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# Exploring the nexus of green energy entrepreneurship performance for sustainable development in emerging economies to decentralize renewable power

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# Abstract

The impact of solar household systems on entrepreneurship in China's off-grid regions is a notable absence of research, even though China has effectively utilized solar apparatus to alleviate these concerns. The objective of this investigation is to address this knowledge deficit by investigating the efficacy of green entrepreneurship in the context of solar home systems. A comprehensive survey was implemented to gather primary data from 653 respondents in Gansu Province. The model was validated, and the data was analyzed using partial least squares structural equation modeling. The empirical results revealed that the economic feasibility of family entrepreneurial culture with solar home systems, the sustainable development of entrepreneurship via solar home systems, and enhanced living standards through the incorporation of solar home systems into entrepreneurship are substantially linked to the entrepreneurial performance of solar home systems. Nevertheless, the performance of these entrepreneurial endeavors is not substantially impacted by energy expenditure savings. Furthermore, all variables were observed to be moderated by social media. This study emphasizes the urgent need to revise societal norms regarding entrepreneurship, raise awareness among entrepreneurs, reform regulatory frameworks, and highlight the advantages of solar home systems for entrepreneurial endeavors.


# 1. Introduction

Energy contributions are essential for sustainable economic growth and communal prosperity by alleviating poverty. The literature has emphasized the importance of electricity access in reducing poverty and improving quality of life. [1]. Immense dependence on updraft energy resources is straining the national budget. It leads to conservation challenges, for instance, environmental variation, greenhouse gas emissions, and erratic climate patterns [2]. Overutilizing conventional fuels depletes natural resources [3]. Increased carbon emissions from the combustion of fossil fuels are detrimental to the environment [4]. As a developing nation, China's primary source of energy generation is fossil fuels [5]. Consequently, it is vital to build a modern energy system [6]. Renewables will be incorporated into the current energy structure, which may reduce the value of imported lubricants and mitigate climate challenges [7]. The Chinese government has proposed several schemes to increase the share of alternative energy sources in China's inclusive energy mix. Solar energy may accelerate innovation in family affairs, provide reasonable vigor, promote sustainable development, and improve the nation's energy infrastructure [8]. Similar outcomes were observed in analyzing the use of solar home systems (SHS) in off-grid regions [10]. Electricity availability enables the creation of new firms and increases working hours, improving revenue prospects [11]. Electricity for entrepreneurship can facilitate the transition from agricultural to non-agricultural activity, particularly in rural regions [12]. Solar energy is a promising strategy for combating entrepreneurial change and addressing environmental issues [13]. As a result of government efforts, entrepreneurs and investors have shown a great deal of interest in solar energy development projects and have started adopting SHS in entrepreneurial activities in numerous locations across the nation; in addition, agricultural and leasing companies will enjoy economic paybacks of aquaculture, and the diversification of income sources [14].

Though green entrepreneurship is a one-way path to the energy that influences well-being, the relationship between energy and private enterprise has not been thoroughly examined in the academic literature [15]. The study [16] has defined entrepreneurship and its philosophy as “Individuals' ability and willingness to perceive and create new economic opportunities (new products, new production methods, new organizational schemes, and new product-market combinations) and to introduce their ideas to the market in the face of uncertainty and other obstacles by making location, form, and resource allocation decisions.” According to this definition, there are two kinds of entrepreneurs: (i) the innovative entrepreneur and (ii) the replicative entrepreneur. Thus, innovative entrepreneurs are creative individuals who identify profit opportunities and accept the related risks. Replicative entrepreneurs organize new businesses without offering a novel product, process, or organizational structure; this distinguishes them from inventive entrepreneurs. There are five types of entrepreneurship (social entrepreneurship, scalable startup entrepreneurship, small business entrepreneurship, large company entrepreneurship, and innovation entrepreneurship). One aligns with business aspirations and focuses on innovation or societal change, while others strive for rapid expansion or growth from an existing business model. Still, others generate profits to support the entrepreneur's lifestyle without expansion plans [17]. Social entrepreneurs seek solutions to significant social issues, such as tackling social injustice, addressing environmental concerns, and promoting more equitable economic development. Scalable startup entrepreneurs are ambitious, focusing on breakthrough ideas that can expand their businesses and generate as much profit as possible as quickly as possible [18]. Entrepreneurs of small businesses are focused on building and operating their businesses, either independently or with family members' assistance [19]. This category of entrepreneurs comprises numerous proprietors of mom-and-pop businesses and boutiques, as well as tradespeople and consultants. Some firms expand naturally over time, while large-company entrepreneurship seeks to develop an established business model into a large company. This sort of entrepreneur focuses on making profits, which allows the business owner to maintain their lifestyle and support the business's continuous growth [20]. Innovative entrepreneurs establish firms to introduce novel goods or concepts to the market. They have a goal or vision for the world and concentrate on how their idea or product can transform society. All types of entrepreneurship need inexpensive, affordable, and accessible energy to perform their entrepreneurial activities [21].

Numerous economies have followed in their footsteps, adopting the proportionality of SHS in their entrepreneurial selections. SHS efforts may enhance entrepreneurs' quality of life in several ways. For example, solar power can reduce production costs, generate new employment and entrepreneurial opportunities that support efficient expansion, provide inexpensive energy, and alleviate future energy costs [1]. SHS power has been proven cost-effective and can improve the country's economic standing through entrepreneurial activities and economic sustainability. The SHS is required globally to increase affluence and transform the financial condition of rural populations through entrepreneurial endeavors. When solar panels are connected to meet the energy needs of a family business, energy can be generated for free, making SHS-generated power a cost-effective option. The independent rooftop SHS can reduce energy expenditures for local companies [22]. The entrepreneurial performance of solar home systems in a sustainable emerging economy to promote the green revolution is an outstanding

contribution to the body of knowledge. This study examines family entrepreneurial activity through the SHS and the significant product development in entrepreneurial businesses. The low cost of SHS investment can entice entrepreneurs and investors and outperform economic benchmarks [23]. We measure the impact of SHS on family-owned businesses' income, actions, and price-related gratification. The study investigated whether SHS has a significant and positive effect on entrepreneurial activities in China, thereby increasing their profitability and performance. According to the literature, using social media in SHS operations is crucial for improving the profitability of entrepreneurial activities.

SHS is an independent photovoltaic power system that provides a cost-effective means of delivering a tremendous volume of energy for various uses, such as lighting, to off-grid family businesses in remote areas. In remote areas where the grid is still unable to reach, SHS can help alleviate entrepreneurs' energy stress and meet their fundamental production requirements. Globally, SHS is a foundation of energy for family enterprises in distant areas where grid-based electricity is not feasible or is limited [24]. Subsequently, the higher energy source provided by SHS empowers family-owned businesses to demonstrate improved functioning and economic activity [22]. In this illustration, SHS's superiority enhances the efficacy of entrepreneurial activity. The low-cost and transparent approach inspires entrepreneurs to embrace SHS constructively [1]. The superior quality of SHSs enables them to meet energy requirements, save entrepreneurs money, reduce maintenance costs, and protect the health of entrepreneurial families [26].

As the preceding findings demonstrate, solar power employment in China is critical for three main reasons. Firstly, China has been identified as low-cost in environmental protection disputes. However, depending on conventional thermal energy, the nation may find itself in an unfavorable situation due to weather variability [27]. Secondly, the usual reliance on fossil fuels for power generation is disastrous for achieving the intended outcomes of resolving challenges posed by weather variation across the nation. This has been disastrous [28]. Finally, if appropriately utilized, China has vast solar power resources that may help address current energy and climate issues [29]. Prior studies were primarily conducted in nations to reduce carbon emissions and increase green entrepreneurship. In Europe, researchers [30] found that age, education, and income significantly affected the likelihood that families would adopt renewable energy in entrepreneurial activities. Poier (2021) evaluated the transition to substitute energy resources in Germany. Based on the results, the country is aggressively implementing alternatives in entrepreneurial endeavors and positively influencing the environment. Similarly, the study [31] investigated alternative energy deployment in the United Arab Emirates. The investigation found that energy intensity and renewable energy negatively and significantly impact the ecological footprint but may enhance entrepreneurial activity and economic growth. Few scholars have explored SHS's societal acceptability and adoption in the context of entrepreneurial activities in developing nations. In this regard, [24] surveyed entrepreneurs' adoption of solar energy in the context of energy challenges. According to the survey results, entrepreneurship has a positive and substantial effect on the likelihood of adopting solar photovoltaic technology; furthermore, the probability increases with family size, rural residence, and participation in the informal labor force.

