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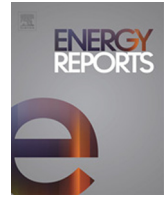
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Acceptance and willingness to pay for solar home system: Survey evidence from northern area of Pakistan



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ABSTRACT

The importance of solar energy has been accepted worldwide for the generation of electricity, but unfortunately, Pakistan has yet to exert efforts on the development of this source of energy. The purpose of this research is to explore the public acceptance and interest in solar home system (SHS). Moreover, the expectations of the public towards SHS development in Pakistan and the difficulties they face in SHS usage are identified. The result of the survey indicates that about 81% of the respondents show higher interest in SHS. However, many respondents claim that some hindrances obstruct them from using SHS which includes; high cost of solar panels, lack of information and trust on solar panel providers. Almost 60% of the respondents expect that government provision of incentives could be the best way to boost the usage of SHS countrywide. For the successful implementation of new SHS policy, the government of Pakistan needs to establish solar power plants, increase installation of solar panels, provides funding and full information for conducting independent research. In addition, almost 90% of the respondents believe that government should take the lead in developing the SHS sector. Therefore, this study provides some valuable references for SHS promotion in Pakistan.

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1. Introduction

Currently, there are 1.317 billion people globally who do not have access to the basic need of electricity and around 99.8% people are living without electricity in developing countries (IEA, 2012). To provide energy services worldwide is indeed a major challenge (WB, 2004). Provision of electricity to all sectors of the economy and for household consumption is a big challenge faced by the developing countries, especially in their rural areas (Rebane and Barham, 2011). Grid electricity can be used for this purpose, but that is accompanied by huge investment such as the construction of power stations, substations, transmission lines etc. Further, it will be dependent on fossil fuels that emit greenhouse gases. Therefore, renewable energy (RE) sources have gained popularity

as alternatives to fossil fuels (Ashnani et al., 2014; Kruzner et al., 2013; Moosavian et al., 2013; Rebane and Barham, 2011; Yee et al., 2009).

SHS are frequently depicted as a reliable energy source which can satisfy the basic energy need such as light (Mondal and Klein, 2011), because the lighting is generally considered to be in the top three energy uses in developing countries. Furthermore, solar technology is playing a prominent role in reduction of poverty, providing comfort and improving the quality of life and living convenience, because dwellers will have more time for entertainment, study and family business (Azimoh et al., 2015; Barua, 2001; Biswas et al., 2004; Cherni and Preston, 2007; Cook, 2011; Dahlstrøm et al., 2012; Gustavsson, 2007; Gustavsson and Ellegård, 2004; Javadi et al., 2013; Komatsu et al., 2013, 2011; Kooijman-van Dijk and Clancy, 2010; Laufer and Schäfer, 2011; Millinger et al., 2012; Rahman and Ahmad, 2013; Sharif and Mithila, 2013; Wijayatunga and Attalage, 2005). Moreover, SHS is a viable option for locations with sparsely populated areas and having sufficient sunshine because it is based on photovoltaic technology, which is environment-friendly. The

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Nomenclature

IEA	International Energy Agency
WB	World Bank
RE	Renewable Energy
SHS	Solar Home System
SSA	Sub-Saharan Africa
PV	Photovoltaic
AEDB	Alternative Energy Development Board
MWh	Megawatt hour
w/m ²	watt per square meter
kWh	kilowatt hour
GW	Gigawatts
PWh	Petawatt hour
MW	Megawatt
NREL	National renewable energy laboratory
USA	United States of America
USAID	The United States Agency for International Development
TOE	Tonne of oil equivalent
GOP	Government of Pakistan
NIST	The national institute of silicon technology
PCAT	The Pakistan council for appropriate technology
PCRET	Pakistan council for renewable energy technology
USD	United State. dollar
SPSS	Statistical Package for the Social Sciences
R&D	Research & Development
PPP	Public–private partnership

International Energy Agency (IEA) estimated that in 2050, about 11% of electricity production would be provided by solar energy worldwide (Katinas et al., 2013; Moosavian et al., 2013).

