



# Modeling the economic viability and performance of solar home systems: a roadmap towards clean energy for environmental sustainability

Shahid Ali<sup>1</sup> · Qingyou Yan<sup>1,2</sup> · Azer Dilanchiev<sup>3</sup> · Muhammad Irfan<sup>4,5,6</sup> · Shah Fahad<sup>7</sup>

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## Abstract

Energy is a necessary source of economic development and social prosperity, linked with primary production and consumption activities worldwide. In this regard, solar home systems (SHSs) are beneficial in two ways, i.e., saving vitality overheads and meeting the energy demand of small enterprises. The current study aims to evaluate the performance of adopting SHS to develop the small-scale industry in Pakistan. An inclusive questionnaire survey was conducted, and respondents were selected using the purposive sampling method. As a step further, we scrutinize the moderating role of awareness and understanding of technology between the node of adopting SHS and the monetary enactment of small-scale industry. We authenticate the model using a sample of 357 respondents by applying the partial least square structural equation modeling (PLS-SEM) technique. The results indicate that low-cost energy through SHSs has a progressive and substantial linkage with the demonstration of small-scale industry and enhances the quality of energy supply in Pakistan. Similarly, awareness and understanding of SHS significantly moderate the relationships between enhanced energy supply through SHS, the quality of SHS, and the performance of the small-scale industry. These findings provide a valuable guideline to the regulation developing authorities that more attention is needed to focus on SHS to further improve the performance of small-scale industry.

**Keywords** Solar home system · Low-cost energy · Enhanced energy supply · Energy economics · Quality of SHS · Small-scale industry

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✉ Muhammad Irfan  
irfansahar@bit.edu.cn

- <sup>1</sup> School of Economics and Management, North China Electric Power University, Beijing 102206, China
- <sup>2</sup> Beijing Key Laboratory of New Energy and Low-Carbon Development, North China Electric Power University, Beijing 102206, China
- <sup>3</sup> International Black Sea University, Tbilisi, Georgia
- <sup>4</sup> School of Management and Economics, Beijing Institute of Technology, Beijing 100081, China
- <sup>5</sup> Center for Energy and Environmental Policy Research, Beijing Institute of Technology, Beijing 100081, China
- <sup>6</sup> School of Business Administration, ILMA University, Karachi 75190, Pakistan
- <sup>7</sup> School of Economics and Management, Leshan Normal University, Leshan 614000, China

## Introduction

Energy is essential in facilitating daily activities and is considered a primary need in modern life (Baig et al. 2022; Ren et al. 2021). All sectors of life are associated with or dependent on energy (Deng et al. 2022; Ongan et al. 2022). The increasing energy needs require adopting and promoting energy sources that can meet the extensive energy requirements and save energy for future generations (Ali et al. 2021). Developing countries face a major challenge of energy poverty for men and women; approximately 1.2 billion people live without household electricity (Gray et al. 2018). Green technology positively impacts cleaner production and renewable energy (RE) projects. Currently, every country can increase the speed of its success by proficiently maintaining its demand and supply of energy (Iqbal et al. 2018). Solar power Europe has determined that the global solar capacity will reach 900 GW by the end of 2021.

Moreover, the grid-connected solar power capacities will reach 1870 GW by 2025. Under optimal conditions, the

world can operate photovoltaic (PV) generation plant capacity, with 2147 at the end of 2025 (IRENA 2020). The present study is a contribution of SHSs to the success of small-scale enterprises in the country's economy. Solar PV and wind turbine renewable electricity generation is a cheaper energy source. Project costs of both energy sources are estimated to decrease significantly in the future. Pakistan has expensive hydropower and thermal plants (Global solar council 2021). Compared with all other alternative energy sources, solar energy is considered robust, active, and available proceeding the Earth matched to bases (Nicholas and Buckley 2018). Countrywide, Pakistan has a solar isolation of  $5.5 \text{ Wh m}^{-2} \text{ day}^{-1}$  and an annual mean sunlight duration of  $8\text{--}10 \text{ h day}^{-1}$ . In the coastal parts of Baluchistan and Sindh, the wind speed ranges from  $5$  to  $7 \text{ m s}^{-1}$  (Ali et al. 2022a; Ghafoor et al. 2016). The average cost of installing a solar panel with a small capacity is between PRs. 8000 and PRs. 13,599. Another cost associated with solar panels is their breakdown. In Pakistan, the prices for 410-W solar panels, 540-W solar panels, 485-W solar panels, and 250-W mono solar panels are PKR18,900, 23,750, 22,800, and 14,000, respectively. You can operate without difficulty installing a 5-kW solar system. A 5-kW solar system may generate up to 16 to 20 kWh per day, which equates to approximately 500 to 600 kWh per month. A 10-kW solar system can generate approximately 1100 to 1200 power each month, or 36 to 40 units per day.

In contrast, solar systems have variable pricing, such as 5 kW for 90,000 PKR and 10 kW for 125,000 PKR including the Green Meter. The financial benefit of solar energy is immense significant savings on electricity bills, solar panel components require zero maintenance, residential solar system installations can increase property value, residential solar system owners are eligible for government incentives, and solar home systems enable small-scale businesses to generate their electricity and reduce their reliance on the grid. RE is a cost-effective energy source, such as SHSs, which can bring high profitability to small-scale businesses due to low-cost energy sources (Yang et al. 2022). Table 1 compares fossil fuel-based energy cost/unit and RE-based cost/unit.

The sustainable development of solar energy projects requires assessing green financing and COVID-19 risks to promote the small-scale industry in the country. There is a need to adopt a solar home system (SHS) to develop small-scale industries in Pakistan. The government needs to improve and develop SHSs for the solid financial performance of the small-scale industry. The energy demand is increasing, which is considered one of the world's decisive complications (Awan and Knight 2020). The performance is needed to measure SHSs regarding low-cost energy and enhanced profitability for small-scale industries in Pakistan. It is necessary to conduct studies that focus on low-cost-based energy. The energy shortfall seriously affects non-professional and professional activities and personal lives (Rafique and Rehman 2017). The governments of developing countries have focused on policy strategies to expand and facilitate renewable energy.

Like other underdeveloped countries, massive power is required to support industry and the large population in Pakistan (NEPRA 2018). Pakistan's electricity demand and supply gap have been uncontrolled in the past few years. In Pakistan, policymakers need to adopt and support those RE sources that can increase the energy demand by replacing fossil fuel-based energy such as oil, gas, and coal. Energy poverty mitigation is inspired by the low-carbon energy revolution, energy efficiency, affordability, clean energy consumption, and reduced poverty under energy availability (Abdelhady 2021). The unexpected or expected fluctuations can be mitigated through adverse impacts on neighboring markets' natural gas and oil (Wu et al. 2021a, b). The current study discussed the RE policy-level problems. The country needs to provide an uninterrupted energy supply to its citizens. Current energy production sources in Pakistan are insufficient to meet the country's rising energy demands. A reliable energy supply can play an active part in developing the financial position through industry progress. Proper policy guidelines are necessary to adopt solar projects in the industrial sector. Several economic and other risk factors must be accommodated and adjusted with these guidelines (Elavarasan et al. 2021).

**Table 1** Per unit energy cost comparison

Households and selected businesses	Fossil fuel-based energy cost/unit	RE-based cost/unit	SHS energy-based cost/unit
Households	25.40 PKR per kWh	15.20 PKR per kWh	12.25 PKR per kWh
Furniture manufacturing	41.5 PKR per kWh	21.35 PKR per kWh	17.50 PKR per kWh
Food bakeries	42.5	21.35	17.50
Book making sector	44.5	21.35	17.50
Fast food making sector	40.5	21.35	17.50
Hotel industry	43.5	21.35	17.50

To ensure sustainable economic growth in Pakistan, conservative and conventional energy generation technologies must replace renewable energy sources. The RE policy of Pakistan has many positive features. However, the facts show that all these features cannot justify Pakistan's vigorous and significant energy growth. The RE policy has failed to address significant issues effectively, even though some have been accepted in the policy framework. Still, RE policy is facing challenges in the country. One of the reasons for to slow acceptance of renewable energy technology (RET) is the lack of competition with conventional power generation in the country. The present study addresses the policy issue of lack of competition with conventional power generation due to the high capital cost of RE projects. The low installation cost of capital for solar power projects can attract investors and beat the economic comparisons. We expect the government to reduce the subsidy from conventional power generation and provide to the RE sector for small-scale business enterprises. The study has prodigious importance to the investors of Pakistan and the developing world because the study suggestions can play an energetic character in enhancing the concert of small-scale industries by adopting low-cost energy sources (SHS).