The study [32] examined the likelihood that society would accept renewable energy sources in entrepreneurial activities. Researchers determined that as informative achievement increases, so does understanding of alternative energy, as evidenced by the growth in the number of solar energy projects approved or pending approval, as well as the number of enterprises active in green hydrogen. Similarly, age and economic conditions are essential factors in the acceptability of renewables. This research [33] investigated the societal acceptance of SHS in entrepreneurship in the Chinese province of Hubei. According to the poll results, entrepreneurs have an encouraging outlook for solar energy. Despite this, their openness to measures such as installing SHS in their family companies or tolerating higher utility rates decreases. Low entrepreneur attentiveness impedes solar energy penetration and frustrates national objectives, showing that entrepreneurs' adoption of SHS in their family businesses plays a vital role in the deployment of entrepreneurship [34]. This study [35] and others have evaluated the impact of SHS on the operational and financial aspects of entrepreneurial activities that require fewer investments in entrepreneurship business services. Adopting SHS, owing to its cost-effectiveness and low initial investment, while connecting to a solar project, might stimulate entrepreneurship. The government must revise its renewable energy strategy to promote entrepreneurship by leveraging SHS's low-cost energy source. Adopting an SHS has advantages for entrepreneurial operations, including reduced traditional power use in family businesses and health and financial advantages for businesses [36]. Until now, most investigations have explored these interactions within the following dimensions: multiple power sources, renewable energy's economic development, and power generation potential [39]. The impact of SHS adoption can benefit monetary growth, decrease ecological contamination, and (iii) entrepreneurship. Some academics have seen the influence of intention factors, including business activities with SHS, solar energy perspective, and expenses [41].

However, the new influences (planned for current research) include the economic viability of family entrepreneurial culture through solar home systems, energy-expense savings in entrepreneurial production through solar home systems, sustainable development of entrepreneurship through solar home systems, and improved standard of living by adopting solar home systems in entrepreneurship. What could influence entrepreneurs' adoption of SHS for solar energy has been discussed in prior literature; however, these factors have not been examined at different times and in different regions. Moreover, in the case of China, these innovative aspects have never been considered in any other context, necessitating a full investigation. This knowledge gap inspired us to address the existing knowledge gap by considering the adoption of SHS by Chinese entrepreneurs in their family businesses or entrepreneurial endeavours. This effort builds on three substantial assists in this area. In contrast to the preceding investigation, the current research fills a gap in the literature by analyzing all factors that may affect innovative action through SHS adoption. According to the sources, this is the original analysis evaluating business performance via SHS in China's Gansu Province. Due to current economic growth and significant population growth, individuals face severe energy-related challenges in their entrepreneurial endeavors, prompting critical research to assess the societal suitability of SHS. The study's second objective is to persuade entrepreneurs to adopt solar home systems for their family businesses by incorporating three dimensions that may influence their energy intentions. Combining

these factors with the Chinese context for the first time is a unique contribution of this document that other scholars have not assembled.

In conclusion, the present investigation encompasses the outcomes in a style dissimilar to previous investigations [41]. For instance, business action and ecological awareness proved crucial to SHS acceptance. Similarly, attitudes regarding the advantages of entrepreneurship through SHS. In contrast, ecological considerations have a negligible effect on SHS acceptance in a family-owned business. This analysis thoroughly explores the probability of Chinese enterprises adopting SHS by integrating established and proposed innovative elements. In terms of the study's significance, although the research was conducted in a specific region (China), the findings reveal the characteristics of entrepreneurs' intentions to use SHS. China can meet its current and future energy needs if its abundant renewable energy potential is utilized efficiently [42]. Nevertheless, China is a rising economy that faces various obstacles to the adoption of solar power, including technological constraints and the unwillingness of businesspersons and designers to serve as drivers of SHS implementation [43]. In addition to being widespread in other emerging economies, the characteristics described in this study and the ongoing energy concerns are prominent in other developing economies. Consequently, the findings of the present research are not area-specific. Still, they are more likely to adopt additional prudence and describe the influence of intention on adopting SHS. To illustrate this, the case of China provides an accepted example. As a result, the understanding gained from this exploration of entrepreneurship will provide crucial guidance for developing SHS-related approaches in other nations.

The research has been split into several sections; the section that follows prepares "Formulation of hypotheses." 3rd section develops on "Research methodology." The 4th section provides " 4. Statistical Analysis and Empirical Results.” The 5th section explains the "Discussion and implications." Lastly, the "Conclusions and Recommendations" section.

## 2. Formulation of hypotheses

Entrepreneurs’ decision to adopt SHS in a entrepreneurship business is complex; several factors influence the adoption of solar energy in entrepreneurship, including societal, emotional, and monetary factors [44]. Several investigators with diverse backgrounds planned studies to identify entrepreneurs with an intention to adopt SHS in their entrepreneurial activities [25]; for instance, studies evaluated entrepreneurship and solar home systems [55]. However, SHS was implemented and repeatedly remained prominent in all research backgrounds [47]. This study predicts entrepreneurs’ intention to adopt SHS in their entrepreneurial activities. Using prior literature, we can identify and forecast entrepreneurs’ intention to adopt SHS in their entrepreneurial activities. Many scholars have expanded the literature on SHS in entrepreneurship to better understand why individuals cannot sustain good intentions [51]. In addition to the fundamental reasons identified in previous studies, literature can further expand on other essential factors influencing entrepreneurs’ intention to adopt SHS in their entrepreneurial activities. We systematically reviewed the literature and combined variables not previously discussed, including the intention to entice entrepreneurs to adopt solar home systems in the

family business, social media as a moderator, and entrepreneurial performance of solar home systems as the dependent variable. The study investigates entrepreneurs' intention to adopt SHS in their entrepreneurial activities. The economic viability of entrepreneurial culture through solar home systems had a less significant effect on entrepreneurs' intention to adopt SHS in their entrepreneurial activities. While the other factors, i.e., energy-expense savings in entrepreneurial production through solar home systems, sustainable development of entrepreneurship through solar home systems, and improved standard of living by adopting solar home systems in entrepreneurship, significantly affected entrepreneurs' intention to adopt SHS in their family business.

## 2.1. Economic sustainability of entrepreneurship using solar energy (ESE)

Entrepreneurship is a crucial indicator of the socio-economic prosperity of states, areas within states, and a country's overall economic standing. The energy produced by SHS is low-priced, as power can be obtained for free after an initial expenditure when connecting solar energy projects to satisfy the energy needs of entrepreneurial activities. As entrepreneurs are required to pay regular electricity bills using power tempos, they do not need to pay any statement for power consumption from SHS. With SHS, enterprises with limited financial resources can better manage their financial concerns [22]. The SHS energy sources save funds for entrepreneurial endeavors and other company operations. Thus, installing SHS enhances entrepreneurs' financial condition and performance [24]. Adopting the innovative idea of a solar power storage structure has increased energy supply for entrepreneurial endeavors via SHS. This improved energy is utilized in commercial enterprises to power various electric equipment and facilitate their operation [51]. SHS has improved entrepreneurs' operations and financial activities [52]. If the SHS can store power, entrepreneurs do not have to worry about future energy necessities and can focus on upcoming business endeavors. Similarly, a high-quality SHS not only meets the vigor requirements of entrepreneurial activities but also saves family businesses money, reduces maintenance costs, and ensures the health and safety of entrepreneurs. Adopting SHS can reduce unit costs of business activities and boost entrepreneurs' profitability and financial output [53]. The study [54] explained the payback of adopting SHS in entrepreneurial activities in rural areas. According to the study, entrepreneurs' production, operations, and financial performance depend on SHS in off-grid areas. The current information helps decision-makers choose solar panels and related equipment, their connections, and their use to meet the energy needs of entrepreneurial activities. In this instance, adopting the SHS approach can enhance the efficacy of entrepreneurship. These factors prompted us to establish the subsequent 1st supposition:

