMSEA, SRMR and X2/DF are below the suggested value. In summary, the results demonstrate that all model fit indices meet acceptable thresholds, consistent with prior studies using the SEM framework [9, 58].

These findings confirm the significance of the model in examining the connection between the adoption of solar energy and the factors influencing the decision to utilize solar energy in the tourism industry (ENV, AWR, cost, EAS, GOV, financial incentives and image of utilizing solar energy). The structural equation model estimation and subsequent determination of the path coefficient values and their significance are displayed in Figure 3 and Table 5.

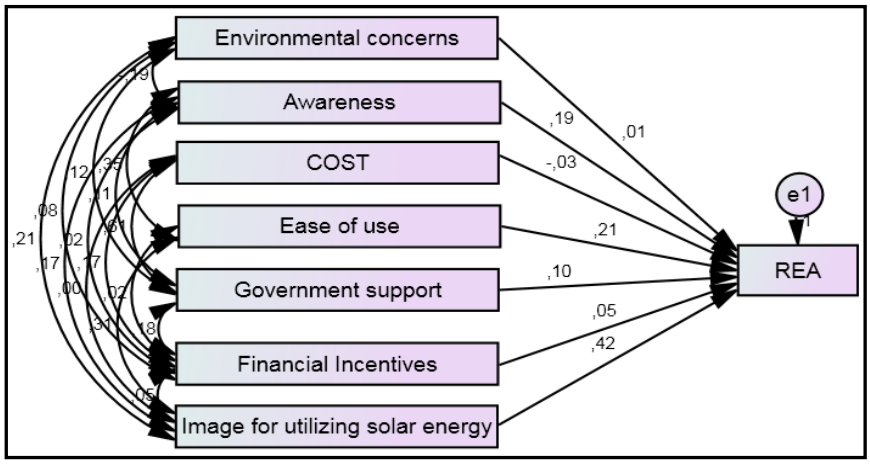

Figure 3. Structural equation modeling

Table 4. SEM goodness of fit criteria

Indices	Abbreviations	Value	Decision
Comparative fit index	CFI	0.988	>0.9 good fit
Incremental fit index	IFI	0.969	>0.9 good fit
Goodness of fit	GFI	0.988	>0.9 good fit
Normed fit index	NFI	0.982	>0.9 good fit
Tucker-Lewis index	TLI	0.930	>0.9 good fit
Root mean squared error of approximation	RMSEA	0.078	<0.08 good fit
Standardized root mean squared residual	SRMR	0.055	<0.09 good fit
Chi-square	X^2/DF	2.016	<0.3 good fit

The results reported in Table 5 show that the variables related to AWR, CST, EAS, GOV, and FIN exert a statistically significant impact on the intention to adopt solar energy technology. At the same time, ENV and the image of utilizing solar energy do not significantly impact the intention to adopt solar energy. More specifically, the variables of AWR, EAS, GOV, and FIN have a positive and significant impact on the decision to adopt solar energy in the tourism sector. The associated performance criteria (PCs) for these variables are positive, and their probability values are below the considered thresholds. Moreover, the variable representing the CST has a negative impact on the adoption of solar energy. However, the adoption of solar energy is not influenced by other variables, i.e., ENV and IMG. This is because their corresponding p-values are significantly higher than the considered threshold. Therefore, the hypotheses, H2, H3, H4, H5, and H6, are deemed valid, while hypotheses H1 and H7 are rejected.

As shown in Figure 3 and Table 5, the is a significant difference in the magnitude of the impact of the five significant factors on the decision to adopt solar energy within the tourism sector. According to the path coefficient, the factors, ranked in descending order of influence, are: ease of use (EAS, 0.214), environmental awareness (AWR, 0.190), government support (GOV, 0.100), financial incentives (FIN, 0.052), and cost (CST, -0.030). This classification is of paramount importance for the strategic formulation of policies designed to promote solar energy adoption within the tourism industry in Makkah region.

Table 5. Results of the hypotheses

Hyp.	Path Relationship	Path Coefficient	*p*-value	Hypothesis Status
H1	**ENV→ REA**	0.010	0.854	Rejected
H2	**AWR→ REA**	0.190 ***	0.000	Accepted
H3	**CST→ REA**	-0.030***	0.000	Accepted
H4	**EAS→ REA**	0.214***	0.000	Accepted
H5	**GOV→ REA**	0.100***	0.000	Accepted
H6	**FIN→ REA**	0.052 ***	0.000	Accepted
H7	**IMG→ REA**	0.420	0.874	Rejected