In this study, we assessed the performance of SHSs regarding low-cost energy and enhanced profitability for small-scale industries in Pakistan. It is necessary to conduct studies that focus on low-cost-based energy. The owners of small-scale industries face a heavy burden due to electricity bills. They even cannot afford this expensive source of electricity and looking for an affordable source of energy. We evaluate the impact of SHSs on small-scale enterprises for their betterment in profit, performance, and cost-related satisfaction. The study has explored that SHSs positively and significantly affect small-scale industries to increase their profit and performance in the study area. The main object of the study is to create awareness and cost affordability regarding SHSs for small-scale industry owners so that they can play an active part in the national economy. The owners of small-scale enterprises are looking for a low-cost and affordable energy source in Pakistan. An SHS is a valuable source to condense the abovementioned energy supply and demand gap. It is also beneficial for the household's energy demand in remote areas and the small-scale industries located in the zones either connected or not connected with the grid. These industries include where the production, manufacturing, and rendering of services assume a micro or small scale. Our study examines the contribution of SHSs to the success of small-scale enterprises in the country's economy. Pakistan is an emerging economy in Asia. It is a highly diverse economy. The small-scale industries cover 90% of the businesses in Pakistan, and they employ 83% of the workforce in the manufacturing industries. The central portion of the economy consists of small-scale established

industries carried by single persons or partners in limited numbers. In the modern age, where electrification through the grid is not possible or minor, the introduction of SHSs has revolutionized. It is only valuable for households, but it has also made an outstanding contribution to the functioning and success of small-scale enterprises. SHS is the cheapest energy source, encouraged in small-scale industries with weak financial positions. Small-scale enterprises successfully achieve better performance because of their low-cost energy, enhanced energy supply, and durability (Duan et al. 2021). The present study is the first one that was conducted to evaluate the performance of SHSs to increase the profitability of the small-scale industry in Pakistan.

Many research studies have been conducted on the energy crisis (Dong et al. 2021; Hao et al. 2023; Wu et al. 2021a, b; Yang et al. 2021), solar energy site selections, and solar energy projects (Ali et al. 2022a; Rena et al. 2019). Still, the literature has a gap concerning adopting solar home systems (SHSs) to develop the small-scale industry. There is a lack of literature regarding the impact of SHSs on increasing the financial performance of the small-scale industry. In Pakistan, previous studies (Iqbal et al. 2018) concerning alternative energy have not focused on this issue primarily; they pin-pointed (i) sources of alternative energy generation, (ii) the direction of the upcoming energy sector, (iii) introduction of alternative energy with arguments, (iv) valuation of the whole energy subdivision in the nation-state, (v) energy combination or assortment, and (vi) demand and supply gap of energy. Although the previous researchers have taken a keen interest in the energy sector, all these studies have some specific gaps, e.g., (i) encouraging the adoption of a solar home system to increase the financial performance of the small-scale industry in Pakistan, (ii) the sustainable development of the local small-scale industry through adopting solar home systems, (iii) it is the alternative of electricity issues to adopting solar home systems to increase the performance of the small-scale or household industry, and (iv) there is a need for green investment through the solar home system to increase the financial performance of the small-scale industry in the country. Due to current study openings, the present research needs to discourse the subsequent queries for research contribution: (i) evaluate the importance of green investment in the solar home system to increase the financial performance and development of the small-scale industry in Pakistan, (ii) highlight the significance of green investment to adopt the solar home system for the development of the small-scale industry, and (iii) empirically explore the moderating part of awareness and understanding to adopt the solar home systems for the financial performance of the small-scale industry.

This research paper is categorized into sections: “Literature review” section discusses the literature review. “Formulation of hypotheses” section describes the formation

of hypotheses with a theoretical background that reflects the research methodology. “[Analysis and results](#)” section defines data analysis with the results. “[Discussion](#)” section discusses. Finally, “[Conclusions and policy implications](#)” section summarizes the study, including limitations and future directions.

## Literature review

Reliable energy resources are needed in modern life to perform routine activities (Dogan et al. 2020; Irfan et al. 2022; Isik et al. 2021); however, Pakistan’s energy sector faces a severe energy crisis, destroying the national economy. The expert and non-expert activities of the people of Pakistan are disturbing due to a severe energy shortage. The introduction of SHSs is evident in numerous industries and households in areas not connected to the electricity grid or where electrification through the grid is limited in benefits. The SHS helps run lower-power appliances with a 12 V direct current (D.C.). Some power conditioners/inverters change the 12/24 V power into 240 V alternating current (VAC) power and help to run larger power appliances. There is a need to adopt a solar home system (SHS) to develop small-scale industries in Pakistan. The government needs to improve and develop SHSs for the solid financial performance of the small-scale industry. The increasing importance of SHSs as an energy source in industry households forces researchers and scholars to make SHSs their topic of discussion and debate about the appliances such as heaters, lights, small plants, TVs, and computers; SHSs have an energy capacity of 5 h a day (GoP. government of Pakistan 2021). Scholars such as Ullah et al. (2020) have analyzed the contribution of SHSs to the operational and financial performance of small-scale industries with fewer investments in business functions. Our study examines the contribution of low-cost energy of SHSs, enhanced energy through SHSs, and the quality of SHSs to the performance of small-scale industries.

Solar home systems (SHSs) are the best energy source from this point of view. SHS is an impartial photovoltaic energy system that presents a cost-effective way of supplying a large amount of power for diverse appliances, such as lighting, to off-grid households in remote areas. In the rural areas where the electric grid is still unable to reach, SHSs can apply to meet household energy requirements, meeting fundamental electric needs. Globally, SHSs are a source of power to numerous homes in remote localities where electrification through the grid is not possible or limited (Jan et al. 2021). Cost occurs at installation or repair, but there is no periodical cost that the enterprises have to bear for operating electric appliances in business operations. Millions of SHSs have been installed for increasing electrification in the rural areas of Latin America, Asia, and Africa. Worldwide

studies support installing SHSs to increase the electricity supply for rural areas at a low cost, which is a significant challenge (SAARC 2020). The SHS is needed worldwide to enhance prosperity and change the economic position of the rural population. The energy generated through SHSs is inexpensive as, in the case of installing solar panels to meet the energy requirements, power can be attained free of charge. The stand-alone rooftop SHSs can minimize energy costs. Rooftop SHSs can decrease the total cost of energy, and the per-unit cost is around USD 0.211, and there are no additional fuel charges. Installing standalone rooftop SHSs can earn an income within a few years. SHSs can reduce fossil fuel load pressure, minimize greenhouse gas emissions, and promote a green environment (Khan et al. 2005). RE is a cost-effective energy source, such as SHSs, which can bring high profitability to small-scale businesses due to low-cost energy sources.

The low-cost energy of SHSs associated with the performance of small-scale industries is checked in the study (Ahmad and Balkhyour 2020; Khattak et al. 2006). The SHSs have an essential role in the sustainable energy supply using microfinance in the poor rural areas of Myanmar and Bangladesh. The SHS is economically efficient in enhancing the electricity supply and has achieved a 15–18% renewable energy installed capacity goal by 2020 (Balkhyour et al. 2018). Consequently, the enhanced energy supply through SHSs enables small-scale industries to show better operational and financial performance (Mujaddad and Ahmad 2016). The RE policy has failed to address significant issues effectively, even though some have been accepted in the policy framework. Still, RE policy is facing challenges in the country. One of the reasons for to slow acceptance of renewable energy technology (RET) is the lack of competition with conventional power generation in the country (Ali et al. 2022c). The invention of the solar energy storage system has enhanced the energy supply through SHSs. This enhanced energy is used in small-scale industries to run diverse electric appliances and make their functions smooth and feasible. Their activities, such as operational and financial performance, have improved (Perpiña et al. 2020). Energy generation through SHSs is proven low-cost energy and can enhance the country’s economic position of small-scale industry and sustainable economic development.

The quality of SHSs and the performance of small-scale industries are excellent contributions to the literature. However, SHS information enables the managers to acquire quality solar panels and related instruments which offer enough energy to meet internal and external energy needs. The present study addresses the policy issue of lack of competition with conventional power generation due to the high capital cost of RE projects. The low installation cost of capital for solar power projects can attract investors and beat the economic comparisons. The awareness of SHS products is high,

and the education level is high, but there is a massive gap between the perceived price of SHSs and the market price of SHSs in Uttar Pradesh, India (Kamran 2018). The quality of SHSs can enhance the satisfaction level of small-scale business owners and investors; the country's government needs to ensure the quality of the SHS. A study (Adwek et al. 2020) demonstrates that awareness and understanding of the SHS can assist professionals in installing the panels. The information exploits them to obtain a lot of solar energy from the sun's waves in the minimum time. Thus, the business processes can run smoothly without any hurdles and with great effectiveness as there is enough energy to run technologies. 60.3% of respondents are aware of their solar systems and their maintenance, but 76% are aware of non-functional solar systems in Nigeria (Rafique et al. 2020). The owners of small-scale industries face a heavy burden due to electricity bills. They even cannot afford this expensive source of electricity and looking for an affordable source of energy. We evaluate the impact of SHSs on small-scale enterprises for their betterment in profit, performance, and cost-related satisfaction. The study has explored that SHSs positively and significantly affect small-scale industries to increase their profit and performance in the study area. The awareness of the SHS in operational activities is essential for small-scale businesses to enhance profitability, which is also proved in the literature.