**Hypothesis 1**

**(H1).** ESE is extremely connected with the entrepreneurial functioning of the solar home system

## 2.2. Use of low-cost solar energy in entrepreneurship (ULSE)

The economy's core consists of entrepreneurial activity carried out by a single individual or small groups of partners. Regardless of the type of businessperson, entrepreneurial movements are essential to economic growth [55]. An upsurge in the pervasiveness of commercial activity is favorably associated with economic development [56]. In the present era, where grid-based electrification in rural areas is either impossible or impractical, the introduction of SHS has changed the performance of entrepreneurial operations. With sustainable economic development in the country, the power of SHS in pastoral areas for business decisions can eliminate deficiencies and increase businesses' profits. Entrepreneurship influences economic growth through innovation, perceptions of profit opportunities, risk-taking, and, primarily, by introducing novelty in accessible, affordable energy [57]. Moreover, entrepreneurship is essential for understanding communities' socio-economic conditions and development, as it provides low-cost energy through SHS [58]. The present research addressed this study's opening questions by contributing to theoretical literature. Consequently, installing an SHS improves entrepreneurs' financial position and enhances the performance of their entrepreneurial activities [21]. Access to affordable, low-cost energy through SHS is essential for establishing and fostering entrepreneurial endeavors. As a production component, electricity generated from SHS in universal and pastoral electrification is associated with increased employed hours for entrepreneurs, particularly those whose companies are located within families [59]. This study [22] found that power outages harm business productivity, particularly in entrepreneurship. Moreover, the low-cost energy in some pastoral electrification settings for entrepreneurial operations imposes restrictions on the actual uses of entrepreneurship, i.e., illumination and production, thereby limiting the entrepreneur’s profit from productive electricity use [60]. The lack of access to energy can also be a barrier to entrepreneurship. Not having access to power will make renewable energy sources less attractive to potential businesspersons in commercial events that require power as a production element. As a result, pastoral electricity through SHS can stimulate entrepreneurship. Established on these influences, the subsequent 2nd assumption was anticipated:

**Hypothesis 2**

**(H2).** ULSE is positively interrelated to the entrepreneurial performance of the solar home system

## 2.3. Entrepreneurial sustainable development with solar energy (ESD)

Given the country's solar energy potential, the SHS provides a crucial alternative for rural entrepreneurs and promotes entrepreneurship. Thus, spreading SHS as an alternative to the power grid in off-grid areas alleviates poverty by encouraging entrepreneurship [21]. Due to the high cost, rural electrification in China through the delayed electrical grid is problematic. The unaffordability of conventional energy for

business owners and the insufficient capacity for energy transport are also problems [61]. The study [62] demonstrates that alternative power bases are the most effective option for electrifying rural areas in China. Furthermore, Grimm et al. reveal that SHS is the optimal strategy for large-scale rural electrification. In China's rural areas, the use of SHS as an alternative power source to the electrical grid has increased rapidly [63]. Legislative initiatives implemented in China's rural areas include equipment subsidies and measures to promote entrepreneurial activities, aimed at reducing the financial hurdles to expanding SHS-based businesses [64]. Analysing the impact of SHS on well-being has identified the revenue network through which SHS affects entrepreneurs' interests. The underlying premise that access to electricity through SHS substantially affects entrepreneurial development is one of the channel's primary reasons. However, the service area rank for SHS is modest, whereas the performance of business endeavors is superior to that of regular grid connections [21]. Given these observations, we formulated the 3rd hypothesis as follows:

**Hypothesis 3**

**(H3).** ESD is positively interconnected with solar energy performance

# 2.4. Improving socio-economic well-being through solar home systems (ISW)

SHS is suited for lighting and essential appliances for groundbreaking occupations that utilize less energy and generate additional revenue for entrepreneurs. Consequently, some investigators find that electricity generated by SHS is substantial and appropriate for all types of entrepreneurships. SHS must be integrated into the solar mini-grid system to provide the necessary electricity to promote small enterprises [65]. In addition, the study [66] notes that only a minority of SHS adopters use their system for commercial purposes. Some researchers' findings demonstrate that the transfer of SHS influence on entrepreneurship in off-grid areas is essential and should be more actively fostered in China. Easy access to SHS may increase entrepreneurship among firms in off-network zones. This study aims to evaluate SHS's impact on private enterprises in off-network areas. It establishes that SHS can improve the probability of engaging in entrepreneurial activity [67]. In addition, adopting SHS has a positive, statistically significant impact on entrepreneurship across the commercial, industrial, and service sectors. An essential campaign is to implement policies that encourage SHS in off-grid communities, thereby alleviating poverty in rural areas of China. In off-grid areas, SHS are well-suited for lighting to support entrepreneurial activities and for powering low-power appliances that generate more profit [24]. Education's effect is likewise contested. Higher education is inversely related to entrepreneurship. Persons with a low level of education are more likely to be involved in remote initiatives than those with a middle-class education; nevertheless, among those with an average level of education, those with an advanced level of education may have an equal or higher probability of being employed in household firms [68]. Regarding the professional atmosphere, factors in the private enterprise include monetary stability, constrained by price increases, tax rates, and other managerial complications; unemployment rate; budget size; financial development; and infrastructure quality. Entrepreneurship is inversely

correlated with the inflation rate [69]. However, economic progress and salary increases can entice workers to apply for salaried positions. Economic development is also associated with expanding market demand, which can favor entrepreneurship [70]. These factors permit testing of the 4th hypothesis.

**Hypothesis 4**

**(H4).** ISW is positively organizing the entrepreneurial performance of the solar home system

# 2.5. Intention to attract entrepreneurs to adopt solar energy in entrepreneurship (IAE)

Intention to entice entrepreneurs to adopt solar home systems in family businesses positively mediates the relationships among the economic viability of family entrepreneurial culture through solar home systems, energy-expense savings in entrepreneurial production through solar home systems, and sustainable development of entrepreneurship through solar home systems. It improves the standard of living by adopting solar home systems in entrepreneurship [71]. If companies in off-network zones have easy access to SHS, they may be more likely to hire them in business occupations. This analysis aims to determine the effect of SHS on private enterprises in off-network areas. Access to secondary education enhances the prospect of engaging in innovative activities. The adoption of SHS has a statistically significant, positive impact on entrepreneurship across the commercial, industrial, and service sectors. Implementing a strategy promoting SHS in off-network communities, which means improving pastoral deprivation in Pakistan, is a crucial campaign. In off-grid regions, SHS is ideally suited for illuminating entrepreneurial activities and increasing profits through low-voltage applications [24]. Also contested is the effect of education. Awareness is negatively correlated with entrepreneurial activity. People with a low level of equality are more likely to be involved in isolated initiatives than those with a central class understanding. However, those with an extraordinary level of alertness may have a higher or identical probability of being attracted to domestic businesses associated with those with a central class understanding [68]. The correlation between free enterprise and the price-increase rate is negative [69].