5.3 Hypothesis testing and discussion

The findings of the structural equation modelling analysis and hypothesis testing displayed in Table 5 indicate that five of the seven hypotheses (H2, H3, H4, H5, and H6) considered in the study are confirmed. The first hypothesis accepted is H2, which is associated with the correlation between awareness of solar energy and the adoption of RE in the tourism sector (AWR → REA). The path coefficient (PC) for this relationship is b = 0.190, which is statistically significant at 1%. These findings suggest that having knowledge and expertise in RE has a significant and favorable impact on the adoption of solar energy within the tourism industry in the Makkah region of Saudi Arabia. These outcomes are in line with those of Irfan et al. [9], who concluded that individuals with solid knowledge of solar energy technology are more inclined to have a positive attitude towards it. Consequently, there is a positive attitude towards the adoption of solar energy. Additional studies have also confirmed the presence of a positive association between awareness and the adoption of RE [31, 33, 36]. The empirical results also confirm the acceptance of hypothesis H3 (CST → REA), indicating that the high costs associated with solar energy technology represent a substantial obstacle to its implementation in the tourism sector. This finding aligns with

numerous previous studies demonstrating that cost is a primary barrier to solar energy technology adoption. For instance, Halim and Wahyuni [59] found that the imported components, installation, and maintenance costs associated with solar photovoltaic technology significantly increase the overall cost, thereby hindering its adoption in Indonesian tourist villages. Similarly, hypothesis H4, which examines the relationship between the EAS of RE and the adoption of solar energy in the tourism sector (EASE → REA), is supported by the findings in Table 5. The path coefficients and p-value are, respectively, (b = 0.214) and (p < 1%). This result confirms that the decision to adopt solar energy in hotels in the Makkah region of Saudi Arabia is significantly influenced by the degree of EAS of this technology. Therefore, there is a positive attitude to adopting solar energy technologies for firms operating in the tourism sector as the perceived EAS increases. This conclusion is consistent with previous research that emphasized the importance of EAS as a determinant of the acceptance and implementation of RE technology across various economic sectors [29, 32]. The empirical results obtained from our model also confirm hypotheses H5 and H6, which specifically address the influence of solar energy on adoption. Specifically, the results indicate that the coefficient (b) for H5 is 0.100 with a significance level of less than 0.01, and the coefficient for H6 is also 0.052 with a significance level of less than 0.01. This indicates that GOV and financial incentives significantly influence the decision to adopt solar energy in the Saudi tourism sector. Previous studies have already demonstrated the presence of a positive correlation between GOV and the adoption of solar energy in the residential sector in the United Arab Emirates [19]. Furthermore, Karagiorgas et al. [21] concluded that government incentives significantly stimulate solar energy adoption in Queensland's tourism sector. Similarly, Li and Cao [60] indicated that supportive policies, particularly increased funding, can substantially enhance RE projects in tourism. Finally, hypotheses H1 and H7 are rejected because their p-values are greater than 10%. Therefore, there is no evidence supporting the importance of ENV and the image associated with the utilization of solar energy in the adoption of solar energy within the tourism sector of the Makkah region in Saudi Arabia. This result suggests that ENV and the image associated with the utilization of solar energy are secondary factors in solar energy investment decisions. Unlike other factors such as cost, EAS, and government incentives, which directly impact profitability, ENV and the image are less influential. Consequently, their effects are less pronounced compared to primary drivers of solar energy adoption. Furthermore, the unique character of tourism in the Makkah region, primarily focused on religious pilgrimage, results in Umrah and Hajj participants placing less emphasis on environmental sustainability and hotel eco-image. Consequently, ENV and hotel eco-image exhibit a weak influence on accommodation selection. Instead, proximity to religious sites, cost, and food availability are prioritized. This largely diverges from leisure tourism, where hoteliers leverage sustainability practices, including environmental compliance and eco-image, as key competitive advantages to enhance visitor experience.

6. CONCLUSIONS AND POLICY RECOMMENDATIONS

This study aimed to identify the factors influencing the adoption of photovoltaic solar panels within the tourism sector in the Makkah region of Saudi Arabia. This was achieved by analyzing data collected from a survey conducted among 332 hotels in the Makkah region. The study investigated the influence of seven factors on the decision to adopt solar energy in the tourism sector: ENV, AWR, cost, EAS, GOV, financial incentives and image of utilizing solar energy. The model was empirically tested using the PLS-SEM approach. The empirical analysis conducted using the PLS-SEM approach indicates that AWR, EAS, GOV, and financial incentives have a positive impact on the adoption of solar energy in hotels within the Makkah region. In contrast, the cost of solar energy technology turns out to have a negative impact. Finally, ENV and image of utilizing solar energy do not significantly impact the willingness of hotel owners/managers to adopt solar energy technology.