A study (Khan et al. 2020) posits that the awareness and understanding of business needs, installation, features, and working determines the quality of the solar panels applied for domestic or commercial use. This study (NEPRA 2018) expresses the process of controlling the capacity of SHSs, and the system operating knowledge can improve the speed and durability of SHSs. The durability and improved efficiency of the SHS can enhance the output of small-scale enterprises and business effectiveness by achieving competitive advantages over rivals. A study (Zubi et al. 2017) expresses that small-scale industries' production, operation, and financial performance depend on SHSs. This awareness helps make decisions regarding the procurement of solar panels and related tools, their installation, and their usage to meet energy needs. In this case, the quality of the SHS improves and increases the effectiveness of the business. The low-cost and transparent policy encourages the general public to adopt SHS significantly and favorably (Ali et al. 2022b). Pakistan is experiencing a plain energy disaster, which consumes detrimental effects on the domestic budget. The energy provided through SHSs is a low-cost and profit-earning energy for small-scale industries. It ultimately plays an extraordinary role in the country's sustainable economic development. Past studies such as Ali et al. (2022b) and Ali et al. (2022a) show the moderator effect of awareness and understanding of underlying factors in the performance of small-scale industries. Small-scale industries are divided

into manufacturing and ancillary industries; other than these kinds of small-scale industries that have continued their professional for countless ages and are from diverse productions, exploration the furniture manufacturing, food bakeries, book making sector, fast food making sector, and hotel industry.

The main object of the study is to create awareness and cost affordability regarding SHSs for small-scale industry owners so that they can play a dynamic character in the nation's economy. The financial resources of these industries are limited. The installation of SHSs proves beneficial to small-scale industries in achieving high operational and financial performance. This energy source keeps their business activities fluent, reduces energy expenses and per-unit costs, and has more profitability in operating results (Barman et al. 2017). The small-scale industry can boost up by adopting SHSs due to cost-effective energy sources with low capital costs when installing solar projects. The government needs to effect change in RE policy by the government to develop the small-scale industry. Adopting an SHS benefits the owner, including lower kerosene consumption and providing health and financial benefits to business and household women (López-vargas et al. 2021). Different SHSs have different qualities and features, including high quality, high durability, low maintenance requirements, high voltage power, and significant safety for health. The system can convert solar power into electric or thermal power fast and store solar energy for future needs, which is helpful in small-scale industries to achieve high operational and financial performance (Hossain et al. 2019). Full-service and plug-and-play SHSs offer high quality, while component-based match-and-mix systems offer low quality at a low cost (Charles et al. 2018). Our study aims to address the low-cost energy of SHSs, enhanced quality, profitability, and power supply as determiners of small-scale industries' operational and financial performance.

The SHS provides energy at a low cost to small-scale industries; thus, it helps meet their energy needs on a minimum budget and improves overall performance. Similarly, the enhanced energy supply through SHSs meets the energy needs of small-scale industries, gives permanent survival, and helps them carry out their functions smoothly. High-quality SHS improves small-scale industries' functioning quality and financial performance (Shaughnessy et al. 2019). Solar photovoltaic systems impact the lives of individuals and small-scale businesses, including the health of individuals, the education of children, social relations, livelihoods, and businesses' financial position (Newcombe and Ko 2017). The energy produced through SHSs is an inexpensive source of energy that can change the economic position of the people living in rural areas and the owner of small-scale industries. The SHS can provide 100% rural electrification for telecommunication, lighting, and self-support business

with the help of tontine financing. The tontine is a concept in which SHSs are delivered to the far-off rural areas of developing countries. The primary purpose of this tool is to provide low-cost electricity through SHSs, replacing kerosene lamps and candles, but not with the help of banks and savings (Khan 2019). Similarly, the excellent quality of SHSs can meet energy requirements in a better way and helps to save money, minimize maintenance costs, and provide health safety. It reduces the small-scale industries' per-unit cost and increases their profitability and financial performance (Charles et al. 2018).

SHSs are not required to pay any bill on electricity generated through the application of SHSs as we are bound to pay monthly bills using electricity meters. In applying SHSs, small-scale industries with limited financial sources are better positioned to handle all financial matters (Narayan et al. 2018). The SHS is an attractive energy source for business owners who perform extra-earning activities such as mobile phones or mobile charging businesses. SHS can play a vital role in increasing energy access and reducing dependency on fossil fuels in Bangladesh. The installed SHS reduces energy costs and CO<sub>2</sub> emissions (Adeyemi et al. 2020). It is not costly as it uses a natural source to generate energy instead of expensive raw material. Installing the solar energy system (SHS) requires money; afterward, it does not require much maintenance. We need to clean it only twice a year. We do not have to bear expenses or some billing as we have to bear in applying other energy sources. The amount saved in this way can be used in small-scale industries in other different business operations. Thus, installing an SHS improves small-scale industries' financial position and performance (Gandini and Almeida 2017). In light of past studies, we can say that SHS is the best energy source that is inexpensive and cost-effective for small-scale industries and Punjab's rural areas. This energy source is the best choice for small-scale industries to increase their profit and surviving period and increase sustainable development in the country.

The benefits of SHSs include a higher level of satisfaction for the business's profit, increasing the quality of SHS equipment, and increased children's study time (Ali et al. 2019). Electrification through SHSs provides direct and indirect benefits to small-scale business owners, such as reducing the use of kerosene and increasing the income of traditional fuel users due to converting solar light. The SHS electrification provides overall satisfaction for small-scale industries and comfort to the users (Mandal et al. 2018). This study has proposed a guideline to the regulation developing authorities that more attention is needed to focus on SHS usage and improve the performance of the small-scale industry. The SHSs can increase sustainability and economic viability through suitable social awareness, local technician availability, and influential energy committees, which positively and significantly affect small-scale businesses. Small-scale

business owners have improved the productivity of their businesses by adopting SHSs for light and production purposes at night (Yadav et al. 2019).

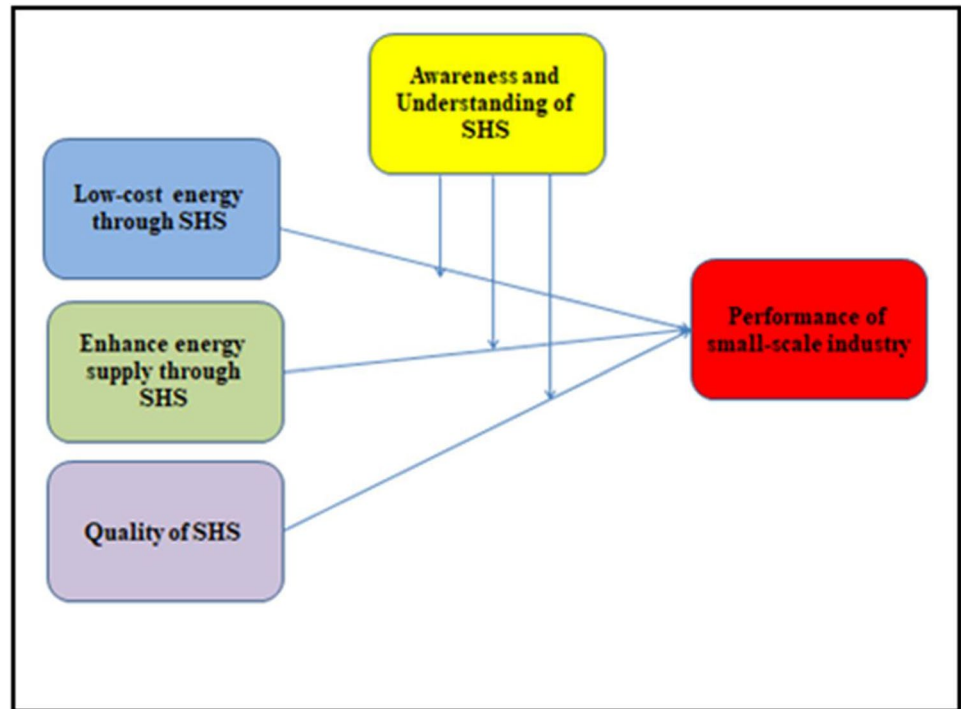
The research study (Opiyo 2019) shows the advantages of SHSs in the small-scale industry. This study implies that SHSs generate electricity or heat to run appliances requiring a low power voltage. After installing an SHS, no periodical payments, daily or monthly, must be made. Thus, the energy generated through an SHS is low cost, and the money saved can be used in the business operation in another way. The healthy and helpful debate of this literature shows that adopting SHSs is very profitable and can remove the poverty level in developing countries due to the satisfactory performance of the small-scale industry. Solar energy is considered an incredible potential energy source due to zero levels of emission production. Due to a reliable energy source, various devices can be connected using clean energy. The solar home system encourages the adoption of RE to increase the financial performance of the small-scale industry in Pakistan, and it can enhance the sustainable development of the local small-scale industry. SHSs are the alternative to electricity issues to increase the performance of the small-scale or household industry. There is a need for green investment through the solar home system to increase the financial performance of the small-scale industry in the country. Figure 1 indicates the conceptual framework and moderation effect based on the above discussion. The current study has used three predictors with moderating relationship testing. The results of the hypotheses are shown in the data analysis section in Table 5. The hypotheses include awareness and understanding of SHS (AU), enhanced energy supply through SHS (EES), low-cost energy (LCE), the performance of the small-scale industry (PSSI), and quality of SHS (QSHS). As a result, the performance of small-scale industries is high.

## Formulation of hypotheses

### Low-cost energy and performance of the small-scale industry

The energy generated through SHS is low cost, as in the case of the installation of solar panels to meet the energy requirements, energy can be attained free of cost. We are not required to pay any bill for using electricity generated through the application of SHS as we are bound to pay monthly bills using electricity meters. With the application of SHS, small-scale industries with limited financial sources are in a better position to handle all their financial matters (Halder 2016). SHS is a renewable energy source. It takes energy from the sun and generates electricity (photovoltaic) and heat (solar thermal), which can run different appliances.