**Hypothesis 5**

**(H5).** IAE is positive and significantly mediating ESE, ULSE, ESD, and ISW.

# 2.6. The moderating role of social media

Information plays a substantial role in individuals' lives, and the effect of social media as a form of communication is an appealing topic for investigation. Social media plays a substantial role in supporting entrepreneurial activities in remote regions of China. In regions where individuals have access to social media, SHS can improve their operational, production, and economic performance in their business activities [72]. Social media influences concerns and other businesses due to their massive user bases, but industrialists may find them particularly interesting given the low cost of using

SHS [73]. The study examines the use of social media in innovative activity and aims to provide a comprehensive understanding of the concerns in developing countries. Regarding community attitudes, social connectedness is considered a vital aspect. In an era of rapid technological growth and persistent digitalization, using social media to foster entrepreneurship is possibly the most prominent form of engagement in the field of interactive association [74]. Social media radically alters how customers use the Internet, posing an opposition to corporate activity. Even though social media provides effective sales networks, it is an appropriate tool for businesspersons with limited resources and integrity [75]. Social media has given folks several options for pursuing business activities. The rise of social media influencers as a driving force in business models is a notable phenomenon. Social media influencers are researching the impact of organized foundations on entrepreneurs' actions in these backgrounds [76]. Social media offers opportunities for free enterprise. Although it has been developed and integrated into company approaches, social media is still mainly used for communication. Other sectors of commercial transactions can also benefit from social networking. Entrepreneurs overlook problems such as establishing customer value, altering business models, and managing the company's operational environment [77]. The conceptual framework illustrates the predicted relationship between independent variables (IV) and dependent factors (DV). The current framework reveals the expected moderation of the IV-DV relationship in accumulation. This study examines the influence of solar energy from solar home systems on entrepreneurs' financial benefits and the moderating role of a social media-grounded understanding between the IV and DV in Pakistan. Established on the effects mentioned above, the 6th anticipated assumption is as follows:

**Hypothesis 6**

**(H6).** Social media positively moderates the relationship between ISW and EPGE

# 3. Research methodology

# 3.1. Main target population regions

To evaluate solar energy as a sustainable opportunity for Pakistani entrepreneurs, this analysis implemented snowball sampling. The random sampling technique employed in this study did not provide all residents with an equal opportunity to participate in the analysis. In the present study, we concentrate on the pastoral territories of China's Gansu province, including Lanzhou, Gauguin, Jincheng, Baying, and Tianzhu. China promotes the development of emerging regions. Many rural residents gradually migrate to larger, more developed municipalities for better employment opportunities, education, and amenities. China is a major producer of green energy, whereas pastoral regions continue to implement green power initiatives to prevent additional environmental damage. Due to their limited exposure to new technology, rural residents are unaware of the availability of green energy solutions for business use. Subsequently, we carefully chose these municipalities to reveal the results of our investigation. We decided on these territories based on the density of their inhabitants. Lanzhou has a population of 3,616,163, whereas Gauguin, Jincheng, Baying, and Tianzhu have populations of 231,853, 464,050, 1,708,751, and 3,262,548,

respectively [78]. Because these localities are less densely populated and have a moderate growth rate, they have little significance for systematic studies. Due to a language barrier that prevented us from collecting accurate data from respondents, we surveyed in the local language and then translated it into English using the Baidu Translate app for this questionnaire. Researchers who polled between January and March 2025 encountered a formidable challenge in locating relevant respondents (local small entrepreneurs) to achieve this objective. The area was remote from current urban areas; we selected an accessible survey method. We evaluated each item using a 5-point Likert scale ranging from 5 ("strongly agree") to 1 ("strongly disagree") for each topic. We employed a test sample of 800 respondents. The response rate was 86.89%; however, 147 surveys were discarded due to unmatched or insufficient answer sets. The study's analysis was conducted with 653 legitimate respondents from the sample. In response to the presence of researchers and acquaintances in the study area, respondents submitted their evidence. A precise explanation of the sample upholds the findings. The following criteria were used to select respondents: operating solar home system owners, local entrepreneurs, and residents in the research area. Furthermore, respondents were required to have a minimum of 6 months to 2 years of proficiency in the alternative power component. Respondents do not have to meet the lowest requirement. Table 1 provides a comprehensive summary and description of the data analysis of the respondents' demographic characteristics.

## 3.2. Development of a questionnaire

Two sections were included in the questionnaire. The "Introduction" segment has five demographic interrogations: gender, age, schooling, revenue, and profession. The "Research framework and development of hypotheses" section includes 35 queries, grounded in each concept, to evaluate the anticipated research discoveries. The research examined the balance of the material identified in the preceding text in the current study. We have identified four factors to measure the economic sustainability of local entrepreneurial culture through the solar home systems ESE concept. These elements were selected and updated based on the study [79]. We have used five questions to measure the use of low-cost solar energy in entrepreneurship, ULSE, designed based on prior research [46]. Three items were fixed to entrepreneurial sustainable development with solar energy ESD, adapted and modified from a previous study [80]. Eight items measured the improvement of socio-economic well-being through entrepreneurial utilization of solar home systems ISW, adapted and altered from a prior study [81]. Four items measured the intention to attract entrepreneurs to adopt solar energy in entrepreneurship at IAE; these items were adopted based on prior research [82]. Three items were used to measure entrepreneurial performance in green energy solar systems, with EPGE as the dependent variable, adjusted from a prior study [24]. As a moderating variable, social media SM is scrutinised by seven items drawn and moderated from the study [83].

# 4. Statistical Analysis and Empirical Results

We conducted the research analysis using the partial least squares structural equation modelling (PLS-SEM) technique, with the exploratory measurement assessment model (MAM) and structural

assessment model (SAM). By investigating the relationships among variables, SEM yields relevant and convincing results [84]. This structure was manipulated to analyze the relational components, as it is a constituent-placed approach [85]. The extensive benefits of PLS-SEM in subsequent studies provide evidence of its suitability; the current technique was chosen for its strength and reliability of conclusions in this study [86]. SEM is superior to conventional arithmetical analysis techniques [87]. This technique is used to obtain reliable, convincing results by examining the relationships among variables [84]. This approach can measure all dependent and independent variables, accounting for dimension errors, whereas most other methods cannot [88]. This procedure can continue to gain popularity in enterprise research due to its ability to handle complex, multiple relationships [99]. Finally, the purpose of smart-PLS is to assess assumptions, and the typical inquiry has been refined to achieve this objective. Smart-PLS endeavors to evaluate theories in the investigation; consequently, comprehensive model research has emerged. Validity is determined by Cronbach's alpha, composite reliability, item-total correlations, and item loadings. Nevertheless, the discriminant, Fornell-Larcker, cross-loading, and Heterotrait-Monotrait ratio. Furthermore, the measurement model includes the research analysis described in the section on outcomes and the examination of hypotheses through route analysis. Based on these principles, SEM is the most efficient and applicable apparatus for estimating relationships among all variables.

# 4.1. Demographic Participants' Profile

Most respondents were male (471, 72.12%), while females numbered about 182 (27.87%). Moreover, the beginning respondents aged less than 27 were 173 (26.49%), respondents aged 27–40 were 161 (24.65%), and 41–55-year-old respondents were 151 (23.12%), in the mainstream from entirely phase varieties surveyed by respondents' elderly 56–65 years who were 143 (21.89%) and respondents aged overhead 65 who were in a small number (15, 2.29%). Conversely, 281 (43.03%) respondents had a place in Metric schooling under the subordinate equal, which is the lowest. We also undergo their experience; respondents with experience lower than 0–5 years were 178 (27.25%), while most of them had 6–10 years (386 (59.11%)), but some respondents had 11–15 years of experience ranging from 44 (6.73%), and finally, some respondent followed by 16–20 years old 45 (6.89%). According to brand adoption, 283 (43.33%) respondents adopted the Trina Solar TSM brand, 166 (25.42%) adopted SunPower, 157 (24.04%) adopted the JA Solar MR series, and 47 (7.19%) adopted the Hanwha Q-Cell Speak Duo solar brand. Statistics are shown in Table 2, but Table 3 provides more detailed statistics.