In light of these findings and given the importance of incorporating RE into the tourism sector, it is imperative to design and implement certain measures. First, the authorities should develop a communication and dissemination strategy to raise AWR among hotel owners/managers about the positive impact of investing in solar energy projects on environmental quality and the long-term viability of the industry. This strategy should also highlight the other advantages of adopting solar energy technology in tourism. Second, the authorities, particularly the Ministry of Tourism and Ministry of Industry and Mineral Resources, should create training programs focused on the utilization of solar energy technology. Technical concerns regarding the feasibility of solar energy installation in hotels require careful consideration, as hoteliers must perceive solar photovoltaics as more practicable and ensure that their installation and operation proceed without incident. In addition, the influential impact of government policies is important in enhancing the adoption of solar energy technology. Indeed, tax subsidies, such as reducing the VAT rate on solar energy products and providing financial incentives, may play a crucial role in encouraging firms to adopt RE technology. Furthermore, the government may implement green financing mechanisms, which could serve as an additional incentive for hotel owners/managers to adopt RE technology. It is important to note in this context that the effective promotion of solar energy adoption within the tourism sector requires the comprehensive reduction of multifaceted challenges, including financial, technical, human, and bureaucratic obstacles to the use of solar energy. The high initial cost required for solar energy investments presents a major financial obstacle. Considering the economic significance of the tourism sector in Makkah region, it is essential for the government and financial institutions to provide incentives that promote green projects, such as the use of solar energy technologies in the tourism sector with Makkah region. Technical obstacles primarily involve ensuring solar panel compatibility with the unique climatic conditions of the Makkah region, where recurrent torrential rainfall and sandstorms can substantially reduce panel performance. Therefore, it is crucial to advance research aimed at developing adaptive solar panel technologies for the specific climatic conditions of the region. Human capital obstacles in renewable energy project implementation stem from a scarcity of qualified managers and technicians in solar panel production and maintenance. To mitigate this, academic institutions may introduce specialized solar energy curricula, and technicians can pursue professional certifications in renewable energy technologies. Finally, the implementation of

simplified licensing procedures, effective incentive schemes, and transparent regulatory requirements are paramount for the implementation of solar energy within the tourism industry.

This study aimed to identify the factors affecting the decision to implement solar energy technology in a particular area of Saudi Arabia, specifically the Makkah region, which is known for its high concentration of hotels due to its role as the hub for Hajj and Umrah activities. However, the tourism sector in Saudi Arabia holds significant importance as a strategic sector of the country's economic diversification strategy, aligning with its 2030 vision. Therefore, it would be intriguing for future research to collect data on other regions of Saudi Arabia and examine the factors influencing the adoption of solar energy in all these regions.

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APPENDIX

Appendix Table A: Survey

Constructs	Items	Sources
	ENV	
ENVI	I am anxious about pollution	[31]
ENV2	I am anxious about climate change	
ENV3	I am anxious about environmental problems	
ENV4	Utilization of solar energy can improve the environment	
	AWR	
AWR1	I can recall what types of energy are renewable	[33]
AWR2	I am aware of solar energy	
AWR3	I can easily recognize solar energy	
AWR4	I do not have any difficulties in imagining solar energy	
	CST	
CST1	Buying solar energy incurs high implementation costs	[55]
CST2	Using solar energy incurs high costs in terms of maintenance and repair	
CST3	Switching to solar energy is not a cost-effective option	
	EAS	
EAS1	Easy to install solar energy materials	[56]
EAS1	Easily understandable manuals	
EAS1	Easy to operate	
EAS4	Easy to master on operating the machine	
	FIN	
FIN1	Loans are available to require solar energy	[29]
FIN2	Grants are available to acquire solar energy technology	
FIN3	Government subsidies renewable solar energy	
	GOV	
GOV1	There are regulations and laws motivating the use of solar energy	[19]
GOV2	There are incentive tax exemptions for the use of solar energy	
GOV3	There are academic programs that provide specialized competencies in the use of solar energy	

GOV4	There is support and encouragement from the state for the solar energy sector	
	IMG	
IMG1	Solar energy is good for the image of the business	
IMG2	The use of solar energy attracts customers because of loyalty to the environment	[32]
IMG3	Image of utilizing solar energy promotes the business revenues	
	SEA	
SEA1	I wish to utilize solar energy	
SEA2	I am ready to utilize solar energy	
SEA3	I have the ability to utilize solar energy	[32]
SEA4	I have the ability to make decisions on whether to utilize solar energy	
SEA5	I will keep on using solar energy in the long-term future	