Fig. 1 Conceptual framework



It is not costly as it uses a natural source to generate energy instead of any costly raw material. Installing a solar energy system (SHS) requires money, and afterward, it does not require much maintenance (Ali et al. 2021). We need to clean it only twice a year. We do not have to bear expenses or some billing as we have to bear in case of applying other energy sources. The amount saved in this way can be used in small-scale industries in other business operations. Thus, installing SHS improves small-scale industries' financial position and performance (Diouf and Avis 2019).

H1: The low-cost energy of SHS has an optimistic association with the concert of small-scale industries.

### Energy supply through SHS and performance of the small-scale industry

The acquisition of energy through SHS has enabled small-scale industries in remote off-grid areas or areas where the electricity through the grid is less supplied to meet the energy needs and run their business activities smoothly. Different kinds of technology requiring a low voltage can be run through the power generated through SHS, such as lightning appliances, fans, water pumps, heaters, computers, and printers. In small-scale industries, electric appliances requiring a low power voltage are mainly used to carry the business activities. Thus, the enhanced energy supply through SHS enables small-scale industries to show better operational and financial performance (Charles et al. 2018). As the world

is getting modern with time, such solar panels are being introduced into the market, which can provide relatively high voltage power and better meet the energy requirements of small-scale, financially weak industries compared to grand-scale industries. Moreover, some well-known companies have introduced solar energy storage systems to complement the SHS. The invention of the solar energy storage system has enhanced the energy supply through SHS. This enhanced energy is used in small-scale industries to run diverse electric appliances and make their functions smooth and feasible. Their operational and financial performance has improved (Yadav et al. 2020). Thus:

H2: Enhanced energy supply through SHS positively affects the performance of small-scale industries.

### Quality of SHS and performance of the small-scale industry

Different SHSs have different qualities like durability, maintenance requirement, voltage power generation, speed to convert solar power into electric power, health safety, and the attachment of solar energy storage systems. The SHSs have high quality; in other words, the SHSs have high durability, low maintenance requirements, provision high voltage power, are highly safe for health, can convert solar power into electric or thermal power fast, and store solar energy for future needs, are helpful in small-scale industries to achieve high operational and financial

performance (Chowdhury and Mourshed 2016). Suppose the applied SHS can generate high voltage power and convert the solar power into electric power fast. In that case, small-scale industries can perform business activities fast and respond to market requirements. If the SHS can store the energy, the small-scale industries do not worry about the energy needs and can preplan their future activities. Similarly, a good quality SHS better meets the energy requirements and helps save money, minimize maintenance costs, and have healthy safety. It reduces the per-unit cost of small-scale industries and increases their profitability and financial performance (Newcombe and Ko 2017). Hence:

H3: The quality of SHS is linked with the performance of small-scale industries in a positive manner.

### **The awareness and understanding of SHS and the performance of the small-scale industry**

In the areas where people have sufficient awareness and understanding of SHS, small-scale industries can benefit from SHS and improve their operational, production, and financial performance. The awareness and understanding in the personnel of small-scale industries about the inventions, needs, installation, working, and quality of SHS result in harnessing low-cost energy from SHS, more enhanced energy supply through SHS, and in the application of better quality solar systems and the achievement of the superior performance of small-scale industries (Sovacool 2018). The small industries have awareness and understanding that SHS can use solar energy systems for energy purposes in such a way that they do not require repairing again and again and give less costly energy. The inexpensive energy through SHS reduces the small-scale industries' expenses and improves profitability and overall performance of small-scale industries. Similarly, the awareness and understanding of SHS enable small-scale industries to install such panels. In this way, these solar panels give high voltage power in a large amount that can better meet industries' energy requirements. When the personnel of small-scale industries has better awareness and understanding of SHS, they can purchase better quality solar panels, giving more energy at a low cost, whose installation and further maintenance do not require considerable amounts and have solar energy storage system (Abdullah et al. 2017). The quality of the SHS improves the operational and financial performance of small-scale industries.

H4: The awareness and understanding of SHS are significant moderators between the low-cost energy of SHS and the performance of small-scale industries.

H5: The awareness and understanding of SHS are significant moderators between the enhanced energy through SHS and small-scale industries' performance.

H6: The awareness and understanding of SHS are significant moderators between SHS quality and the performance of small-scale industries.

## **Research methodology**

Purposive or non-probability sampling was used in the current study for the performance of the small-scale industry through SHSs in Pakistan. In the research study, this sampling method did not provide an equal opportunity for all population members. Purposive sampling is utilized for specific demographic features and pilot, qualitative, or exploratory research. There are five primary non-probability sampling strategies: quota sampling, snowball sampling, purposive sampling, voluntary response sampling, and convenience sampling. We have selected small-scale industries as a part of this study on an SHS's performance and quality. The study adopted specific criteria to present our sample of small-scale businesses in Pakistan: (i) include small-scale industries that have continued their business for many years and are from four cities (Lahore, Multan, Faisalabad, and Gujranwala), Pakistan. This research study includes diverse industries, including furniture manufacturing, food bakeries, bookmaking, fast food making, and hotel industries. A hierarchy was followed while selecting small-scale businesses where a minimum of five and a maximum of nineteen employees are working in the chosen industries (Stojanovski et al. 2017). (ii) The small-scale industries must have a 2.5 lac per day turnover in RMB. The authors surveyed from April to September (2021) to complete the research purpose; there was a fourth wave of coronavirus (COVID-19), named the delta variant virus, in Pakistan (Chowdhury and Mourshed 2016; Komatsu et al. 2013). It was challenging to obtain information from related respondents due to the pandemic situation, and mobile applications (e.g., WhatsApp, Facebook, and LinkedIn) were used to send the questionnaire.

## **Instruments and procedure**

This study used questionnaires that comprised 23 measurement items and required a minor collection level of 115 (23\*5) useful questionnaires. The past study (Groenewoudt et al. 2020) recommended the rule of thumb for the proposed sample size used in this study. In this regard, 570 questionnaires were distributed to small industry owners using SHSs, 487 were returned, and 357 were useable for analysis. The response rate was 62.63%; however, the researchers deleted 83 surveys because of unmatched and poor responses. The demographic characteristics of the respondents, including



age, experience, income, and gender, as well as their various backgrounds, give the appropriate response in this study (see Appendix, Table A1). In addition, all delegates have diverse business experience and demographic characteristics. In addition, a purposive sample was used to recruit respondents for this study from four cities in Pakistan, including respondents with varied cultural and behavioral backgrounds. Purposive sampling is used to access the entire population and fits theoretical generalization (Lemaire 2018). The ongoing research investigates the impact of SHSs on the performance of the small-scale industry. The other primary aim of this research includes investigating the moderating effect of awareness and understanding of SHS among the links of low-cost energy through SHS, enhanced energy supply through SHS, quality of SHS, and performance of small-scale industry of Pakistan. The study followed quantitative data collection methods and received the data using questionnaires. The owners of the small-scale industry sector use the solar system for production. Respondents were selected based on purposive sampling. The present study utilized the usual 5-category scale, in which one always represents and five never expresses. The first half of the questionnaire pertains to the respondent's personal information. In contrast, the second piece is concerned with the characteristics of the SHS, such as quality, cost, and energy supply. In addition, the last segment of the questionnaire connected to the changes in the small-scale industry's performance due to SHSs. The current

research has taken three predictors, such as low-cost energy through SHS (LCESHS) with four items, enhanced energy supply through SHS (EESHS) with six items, and quality of SHS (QSHS) with four things. In addition, the performance of the small-scale industry (PSSI) engaged as a reliant on adaptable with five items and awareness and understanding of SHS (AUSHS) has taken four things as moderators. These constructs, along with the nexus, are shown in Table 2.

### Measurement instrument and variables

In this study, all items from previous research have been incorporated. Items constructed on awareness and understanding were constructed from the study (Diouf 2016). Things regarding low-cost energy were adopted (Bisaga et al. 2019). Items related to enhancing energy supply through SHSs were adopted (Halder 2016). Objects related to SHS quality were constructed based on Hoque and Das (2013). Items that belong to the performance of small-scale industries were adopted (Diouf and Avis 2019). For this purpose, two professional translators were hired; first, questionnaires were converted into the native language, i.e., Urdu. Given the proposal of 62, a second translator translated these statements from the native language into English. There were no substantial discrepancies in the translation. However, a few grammatical errors were discovered and corrected. Finally, data collection questionnaires were issued in the local language.