Table 1
Demographic profile of Respondents, operating solar home system owners, local entrepreneurs, and residents in the research area (N = 653)

| Variables | Features | Frequency | % |
|---|---|---|---|
| Gender | Male | 471 | 72.12 |
| | Female | 182 | 27.87 |
| Age | Less than 27 | 173 | 27.96 |
| | 27–40 | 161 | 24.65 |
| | 41–55 | 151 | 19.54 |
| | 56–65 | 143 | 21.89 |
| | 65 and above | 15 | 2.29 |
| Education | Metric | 281 | 43.03 |
| | Secondary school | 174 | 26.64 |
| | Bachelor's degree | 157 | 24.04 |
| | Master's degree | 41 | 6.27 |
| Experience | 0–5 years | 178 | 27.25 |
| | 6–10 years | 386 | 59.11 |
| | 11–15 years | 44 | 6.73 |
| | 16–20 years | 45 | 6.89 |
| Brand | Trina Solar TSM | 283 | 43.33 |
| | Sun power x22 | 166 | 25.42 |
| | Ja Solar MR series | 157 | 24.04 |
| | Hanwha Q Cell Speak Duo | 47 | 7.19 |

# 4.2. Measurement Assessment Model

## 4.2.1. Reliability Analysis

It was necessary to examine the measurement model used in this investigation to conduct validity and reliability assessments for each construct. In addition to establishing the dependability and factor loadings of the constructs, the measurement model verifies their reliability and validity (Collier, 2020). The approach to assessing measurement reliability and validity (convergent and discriminant) is consistent with Hair et al. (2011). This study evaluated convergent validity using average variance

extracted (AVE), internal consistency reliability using composite reliability (C.R.), and item reliability using factor loadings. The results are summarised in Table 1; all item loadings exceed the criterion value of 0.50 (Collier, 2020). Each factor loading was greater than 0.50, and the produced variable supported each reflection. AVE surpasses the suggested threshold of 0.50 (Arbuckle, 2011). Each standard's overall reliability exceeds 0.70, indicating precise measurements (Anderson and Gerbing 1988). The results of biogas production from human organic waste and locally sourced materials suggest that all AVE values fall between 0.577 (improving socio-economic well-being through solar home systems) and 0.861 (economic sustainability of entrepreneurship using solar energy). C.R. values range from 0.854 (entrepreneurial performance of green energy with solar systems) to 0.961 (economic sustainability of entrepreneurship using solar energy). The values of all additional loadings range from 0.5 to 0.968. Table 2 presents convergent validity as measured by average variance extracted. All validated factor loadings and reliability values for this measurement model are presented. All factor loadings are greater than 0.50; hence, the convergent validity of all items in the measurement model is established.

Table 2
Evaluation of convergent validity

| Constructs | Items | SLF | α | C.R | AVE |
|---|---|---|---|---|---|
| Economic sustainability of entrepreneurship using solar energy | ESE1 | 0.968 | 0.944 | 0.961 | 0.861 |
| | ESE2 | 0.798 | | | |
| | ESE3 | 0.966 | | | |
| | ESE4 | 0.968 | | | |
| Use of low-cost solar energy in entrepreneurship | ULSE1 | 0.881 | 0.919 | 0.939 | 0.756 |
| | ULSE2 | 0.867 | | | |
| | ULSE3 | 0.873 | | | |
| | ULSE4 | 0.878 | | | |
| | ULSE5 | 0.849 | | | |
| Entrepreneurial sustainable development with solar energy | ESD1 | 0.903 | 0.885 | 0.929 | 0.813 |
| | ESD2 | 0.917 | | | |
| | ESD3 | 0.885 | | | |
| Improving socio-economic well-being through solar home systems | ISW1 | 0.851 | 0.900 | 0.916 | 0.577 |
| | ISW2 | 0.893 | | | |
| | ISW3 | 0.799 | | | |
| | ISW4 | 0.839 | | | |
| | ISW5 | 0.803 | | | |
| | ISW6 | 0.726 | | | |
| | ISW7 | 0.722 | | | |
| | ISW8 | 0.712 | | | |
| The moderating role of social media | SMI1 | 0.838 | 0.922 | 0.936 | 0.678 |
| | SM2 | 0.711 | | | |
| | SM3 | 0.880 | | | |
| | SM4 | 0.860 | | | |

Note: N = 653; AVE = average variance extracted; CR =composite reliability; α = Cronbach's alpha; SFL = standard factor loading

| Constructs | Items | SLF | α | C.R | AVE |
|---|---|---|---|---|---|
| | SM5 | 0.836 | | | |
| | SM6 | 0.847 | | | |
| | SM7 | 0.781 | | | |
| Intention to attract entrepreneurs to adopt solar energy in entrepreneurships | IAE1 | 0.851 | 0.888 | 0.923 | 0.749 |
| | IAE2 | 0.893 | | | |
| | IAE3 | 0.878 | | | |
| | IAE4 | 0.839 | | | |
| Entrepreneurial performance of green energy with solar systems | EPGE1 | 0.764 | 0.743 | 0.854 | 0.661 |
| | EPGE2 | 0.879 | | | |
| | EPGE3 | 0.792 | | | |

Note: N = 653; AVE = average variance extracted; CR =composite reliability; α = Cronbach's alpha; SFL = standard factor loading

# 4.2.2 Measurement Model Validation

# 4.2.3 Convergent validity

This research also examines the relationship between discriminant legitimacy and the number of variables. Primarily, the discriminant rationality was assessed using the Fornell–Larcker criteria in Table 3. Numerous investigators have critiqued the Fornell-Larcker measure; therefore, the Heterotrait-Monotrait ratio of relationships (HTMT) is considered an acceptable indicator of discriminant validity (Akbar et al., 2019). This value is considered valid if the discriminant validity is less than 0.85 (Cohen, 1988) or 0.90 (Ali et al., 2022b). Table 4 shows the discriminant validity through the Heterotrait-Monotrait ratio (HTMT), which contains no value exceeding 0.90. The outcomes segment also displays the discriminant authenticity of the variables' interrelationships. The importance of the variable indicates that the worth associated with it is preferable to that associated with other variable quantities. This conclusion also evaluated the interrelationships among variables using the HTMT proportion. Based on the HTMT values, the assessments are below 0.85. The values in Table four imply that direct effects strongly correlate with some other influences but modestly correlate with others. Table 5 shows the cross-loadings. The discriminant validity test was conducted by matching the bolded standards in the cross-load table with those of the additional factors in each row. In this study, incorporating solar energy is more critical than other mechanisms row-wise and demonstrates strong discriminant validity. Furthermore, the cross-loadings indicate compelling correlations among the elements, while other influences have weaker effects. Cross-loadings for the additional instruments in each support are

analyzed to evaluate discriminant validity. These numbers indicated an exhausted relationship between variables and authenticated the discriminant rationality of adopting solar home energy facilities. Figure 2 illustrates the measurement evaluation template and adaptable aspect loads.

Table 3
Discriminant validity through Fornell-Larcker. **N = 653;** EPGE = entrepreneurial performance of green energy with solar systems; ESD = entrepreneurial sustainable development with solar energy; ESE = economic sustainability of entrepreneurship using solar energy; IAE= Intention to attract entrepreneurs to adopt solar energy in entrepreneurships; ISW = improving socio-economic well-being through solar home systems; SM = the moderating role of social media; ULSE = use of low-cost solar energy in entrepreneurship.

| **Factors** | **EPGE** | **ESD** | **ESE** | **IAE** | **ISW** | **SM** | **ULSE** |
|---|---|---|---|---|---|---|---|
| EPGE | 0.813 | | | | | | |
| ESD | 0.133 | 0.901 | | | | | |
| ESE | 0.385 | 0.209 | 0.928 | | | | |
| IAE | 0.298 | 0.717 | 0.366 | 0.865 | | | |
| ISW | 0.112 | 0.089 | 0.038 | 0.112 | 0.759 | | |
| SM | 0.254 | 0.256 | 0.176 | 0.202 | 0.029 | 0.824 | |
| ULSE | 0.434 | 0.263 | 0.875 | 0.402 | 0.001 | 0.179 | 0.870 |

Table 4
Discriminant validity through Heterotrait-Monotrait ratio (HTMT).

| **Factors** | **EPGE** | **ESD** | **ESE** | **IAE** | **ISW** | **SM** | **ULSE** |
|---|---|---|---|---|---|---|---|
| EPGE | | | | | | | |
| ESD | 0.160 | | | | | | |
| ESE | 0.447 | 0.225 | | | | | |
| IAE | 0.361 | 0.807 | 0.395 | | | | |
| ISW | 0.132 | 0.09 | 0.056 | 0.108 | | | |
| SM | 0.281 | 0.278 | 0.180 | 0.205 | 0.052 | | |
| ULSE | 0.514 | 0.290 | 0.428 | 0.443 | 0.069 | 0.184 | |

Table 5
Cross-loading.

| Items | EPGE | ESD | ESE | IAE | ISW | SM | ULSE |
|---|---|---|---|---|---|---|---|
| EPGE1 | 0.764 | 0.027 | 0.275 | 0.184 | 0.097 | 0.254 | 0.314 |
| EPGE2 | 0.879 | 0.185 | 0.399 | 0.313 | 0.084 | 0.194 | 0.457 |
| EPGE3 | 0.792 | 0.097 | 0.247 | 0.216 | 0.096 | 0.174 | 0.264 |
| ESD1 | 0.125 | 0.903 | 0.218 | 0.645 | 0.037 | 0.156 | 0.255 |
| ESD2 | 0.114 | 0.917 | 0.183 | 0.679 | 0.095 | 0.274 | 0.232 |
| ESD3 | 0.122 | 0.885 | 0.164 | 0.611 | 0.109 | 0.263 | 0.223 |
| ESE1 | 0.348 | 0.177 | 0.968 | 0.32 | 0.036 | 0.169 | 0.778 |
| ESE2 | 0.378 | 0.237 | 0.798 | 0.379 | 0.036 | 0.149 | 0.871 |
| ESE3 | 0.348 | 0.168 | 0.966 | 0.319 | 0.034 | 0.164 | 0.776 |
| ESE4 | 0.338 | 0.18 | 0.968 | 0.323 | 0.033 | 0.170 | 0.782 |
| IAE1 | 0.301 | 0.597 | 0.287 | 0.851 | 0.091 | 0.183 | 0.317 |
| IAE2 | 0.257 | 0.648 | 0.335 | 0.893 | 0.108 | 0.154 | 0.364 |
| IAE3 | 0.263 | 0.600 | 0.300 | 0.878 | 0.119 | 0.182 | 0.346 |
| IAE4 | 0.211 | 0.634 | 0.344 | 0.839 | 0.069 | 0.182 | 0.362 |
| ISW1 | 0.027 | 0.053 | 0.068 | 0.065 | 0.730 | 0.007 | 0.035 |
| ISW2 | 0.112 | 0.076 | 0.002 | 0.119 | 0.815 | 0.048 | 0.028 |
| ISW3 | 0.081 | 0.103 | 0.028 | 0.074 | 0.799 | 0.004 | 0.000 |
| ISW4 | 0.074 | 0.064 | 0.051 | 0.089 | 0.762 | 0.041 | 0.022 |
| ISW5 | 0.127 | 0.104 | 0.009 | 0.116 | 0.803 | 0.004 | 0.044 |
| ISW6 | 0.040 | 0.008 | 0.090 | 0.055 | 0.726 | 0.025 | 0.094 |
| ISW7 | 0.084 | 0.011 | 0.046 | 0.028 | 0.722 | 0.015 | 0.029 |
| ISW8 | 0.106 | 0.040 | 0.011 | 0.035 | 0.712 | 0.040 | 0.069 |
| SM2 | 0.289 | 0.180 | 0.138 | 0.265 | 0.074 | 0.711 | 0.156 |
| SM3 | 0.249 | 0.226 | 0.203 | 0.156 | 0.014 | 0.880 | 0.196 |
| SM4 | 0.159 | 0.272 | 0.166 | 0.150 | 0.032 | 0.860 | 0.151 |
| SM5 | 0.159 | 0.153 | 0.102 | 0.115 | 0.052 | 0.836 | 0.085 |
| SM6 | 0.130 | 0.188 | 0.098 | 0.117 | 0.004 | 0.847 | 0.111 |

| Items | EPGE | ESD | ESE | IAE | ISW | SM | ULSE |
|---|---|---|---|---|---|---|---|
| SM7 | 0.144 | 0.173 | 0.124 | 0.111 | 0.034 | 0.781 | 0.139 |
| SMI1 | 0.210 | 0.259 | 0.139 | 0.155 | 0.008 | 0.838 | 0.141 |
| ULSE1 | 0.393 | 0.230 | 0.728 | 0.335 | 0.047 | 0.144 | 0.881 |
| ULSE2 | 0.356 | 0.254 | 0.790 | 0.371 | 0.008 | 0.162 | 0.867 |
| ULSE3 | 0.358 | 0.206 | 0.765 | 0.332 | 0.006 | 0.184 | 0.873 |
| ULSE4 | 0.386 | 0.230 | 0.788 | 0.365 | 0.040 | 0.158 | 0.878 |
| ULSE5 | 0.397 | 0.219 | 0.728 | 0.340 | 0.004 | 0.130 | 0.849 |

# 4.3. Structural Model

The association between inside and outside influences has been established using the structural paradigm. The model's T estimates, path constant, outcome scale, prognostic significance, and willpower constant have been assessed. The inference on the hypotheses was finalized by applying the bootstrap procedure with 5000 replicates and an implication at the 5% significance level (one-tailed). The investigation's conclusions imply that all assumptions, except H4, are supported. Hypotheses with a straight upshot, such as ESD ($\beta = 0.654$, $p < 0.05$), ESE ($\beta = 0.132$, $p < 0.05$), and ULSE ($\beta = 0.257$, $p < 0.05$), exhibit a confirmed and statistically significant impact when resolved by IES (ABP). Social media is clearly and substantially associated with IAE ($\beta = 0.257$, $p < 0.05$). The $R^2$ estimate for accepting a biogas-powered plant in private enterprise to improve Pakistan's quality of life is 0.481, indicating substantial predictive power. Conversely, it is incorrect and ineffective to rely solely on a model's $R^2$ value to determine its validity [89]. The best approximation, thus, is to estimate the projected legitimacy of simulation $Q^2$. If $Q^2$ is substantially greater than zero, then the projected energy of dormant exogenic theories is rationally powerful [1]. The outcomes indicate that the $Q^2$ value for the intention to encourage rural society to adopt biogas energy is 0.236, demonstrating that the model's analytical rationality is reasonably high. The $f^2$ significances of 0.02, 0.15, and 0.35 denote insignificant, normal, and significant effects, respectively [90]. Subsequently, the significance of $f^2$ implies that the effect size decreases from intermediate to more significant (see Table 6 and Fig. 3 below). The relationship between the variable quantity in the structural template is signified by T-standards (1.64), which are more significant than p-standards. Biogas technology largely contributes to the financial and communal success of Pakistan. The model, accepted with sensible adjustability, shows promising results. The structural valuation prototype specifies a positive relationship between biogas machinery agreement and accomplishment in Pakistan. Table 6 shows the hypothesis testing using structural modeling.

Table 6
Hypothesis testing with a structural model (results).

| H1 | Hypothesis | B-values | S.D. | T-values | *P*-values | Supported | $R^2$ | $Q^2$ | $f^2$ |
|---|---|---|---|---|---|---|---|---|---|
| | **ESD -> IAE** | **0.654** | **0.033** | **19.841** | **0.000** | **Yes** | **0.471** | **0.261** | **0.063** |
| H2 | ESE -> IAE | 0.132 | 0.075 | 1.761 | 0.041 | Yes | | 0.113 | 0.012 |
| H3 | ULSE -> IAE | 0.115 | 0.064 | 1.794 | 0.038 | Yes | 0.411 | | 0.010 |
| H4 | ISW -> IAE | 0.059 | 0.055 | 1.073 | 0.143 | No | | | 0.019 |
| H5 | SM -> EPGE | 0.202 | 0.061 | 3.327 | 0.001 | Yes | | | 0.013 |
| H6 | IAE -> EPGE | 0.257 | 0.05 | 5.167 | 0.000 | Yes | | | 0.017 |

# 5. Discussion and implications

The study results indicate that an SHS's affordable energy correlates well with its entrepreneurial performance. The findings recommend that the vigor attached to SHS is an alternative, less expensive option for commercial activity. This type of energy enables businesses with inadequate economic resources to reduce electricity expenses. The reserves are held and invested in corporate operations and entrepreneurial endeavors to meet market demand and enhance performance. The previous study [21] identifies SHS as a considerable and profitable energy source for entrepreneurial activities. It recommends that, following the initial installation, the SHS requires minimal maintenance. Entrepreneurs do not compensate for power mandibles because they generate their power [91]. Consequently, the entrepreneurs' full and per-unit prices are low, and their productivity is excellent [92]. The outcomes also indicate that SHS's improved energy source influences business performance. The results confirm the findings of a previous study [24] that using the SHS for power production has expanded the energy source and that the solar power storage structure is an outstanding complement to entrepreneurial endeavors. Consequently, in the early phases, the Chinese administration should inform the population about selected expertise so aspiring entrepreneurs can choose SHS for their ventures.