**Table 2** Convergent validity

Constructs	Items	Loadings	Alpha	CR	AVE
Awareness and understanding of SHS	AU(SHS)1	0.885	0.845	0.820	0.536
	AU(SHS)2	0.670			
	AU(SHS)3	0.677			
	AU(SHS)4	0.675			
Enhanced energy supply through SHS	EES(SHS)1	0.912	0.944	0.956	0.782
	EES(SHS)2	0.823			
	EES(SHS)3	0.905			
	EES(SHS)4	0.904			
	EES(SHS)5	0.912			
	EES(SHS)6	0.846			
Low-cost energy through SHS	LCE(SHS)1	0.880	0.909	0.936	0.785
	LCE(SHS)2	0.879			
	LCE(SHS)3	0.888			
	LCE(SHS)4	0.896			
Performance of small-scale industry	PSSI1	0.808	0.889	0.918	0.692
	PSSI2	0.818			
	PSSI3	0.854			
	PSSI4	0.817			
	PSSI5	0.863			
Quality of SHS	QSHS1	0.958	0.966	0.975	0.908
	QSHS2	0.943			
	QSHS3	0.952			
	QSHS4	0.959			

## Analysis and results

Structural equation modeling (SEM) was used for data analysis in the present investigation (Mondal and Klein 2011). We use this approach to examine the interpersonal proportions because it is considered factor attentive (Azimoh et al. 2015). Many studies have adopted PLS-SEM; we have used this method based on the evidence of these subsequent studies (Abdullah et al. 2017; Aberilla et al. 2019). The traditional statistical analysis approach is less important than structural equation modeling (SEM). It can facilitate the statistical analysis concerning convenience, accuracy, and efficiency (Ali et al. 2014; Ghafoor et al. 2016). SEM is a second-generation technique that solves the issues of first-generation studies. SEM is a multivariate investigation method that may investigate numerous variables concurrently. SEM can instantaneously deal with several compound interactions in business research; thus, it is continuously popular (Pakistan economic survey 2021). There are two categories of well-known SEM techniques: first, partial least square (PLS)-SEM or variance-based SEM (VB-SBM); second, most minor absolute deviation (LAD)-SEM, covariance-based SEM (CB-SBM). Measurement and structural models are two analytical techniques in PLS-SEM that display measurement findings in two phases (Akbar et al. 2019). The measurement assessment model has two tests: evaluation of the inner model or dependability and validity. On the other hand, the structural assessment model has hypotheses testing or evaluating the outer model. The current study has applied PLS 3.0 software for significant data analysis. Furthermore, covariance-based structural equation modeling has low potential than partial least square path modeling. PLS-SEM can break relationships among the variables and is more beneficial.

### Measurement assessment model

Reliability and validity tests are required for each measurement assessment model's provided constructs. The measuring model confirms the validity and reliability. All of the factor loadings for model are approved. The measurement evaluation model requires item reliability tests and internal consistency reliability. The model includes convergent and discriminant validity under validity tests (Amado and Poggi 2014). The average variance extracted (AVE) can measure convergent validity, the composite reliability (CR) can measure internal consistency, and outer loading can measure item reliability. The threshold value of all item loadings is well up to 0.5 (Sarker et al. 2020) (see Table 2). The averaged factor loadings in this investigation were more significant than 0.50; the analysis provided it, and each observation can contribute to a constructed variable (Urban and Heydenrych

2015). All values of AVE exceed the recommended assessment of 0.5. The average value surpasses the composite reliability under the threshold value of 0.7; the measurements are accurate, as the study indicated (Brislin 1970). In the present research, the values of results designate that completely the standards of AVE are 0.536 (awareness and understanding of SHS) and 0.908 (quality of SHS), and CR values are between 0.820 (awareness and understanding) and 0.975 (quality of SHS). All additional loading values are between 0.5 and 0.959.

Table 2 displays the measurement model's validated validity and reliability results. The present mode shows how the variables are loaded with factors. The significance of each factor loading value is greater than (0.50). The measurement assessment model shows the convergent rationality of entire substances is effective. The path analysis was facilitated among the variables. The study results have confirmed that low-cost energy through SHS, enhanced energy supply through SHS, and quality of SHS have positive nexus with the small-scale industry of Pakistan. Hypotheses H1, H2, and H3 are accepted. The outcomes likewise revealed that awareness and understanding of SHS suggestively moderated amid the links enhanced energy supply through SHS, quality of SHS, and performance of small-scale industry of Pakistan and accepted H5 and H6. However, the findings also exposed that awareness and understanding of SHS are insignificantly moderated among the energy of the low-cost link through SHS and performance of small-scale industry of Pakistan and rejected H4. The measurement model first demonstrated the nexus's convergent validity among the items. According to the results, loadings and AVE are greater than 0.50, whereas composite reliability (CR) values and alpha are more significant than 0.70. These numbers show that the items' convergent validity—their strong correlation—is valid.

The outcome segment has similarly exposed, in Table 3, the discriminant rationality of the variables' interconnection. Firstly, the discriminant validity was checked through Fornell-Larcker and cross-loadings. The values reflecting the variables' links are higher than those with other variables in Fig. 2, which shows these values. The results reveal that the discriminant validity is sound, and there is little correlation between the variables. Table 4's bold values demonstrate that all components have both strong and weak correlations with one another. The bold values in the cross-loadings table are compared row-wise with other factors in the test discriminant validity. The AU(SHS) values are more significant than other factors row-wise and show strong discriminant validity. The bold numbers in Table 4 are smaller than the other left and correct values.

Numerous scholars have questioned the Fornell-Larcker criterion. Therefore, the heterotrait-monotrait ratio of correlations (HTMT) is considered suitable for measuring

**Table 3** Fornell-Larcker analysis

	AU(SHS)	EES(SHS)	LCE(SHS)	PSSI	QSHS
AU(SHS)	0.732				
EES(SHS)	0.394	0.831			
LCE(SHS)	0.335	0.385	0.824		
PSSI	0.325	0.507	0.371	0.832	
QSHS	0.726	0.470	0.384	0.408	0.841

*N*=357; *AU*, awareness and understanding of SHS; *EES*, enhance energy supply through SHS; *LCE*, low-cost energy; *PSSI*, performance of small-scale industry; *QSHS*, quality of SHS

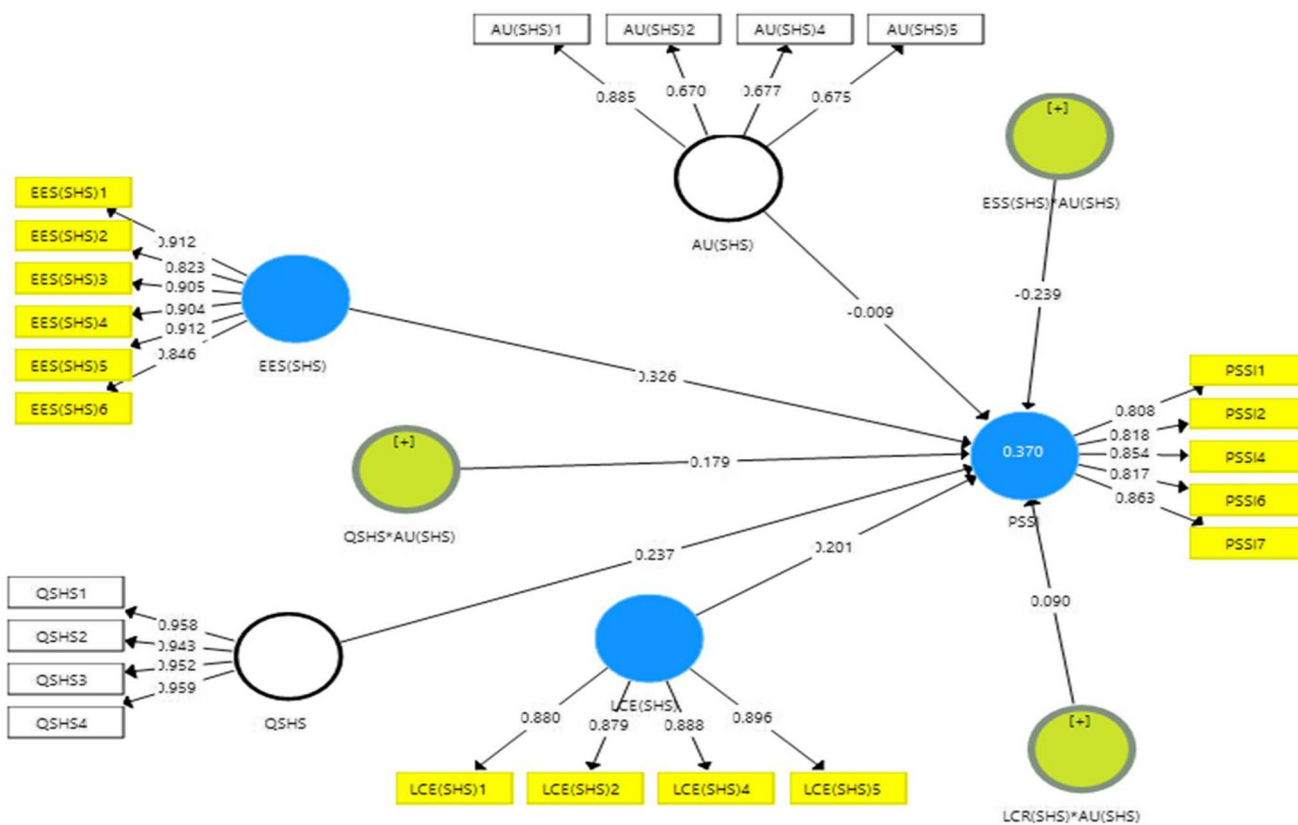
discriminant validity (Wang et al. 2020). Less than 0.85 is the confirmed value of discriminant validity or 0.90 (Urbach and Ahlemann 2010). The total values in Table 5 are less than 0.90. The findings section also highlights how the factors of discriminant validity are related to one another. The values are highlighted in Table 5.