Even when electricity is unavailable, businesspeople in remote areas can continue operating their businesses by using the higher-quality energy supplied by SHS [93]. It facilitates entrepreneurial endeavors and enhances their economic performance. Results indicate that SHS positively correlates with entrepreneurial achievement in China's remote regions [94]. Independent electricity from SHS reduces costs and improves business operations efficiency. These results are consistent with previous research [22] indicating that the SHS is durable, requires no maintenance, generates full power, and includes a solar energy storage system, which helps entrepreneurs achieve their business objectives. The study results reveal that social media substantially modifies the adoption of SHS's low-cost energy and entrepreneurial activities. These results align with the scholarly study by [56], which demonstrates

that the effects of SHS's low-cost energy on entrepreneurial activities are more pronounced in the context of social media. In addition, the study results reveal that social media is a significant moderator of the relationship between the intention to persuade entrepreneurs to adopt solar home approaches in family businesses and the execution of entrepreneurial actions. These conclusions are consistent with prior research [95], indicating that social media improves the effects of increased supply through SHS on entrepreneurial performance.

# 5.1. Managerial implications

This research has both practical and theoretical ramifications. It is a significant literary work that contributes to the economic health of the literary industry. The study contributes to the literature by demonstrating the impact of five new parameters on the performance of entrepreneurial activities: ESD, ULSE, ESE, and ISW. This research guides local entrepreneurs, family businesses, and alternative energy policymakers to adopt SHS to improve output and boost the financial performance of entrepreneurial activities. The study has immense significance for Chinese entrepreneurs, particularly in Gansu province and the developing world, as its recommendations can be critical for boosting entrepreneurial performance through SHS adoption. The simple use of SHS can reduce manufacturing costs and enhance businesses' economic performance. Therefore, adopting SHS can increase the availability of low-cost energy, alleviate the energy crisis, and boost entrepreneurs' economic output in China's Gansu province.

The study concludes that there is a reasonable, statistically significant association between SHS and the rising performance of entrepreneurial activities. The study also examines whether SHS can reduce energy costs for entrepreneurial operations in rural China. This study has demonstrated that SHS is crucial for reducing energy costs, improving off-grid power systems, overcoming power shortages, promoting sustainable lifestyle changes, and boosting the economic activity of rural entrepreneurs in Gansu province. All propositions except H2 are accepted. All the moderate-adjusted quantity standards are positive, indicating a significant link. The moderated variables exhibited favorable indications and a highly significant correlation in the structural assessment model for entrepreneurship. The study found that SHS and its chosen moderator have a substantial, positive impact on the economic success of entrepreneurial activities. Also, the administration must develop a community consciousness movement to transition people from traditional energy systems to mainstream SHS technologies, highlighting the advantages of these technologies for entrepreneurship in China. In addition, the results indicate that social media is a crucial modulator of the relationship between the economic viability of family entrepreneurial culture through solar home systems and the entrepreneurial performance of solar home systems. According to a previous study [83], social media improves awareness and the implementation of entrepreneurial operations. The study highlighted to businesspersons that affordable power from SHS supports the growth and excellent performance of entrepreneurial and family-owned businesses. SHS is a reliable and affordable power source with significant, favourable relationships that enhance the financial performance of entrepreneurial endeavours.

# 6. Conclusions and recommendations

The research investigates the function of SHS in the entrepreneurial sector, particularly in entrepreneurial activities. It examines the effects of four influences: (i) economic sustainability of entrepreneurship using solar energy, (ii) use of low-cost solar energy in entrepreneurship, (iii) entrepreneurial sustainable development with solar energy, and (iv) improving socio-economic well-being through solar home systems. The study estimates whether SHS is a gainful basis. It also helps entrepreneurial enterprises control other energy costs, thereby reducing unit costs and increasing profitability. According to the study, in the current situation, when energy stress has escalated, SHS is the only inexpensive solution to meet the energy requirements of entrepreneurial processes. The deployment of SHS accelerates the completion of power-related responsibilities and simplifies operational and engineering measures. The superiority of their SHS influences the operational and economic performance of entrepreneurial enterprises. The study demonstrates that an SHS may support an innovative enterprise's commercial operations with high flexibility, reduced storage requirements, and substantial energy needs for profitable processes. It shows that SHS helps entrepreneurial endeavors achieve better performance. Consistent with this analysis, entrepreneurial enterprises' production and financial performance were positively associated with the growing availability of energy resources from SHS. SHS is operational machinery that assists industrialists and advances the realisation of entrepreneurial endeavours in a particular region of China.

This study's findings provide mechanisms and helpful advice for legislators to foster business values by accepting the SHS to establish entrepreneurial enterprises. Appropriate alternative energy organizations and responsible institutions must consider affordable, low-$CO_2$ emission energy sources, such as SHS, to boost entrepreneurial activities. This research supports the claim that social media plays a role in promoting SHS as a moderator variable between the independent variable and the dependent variable. The analysis reveals that the accomplishment of innovative enterprises can be strengthened by affordable power from SHS, increased influence from SHS, and increased profits from SHS. This study also demonstrates how social media awareness improves the impact of variables (mentioned above) on the performance of business companies. However, the work has practical limitations that future researchers must investigate. First, only four components, namely ESD, ULSE, ESE, and ISW, have been examined in this study. The research investigates their special effects on the performance of business endeavors. Many other elements also significantly affect the execution of innovative corporations. In assessing the four characteristics mentioned above, researchers should also examine additional factors that affect entrepreneurial activity performance. The statistics obtained from a single source to support this study do not meet the standard for inclusive facts. Future scholars are encouraged to obtain data from multiple sources when repeating the existing study to improve its validity. The main decisions can be summarized as follows: Initially, the findings described could not analyze the technological characteristics of the respective machinery in the context of risk-taking administrative production. Subsequently, this analysis neglects the importance of various strategic interventions in encouraging industrialists to adopt SHS technologies. Moreover, the existing findings cannot distinguish between early-phase and senior industrialists, an essential component for raising concern about the

implementation of SHS technology as an alternative electric resource to innovative behaviors. We have calculated each item with cross-examination (see Table A1 in the Appendix).

# Declarations

**Author's contribution:** SY: Writing—innovative plan, formal assessment, supervision, and acquisition of financial support for the project leading to this publication; SA: Conceptualization, data handling, methodology, formulation, and variable comprehension; NAA: writing, reviewing, and editing; NMS: data handling and writing, reviewing, and editing

**Data availability:** The statistics supporting the findings of this study are accessible from the corresponding author upon reasonable request.

**Ethical approval:** This study was conducted in accordance with the ethical principles of the Declaration of Helsinki. Ethical approval was obtained from the Universiti Utara Malaysia research ethics committee (Protocol No, 1887–17 on 11 February 2026]).

**Consent to Participate**: Informed consent was obtained from all participants prior to their participation in the study.

**Consent to Publish:** Not applicable

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**Competing interest:** On behalf of the corresponding author, no competing interest.

**Clinical trial number:** Not applicable

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# Figures

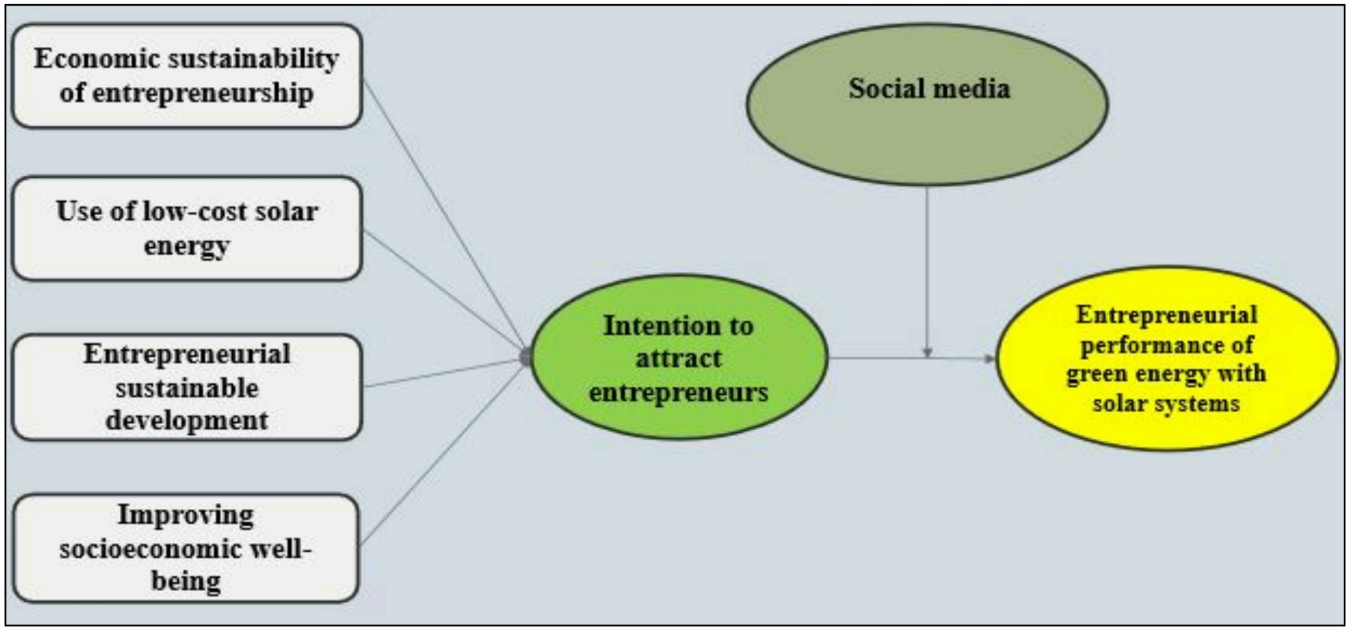



**Figure 1**

Theoretical framework.

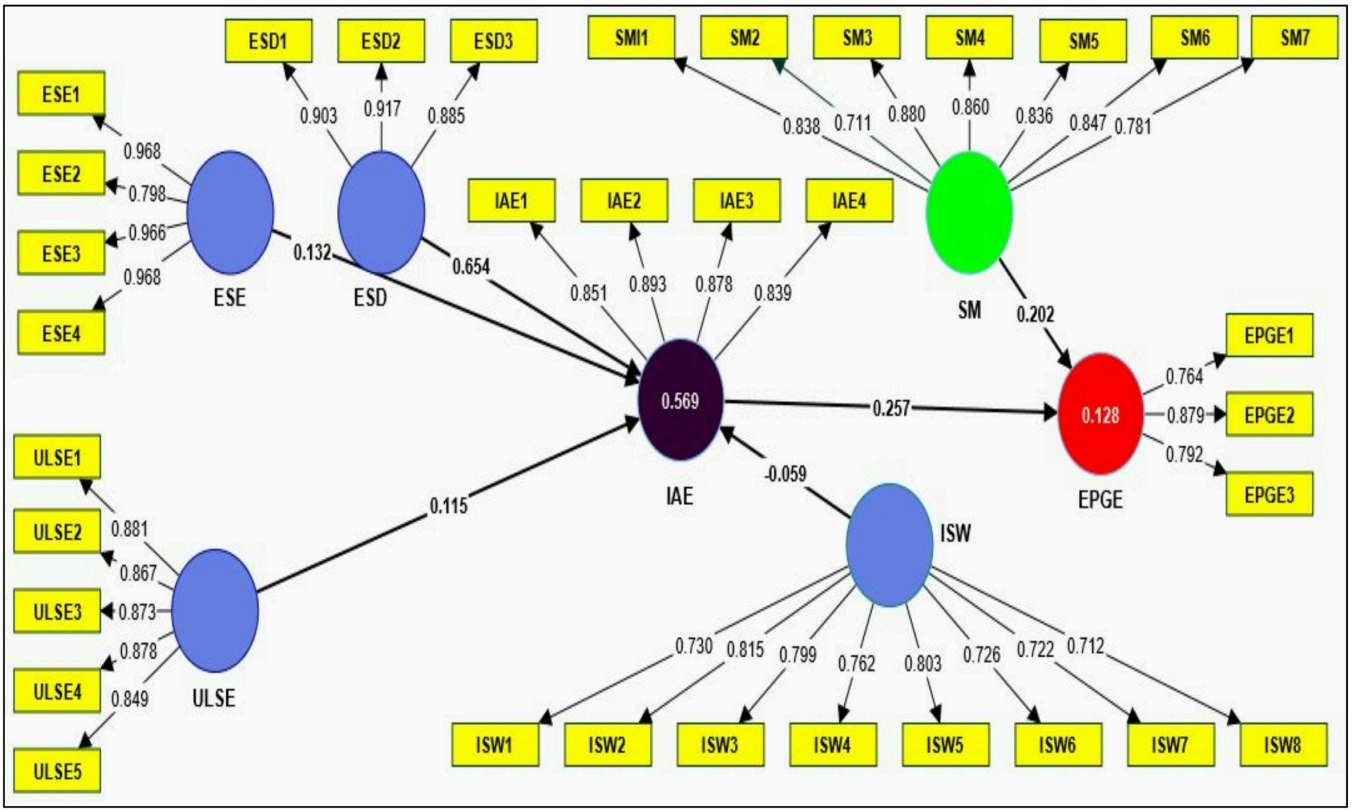


**Figure 2**

Measurement assessment model.

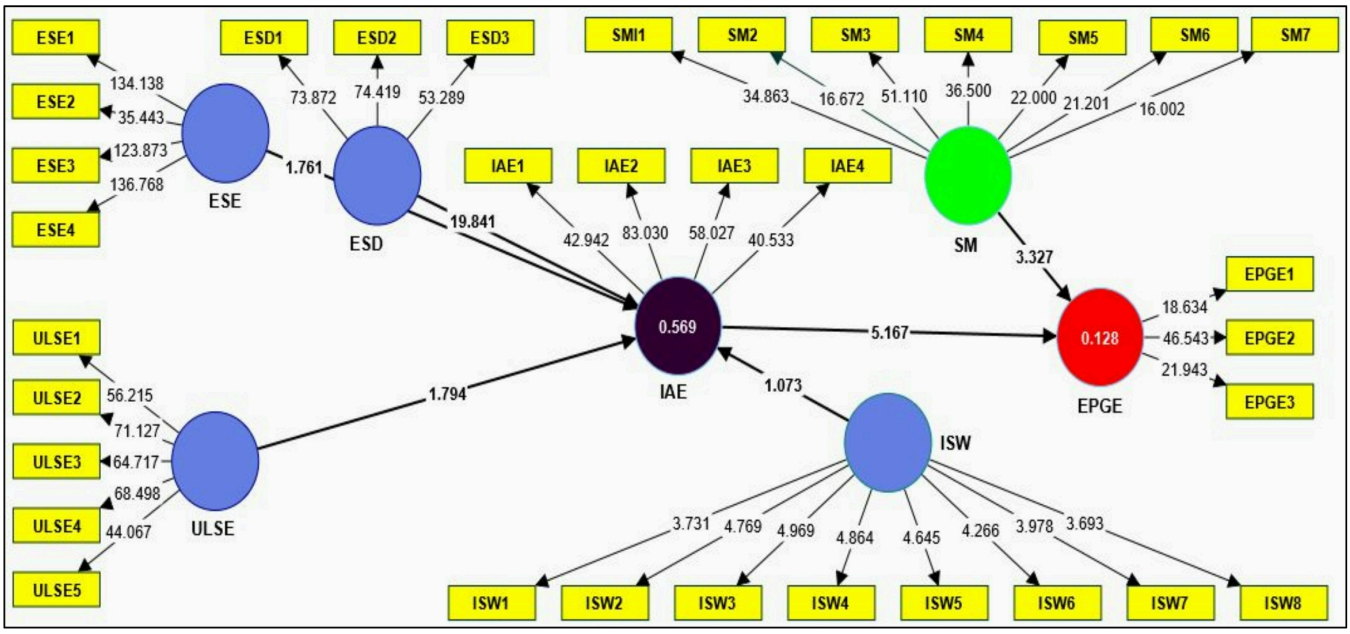



**Figure 3**

Structural assessment model.

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