**Structural assessment model**

We measured the measurement assessment model; in the second round, the link between exogenous and endogenous factors is examined using the structural assessment model.

The evaluation of the structural model is based on various statistical metrics, such as  $f^2$  shows effect size,  $Q^2$  indicating predictive relevance,  $R^2$  expressing the coefficient of determination,  $t$  values, and  $\beta$  values displaying path coefficient. The PLS-SEM literature includes evaluation criteria for hypotheses and path coefficient significance estimates (Wang et al. 2020). The bootstrapping procedure was active through 5000 sub-samples to test the significance level of the hypotheses, based on a 5% one-tailed significance level [81]. All hypotheses are accepted, which is discussed in the results. Low-cost energy ( $\beta=0.326, t=5.105 > 1.64, p < 0.05$ ), low-cost energy association (moderator) ( $\beta=0.095, t=1.599 > 1.64, p < 0.05$ ), enhance energy supply ( $\beta=-0.239, t=3.681 > 1.64, p < 0.05$ ), enhance energy association (moderator) ( $\beta=0.237, t=2.604 > 1.64, p < 0.05$ ), quality of SHS ( $\beta=0.201, t=3.514 > 1.64, p < 0.05$ ), and quality of SHS association (moderator) ( $\beta=0.189, t=2.681 > 1.64, p < 0.05$ ) indicated a substantial progressive influence on the performance of the small-scale industry.

The model has a considerable descriptive influence on enhancing the income level of the small-scale industry in Pakistan due to an  $R^2$  value of 0.462 for low-cost energy through SHS. However, the value of  $R^2$  has some difficulties in supporting the model, and we consider it ineffective and



**Fig. 2** Measurement model assessment

**Table 4** Cross-loadings

	AU(SHS)	EES(SHS)	LCE(SHS)	PSSI	QSHS
AU(SHS)1	<b>0.885</b>	0.458	0.372	0.378	0.828
AU(SHS)2	<b>0.670</b>	0.134	0.120	0.090	0.267
AU(SHS)3	<b>0.677</b>	0.081	0.109	0.099	0.264
AU(SHS)4	<b>0.675</b>	0.113	0.118	0.071	0.243
EES(SHS)1	0.331	<b>0.912</b>	0.340	0.447	0.391
EES(SHS)2	0.362	<b>0.823</b>	0.328	0.465	0.434
EES(SHS)3	0.356	<b>0.905</b>	0.345	0.446	0.445
EES(SHS)4	0.352	<b>0.904</b>	0.339	0.453	0.440
EES(SHS)5	0.327	<b>0.912</b>	0.336	0.434	0.381
EES(SHS)6	0.361	<b>0.846</b>	0.351	0.438	0.400
LCE(SHS)1	0.313	0.307	<b>0.880</b>	0.341	0.322
LCE(SHS)2	0.276	0.351	<b>0.879</b>	0.339	0.350
LCE(SHS)3	0.289	0.340	<b>0.888</b>	0.327	0.330
LCE(SHS)4	0.308	0.369	<b>0.896</b>	0.305	0.359
PSSI1	0.333	0.473	0.295	<b>0.808</b>	0.378
PSSI2	0.288	0.455	0.306	<b>0.818</b>	0.350
PSSI3	0.242	0.369	0.285	<b>0.854</b>	0.296
PSSI4	0.214	0.392	0.335	<b>0.817</b>	0.330
PSSI5	0.261	0.402	0.321	<b>0.863</b>	0.330
QSHS1	0.713	0.448	0.338	0.399	<b>0.958</b>
QSHS2	0.705	0.444	0.400	0.360	<b>0.943</b>
QSHS3	0.718	0.448	0.386	0.391	<b>0.952</b>
QSHS4	0.709	0.453	0.342	0.401	<b>0.959</b>

Bold data are square root of AVEs

**Table 5** Discriminant validity heterotrait-monotrait (HTMT)

Factors	AU(SHS)	EES(SHS)	LCE(SHS)	PSSI	QSHS
AU(SHS)					
EES(SHS)	0.266				
LCE(SHS)	0.249	0.416			
PSSI	0.220	0.548	0.411		
QSHS	0.537	0.492	0.419	0.436	

*N*=357; *AU*, awareness and understanding of SHS; *EES*, enhance energy supply through SHS; *LCE*, low-cost energy; *PSSI*, performance of small-scale industry; *QSHS*, quality of SHS

**Table 6** Hypotheses testing results

Hypothesis	Relationship	Beta	S.D	<i>T</i> -statistics	<i>p</i> values	Supported	<i>R</i> <sup>2</sup>	<i>Q</i> <sup>2</sup>	<i>F</i> <sup>2</sup>
H1	LCE(SHS)→PSSI	0.326	0.064	3.514	0.000	Yes	0.462	0.242	0.097
H2	EES(SHS) PSSI	0.239	0.065	5.105	0.000	Yes		0.237	0.041
H3	QSHS →PSSI	0.201	0.057	2.604	0.009	Yes			0.116
H4	LCE(SHS)* AU(SHS)→PSSI	0.095	0.056	1.599	0.056	No			0.019
H5	EES(SHS)* AU(SHS)→PSSI	0.237	0.091	3.681	0.000	Yes			0.015
H6	QSHS* AU(SHS)→PSSI	0.189	0.067	2.681	0.004	Yes	0.483		0.021

*N*=357; *AU*, awareness and understanding of SHS; *EES*, enhance energy supply through SHS; *LCE*, low-cost energy; *PSSI*, performance of small-scale industry; *QSHS*, quality of SHS. The moderating relationship has indicated by the asterisk among the variables

unsuitable based on the *R*<sup>2</sup> value (Brislin 1970). Consequently, the model’s *Q*<sup>2</sup> predicted relevance measurement is the most accurate. The latent exogenous standards are highly predictive and imply that the value of *Q*<sup>2</sup> is more complex than zero. The value of *Q*<sup>2</sup> is 0.242, indicating that the model has considerable predictive validity and that SHS can improve the performance of the small-scale sector. The *f*<sup>2</sup> has typical values, including 0.02, 0.15, and 0.35, indicating modest, medium, and significant effects, respectively (Wang et al. 2020).

Consequently, the value of *f*<sup>2</sup> assumes that effect size differs between moderate and significant (see Table 6). Table 6 is a listing of numerous statistical methods. Figure 3 depicts the structural assessment model, which suggests a significant association between the variables because the *T* values are greater than zero (1.64). Except for H4, all hypotheses are accepted. All the values of the moderated variables are positive, indicating that the structural evaluation model for solar projects in Pakistan reveals a significant link.

The moderation results are indicated in Fig. 4, so a positive or negative relationship is indicated among moderated variables through the green line in the figures. It will be considered a positive relationship if the red and blue lines are below the green line. The moderate variable shows a negative relationship in Fig. 4 because the red and blue lines are above the green. Conversely, the moderate variables show a positive relationship in Fig. 5 because the red and blue lines are below the green line. There are progressive associations amid the moderate variables in Fig. 6 because the red and blue lines are below the green.

## Discussion

The research outcomes have revealed that the low-cost energy of an SHS has a positive relationship with the performance of the small-scale industry. The studies imply that the energy harnessed through solar panels is renewable and less costly. This sort of energy enables small-scale industries with limited financial sources to save the money spent to pay electricity bills. The money is saved and used in business operations and production procedures to meet the market requirements and improve performance. The

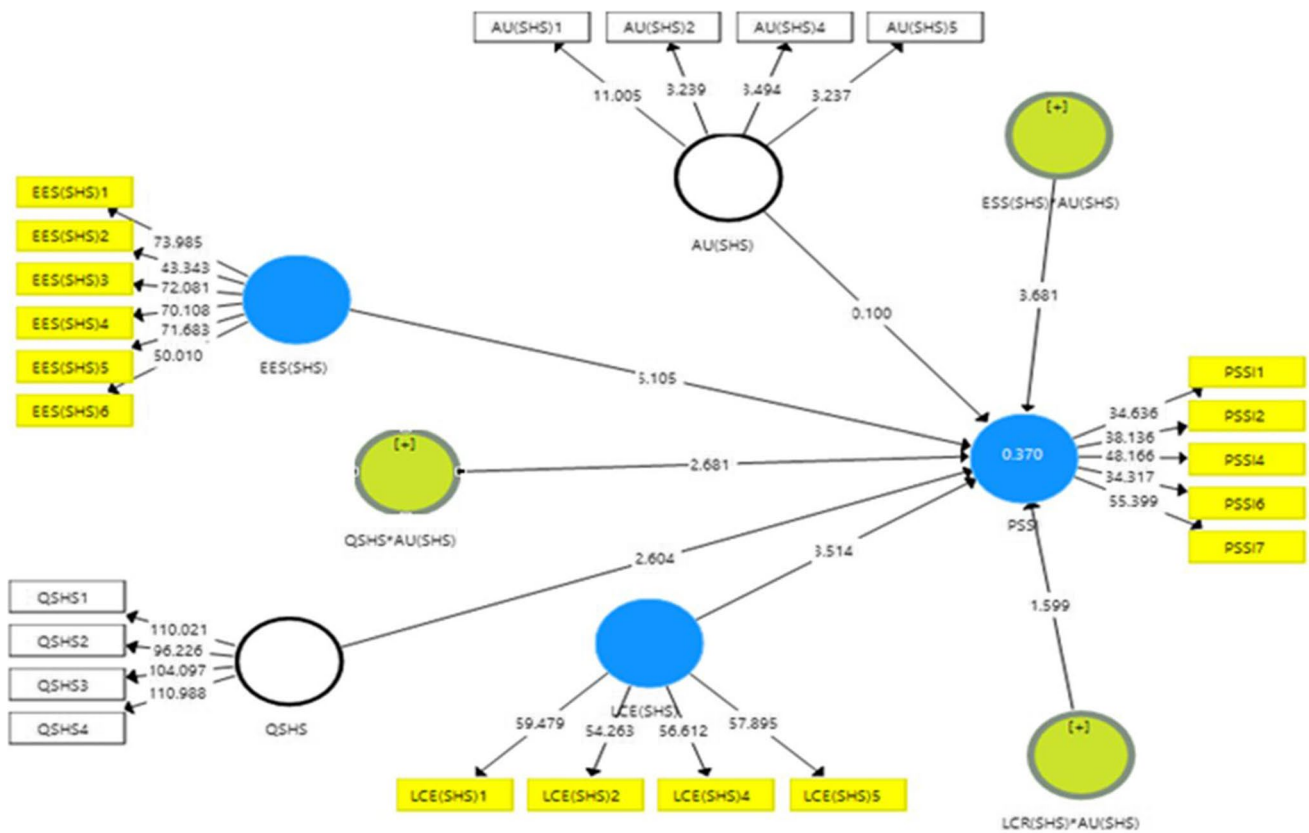
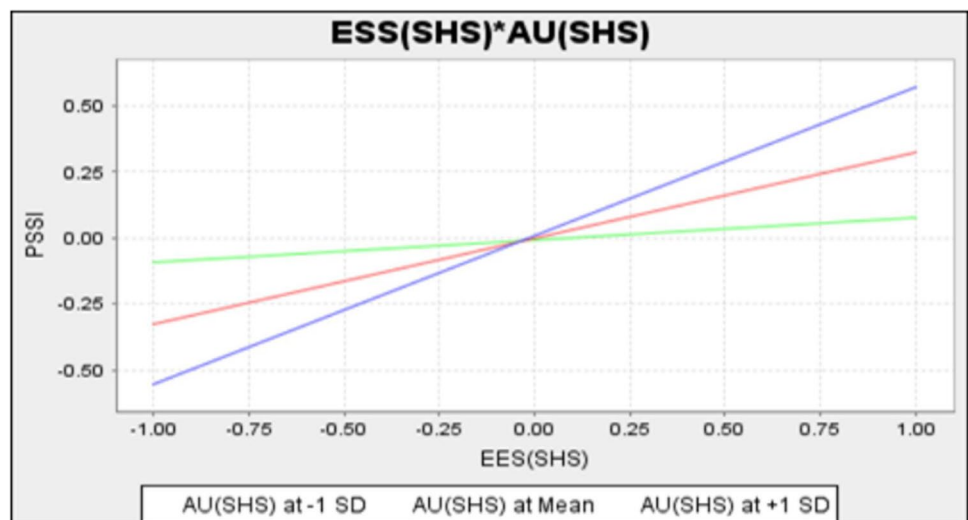


Fig. 3 Structural assessment model

Fig. 4 ESS(SHS)\* AU(SHS)



past study (Amado and Poggi 2014) addresses the SHS as a significant energy source and profitable to small-scale industries. It implies that the solar panel system does not require much maintenance after installation at the beginning. The industries do not pay electricity bills because it is a personal energy source. Thus, the small-scale industries' total cost and per-unit cost are low, and profitability

is high. The results have also indicated that the enhanced energy supply through SHS positively affects the performance of small-scale industries. The results support the past study of Sarker et al. (2020), which shows that the application of the solar system for generating power has enhanced the energy supply, and the solar energy storage system is an excellent complement to it.

Fig. 5 LCR(SHS)\* AU(SHS)

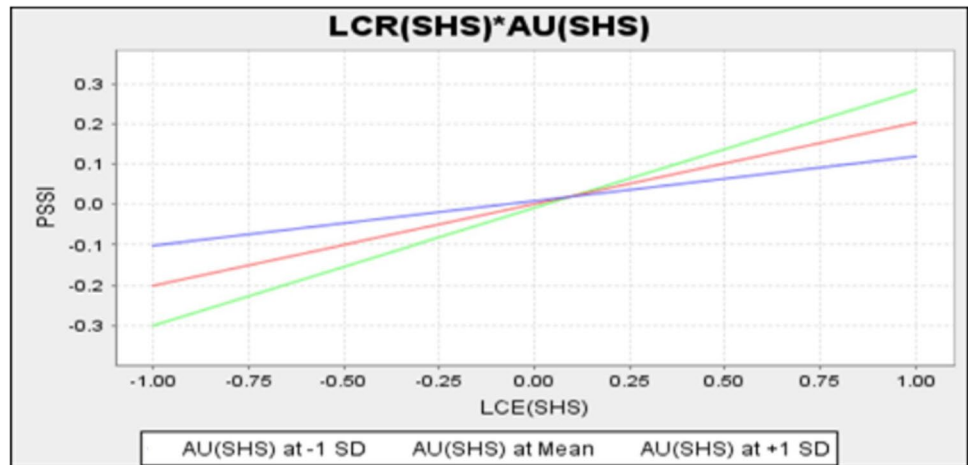
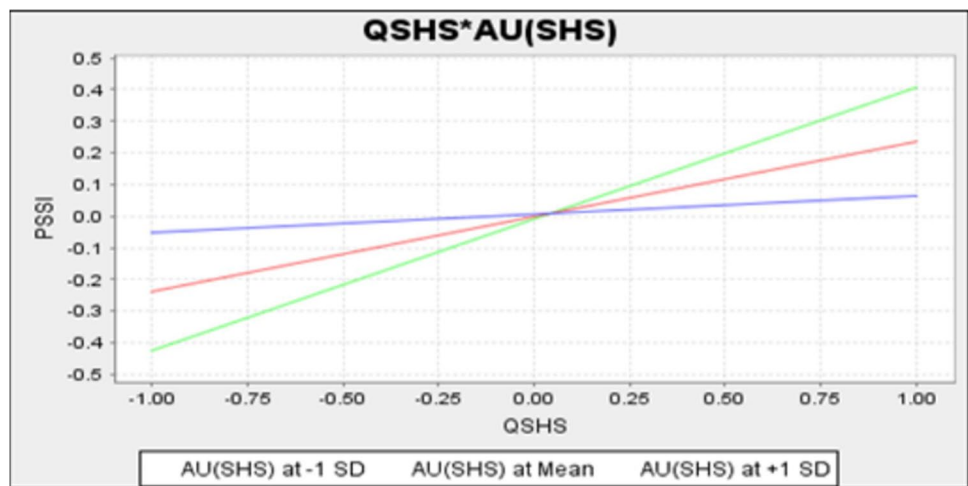


Fig. 6 QSHS\* AU(SHS)



The improved energy produced from installing solar panels can use running technology even when electricity is unavailable to meet the power requirements. It creates fluency in the activities of small-scale enterprises and improves their performance. The results have shown that the SHS quality positively links with the performance of small-scale industries. The high quality of SHS reduces the cost and improves the functioning of small-scale enterprises. These results are in line with past studies (Urban and Heydenrych 2015), which show that the SHS had good quality, such as durability, lack of maintenance requirements, high generation of energy, and the attachment of solar energy storage system, which is helpful in small-scale industries to achieve higher performance. The study results have indicated that the awareness and understanding of SHSs play a significant moderating role between the low-cost energy of SHSs and the small-scale industry’s performance. These results align with the scholarly article of Urban and Heydenrych (2015), which shows that the influences of low-cost energy of SHSs on the performance of small-scale industries become more

robust in the case of high awareness and understanding of SHS. The research outcomes have similarly indicated that the awareness and understanding of SHSs is a substantial arbitrator amid enhanced energy supply through SHSs and the performance of small-scale industries. These outcomes align with the previous study (Brislin 1970), which designates that the awareness and understanding of SHSs strengthen the influences of enhanced supply through SHSs on the performance of small-scale industries.

This work has both empirical and theoretical consequences. It is a substantial fictional work and participates in literature economically. The study contributes to the literature with the influence of three new factors such as LCE, EES, PSSI, and QSHS, to increase the performance of the small-scale industry. The present research work is a guideline for private investors, household families, and government officials in alternative energy to embrace SHSs for better output and financial performance for the small-scale industry. The study has prodigious importance to the investors of Pakistan and the developing world because the study suggestions can play an active part in enhancing the

concert of small-scale industries by adopting low-cost energy sources (SHS). The easy adoption of SHS can decrease production costs and improve the financial performance of the small-scale industry in Pakistan. Hence, adopting SHS can increase low-cost energy, decrease the drive of disaster, and progress Pakistan's small-scale industry's economic performance.

Consequently, the study indicates that solar home systems have a positive and significant correlation with the increasing performance of the small-scale industry in Pakistan. The study also investigates how the energy cost of the small-scale industry can reduce through SHSs in Pakistan. The existing research has shown that SHSs are substantial for low energy cost, increasing off-grid energy levels, overcoming the energy shortfall, positive change in lifestyle, and better financial performance of the small-scale industry in the country. The  $R^2$  value for low-cost energy through SHSs, as reported in Table 6, is 0.462, indicating that the model has strong explanatory power for enhancing the performance of small-scale manufacturing in Pakistan. The model has substantial predictive relevance since the results indicate that the value of  $Q^2$  is 0.242, which shows that the performance of the small-scale sector can be improved using SHSs. Figure 5 depicts the structural assessment model, which suggests a significant association between the variables because the  $T$  values are greater than zero (1.64). Except for H4, all hypotheses are accepted. All moderated variable values are positive and show a meaningful link in the structural evaluation model for solar energy projects in Pakistan. The moderated variables indicated positive signs and showed an entirely substantial relationship in the structural assessment model for the small-scale industry in Pakistan. Finally, the present study expressed that SHS and its adopted moderation have a significant and positive impact on the financial performance of the small-scale industry in Pakistan.

Moreover, the results indicate that the awareness and understanding of SHS are significant moderators between SHS quality and the small-scale industry's performance. These results align with the past study (Brislin 1970), which shows that the awareness and understanding of SHS improve the quality of SHSs applied and the performance of small-scale industries and their mutual association between the quality of SHSs and the small-scale industry's performance. The present study suggested to the investors that low-cost energy through SHSs is advantageous for the development and high performance of the small-scale industry. The SHS is an easy and low-cost energy source and has significant and positive links to increasing the financial performance of the small-scale industry in Pakistan.

## Conclusions and policy implications

The study examines the role of SHS in the economy, especially in small-scale industries. It deals with the influences of three factors: the low-cost energy of SHS, the enhanced

energy supply through SHS, and the quality of SHS on the performance of small-scale industries. The study examines that SHS is a cheap way of generating energy. It also helps the small-scale industries control other energy costs; thus, the per-unit cost of the small-scale industries is low, and profitability is high. The study states that, in the modern age, where the energy requirements have increased, the solar energy system is the cheap but sole way to obtain the energy to meet the excessive requirements. Due to the application of the SHSs, the need for power can be completed quickly, and it creates fluency in the operational and production processes. The quality of an SHS affects the operational and financial performance of small-scale industries. The study shows that an SHS has good quality, including high durability, fewer maintenance requirements, a large amount of energy generated from it, and the availability of an excellent solar energy storage system. It proves to be helpful to small-scale industries to achieve higher performance.

The current study examines the influences of the awareness and understanding of the personnel of small-scale enterprises about the nature and installation of SHS, making it possible for them to apply, install, and maintain SHSs. This awareness and understanding of SHSs enable the three factors, such as the low-cost energy of SHS, the enhanced energy supply through SHS, and the quality of SHS, to improve the performance of small-scale industries. The study results have confirmed that low-cost energy through SHS, enhanced energy supply through SHS, and quality of SHS have positive nexus with the small-scale industry of Pakistan. Hypotheses H1, H2, and H3 are accepted. The outcomes similarly revealed that awareness and understanding of SHS suggestively moderated amid the links enhanced energy supply through SHS, quality of SHS, and performance of small-scale industry of Pakistan and accepted H5 and H6. However, the findings also exposed that awareness and understanding of SHS insignificantly moderated the energy of the low-cost link through SHS and the performance of the small-scale industry of Pakistan and rejected H4.

The results of this study displayed that the enhanced energy supply through SHS is positively associated with the output and economic performance of the small-scale industry. The quality of SHS is an effective instrument that facilitates investors and improves the performance of the small-scale industry in Pakistan. The findings of this study offer valuable guidelines for regulators and policymakers to adopt the solar home system to develop the small-scale industry. The relevant renewable energy institutions and competent authorities need to consider low-cost and low CO<sub>2</sub> emission energy sources such as SHSs to develop small-scale industries in Pakistan. This study adds literature to introduce the awareness and understanding of SHS as a moderator between the low-cost energy of SHS, enhanced power through SHS, the quality of SHS, and the performance of small-scale industries. The study suggests that the performance of the

small-scale industries can enhance with the low-cost energy from SHS, enhanced power through SHS, and increase profit with better quality of SHS. This study also implies how the influences of these variables mentioned above on small-scale industries' performance improve if the individuals have great awareness and understanding of SHS.

Though the study has a practical implementation, it also has several limitations, which scholars must explore in the future. First, the study has addressed only four factors, such

as the low-cost energy of SHS, enhanced power through SHS, and quality of SHS, and checks their influences on the performance of small-scale industries. Many factors other than these also substantially affect small-scale industries' performance. Scholars must also analyze other factors except for the four elements above with the performance of small-scale industries. The data collected through a single source supporting this study do not give comprehensive data per the requirements. For better validity, in the future, scholars recommend applying more than one source to collect data while replicating the current study.

## Appendix

**Table A1** Different questions and behavior of respondents was mentioned during the semi-structured interview

Part A: Demographic characteristics of the participating respondents

Range	Options	Frequency	Percentage
Gender	Male	271	75.9
	Female	86	24.0
Age	Less than 25	111	31.09
	26–32	51	14.28
	33–42	47	13.16
	43–57	57	15.96
	58–65	48	13.44
	66 and above	43	11.48
Income of small-scale enterprises owners	Less than 250,000	81	22.68
	250,001–275,000	79	22.12
	275,001–300,000	85	23.80
	300,001–355,000	56	15.68
	355,001 and above	56	15.68
Selected small-scale industries	Furniture manufacturing	61	17.08
	Food bakeries	83	23.24
	Book making sector	78	21.84
	Fast food making sector	84	23.52
	Hotel industry	51	14.28
Owners of solar panels	2–3	145	40.61
	4–5	107	29.97
	6–7	71	19.88
	8–9	63	17.64
	10 and above	34	0.095
Solar panel brand name adopted by the owners	Jinko Eagle 72 H.M. G2	113	31.65
	Trina solar TSM	103	28.85
	Sun power×22	64	17.92
	Ja solar MR series	51	14.28
	Hanwha Q cell Speak Duo	43	12.04



**Table A1** (continued)

## Part B: Influencing factors of solar home systems

Variables	Items	Questions	Percentage
Low-cost energy through SHS	LCE1	Solar home systems are the low-cost energy source for small-scale industry	29.3
	LCE2	Performance of small-scale industry can increase adopting solar home systems due to low-cost energy	26.4
	LCE3	Small-scale industry by adopting solar home systems can support the development of solar energy	27.1
	LCE4	There is a need to adopt solar home systems for the low cost of the products produced by the small-scale industry	17.2
Enhance energy supply through SHS	EES1	Adopting solar home systems can enhance the energy supply for local people and a small-scale industry	26.1
	EES2	Solar home systems can eliminate the energy crisis by increasing the level of energy supply	23.2
	EES3	There is a need to adopt solar home systems to increase energy supply at a low cost for local industry	13.1
	EES4	Energy supply through solar home systems can support to minimize the conventional energy expense	18.3
	EE5	Solar home systems are the reliable energy source with low maintenance cost	11.3
	EE6	Small-scale industry is required to adopt solar home systems for saving utility bills and earning money	8.0
Quality of the solar home system	QSHS1	There is needed a set of quality standards using certification procedure for the performance of the solar home system	33.7
	QSHS2	Solar home systems are required to ensure high quality with durability and reliability for small-scale industry	34.9
	QSHS3	Government should monitor private and government-based solar organizations for quality assurance of the solar home systems	20.3
	QSHS4	Solar organizations are required to set a specific quality assurance for the components of solar home systems	11.3
Performance of small-scale industry	PSSI1	Small-scale industry can significantly contribute to economic development through energy supply of solar home system	27.4
	PSSI2	Small-scale industry can also be an essential source of foreign exchange earnings by adopting solar home systems	20.2
	PSSI3	Promotion of small-scale industry can help in reducing the problem of widespread unemployment using energy produced by solar home systems	18.1
	PSSI4	There is a need to increase exports and reduce imports of goods through the high performance of small-scale industry by adopting solar home systems	23.1
	PSSI5	Small-scale industry can play an essential role in gross domestic products with the energy source of solar home systems	11.2
Awareness and understanding of the solar home system	AUSHS1	Awareness and understanding of solar home systems is a crucial factor for solar companies but suitable for users	26.3
	AUSHS2	There is a need to encourage solar home systems by providing awareness and promoting material	18.3
	AUSHS3	There is a need to educate rural people about the installation and maintenance of solar home systems for the improvement of small-scale industry	27.2
	AUSHS4	Awareness and understanding are most effective spread through word of mouth for solar home systems	28.2

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**Data availability** The data supporting to findings of this study are available from the first author upon reasonable request.

## Declarations

**Ethical approval** This research study was conducted according to the Declaration of Helsinki guidelines. The Institutional Review Board of North China Electric Power University has approved the study (protocol code 110826–3).

**Consent to participate** Informed consent was obtained from all respondents belonging to this research study.

**Consent for publication** Not applicable.

**Competing interests** The authors declare no competing interests.

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