Urpelainen and Yoon (2015) define SHS in an eminent way. They stated, “SHS consists of a solar panel and the ancillary equipment – typically batteries, charge controllers, wiring, and electric appliances – needed to generate electricity for household uses, such as lighting and mobile charging”.

Now-a-days it has become a global issue to balance the energy demand and supply relative to consumption. The World Bank report revealed that major challenge is to provide energy services to 1.6 billion people who do not have access to electricity and the other 2.4 billion who use traditional biomass for heating and cooking. About 58% of the total energy is consumed by the world 20% richest population, whereas the poorest 20% consume less than 4%. The majority of the poor reside in Sub-Saharan Africa (SSA) and Asia (WB, 2004). In the developing countries, household energy demand has become an important part of the overall energy demand in rural areas. The choices made by the household about lighting fuels and cooking will have a greater influence to shape the energy system of those countries and hence energy access has become an important topic for both academics and practitioners (Cook, 2011; Javadi et al., 2013). The fall in the price of solar photovoltaic panels has attracted many of the firms to deliver solar panels to rural poor (Economist, 2012). SHS can be used in urban, peri-urban as well as in rural areas. Solar photovoltaic electricity system can be utilized for the electrification of a single home, having a generation capacity of 200 W or less (Nieuwenhout et al., 2000). However, developing countries are confronted with many challenges at the household level regarding the installation of SHS including; immature markets, lack of technical skills needed at the time of mechanical troubles, lack of income to purchase SHS, lack of awareness about PV systems and lack of home appliances suitable for SHS (Alam et al., 2003; Nieuwenhout et al., 2001; Wamukonya, 2007).

The public acceptance and willingness to pay for SHS will be examined to determine the acceptance of SHS technology in Pakistan. Keeping in view the current global energy trend and future energy scenarios in Pakistan, this study reviews the existing utilization of solar energy and aims to investigate the perspective of the general public on the acceptance of SHS. The result of the survey indicates that nearly 20% of the respondents were familiar, 38% were somewhat familiar and almost 42% were not familiar at all with Renewable energy. The level of awareness about RE remains low even among potential consumers of SHS, moreover, the result of the survey cover such things as the importance of solar energy, awareness among respondents, and reliable & correct information about SHS in Pakistan. In a nutshell, this study aims to bridge the gap between the general public, investors and policy makers regarding the understanding of the SHS market.

More specifically the purpose of this study is four-fold. First, this study will inquire about the level of awareness of SHS among rural inhabitants. Second, this study will explore the attitude of public toward SHS utilization. Third, this study will investigate the difficulties faced in SHS usage. Fourth, this study will examine the perspectives of public on the enhancement of SHS dissemination in Pakistan.

2. Review on Pakistan's solar energy situation

Pakistan lies at latitudes 24° and 36° north and longitudes 61° and 76° east covering an area of 796,096 km² (AEDB, 2014). Pakistan lies in the sunny belt having a high level of insolation and adequate hours of sunshine. This energy source is distributed widely and available abundantly in the country. Pakistan receives global insolation over more than 95% of its area (AEDB, 2014). The mean of global irradiation which is falling on a horizontal surface is about 200–250 W per day, this results in about 1500–3000 sunshine hours making 1.9–2.3 MWh per m per year (Mirza et al., 2003). The value of solar radiation at sea level is from 900 to 1000 w/m². The solar insolation falling on the horizontal surface differs depending on the site of location, but the average ranges from 450–650 W per m² per day amounting to about 1500–3000 sunshine hours and 1.9–2.3 M Wh per m² per year with an annual mean sunshine duration of 8–8.5 h a day. This amount is sufficient to provide electricity to about 40,000 villages (Mirza and Khalil, 2011). The sunny days in Pakistan ranges from 185 to 290 in a year as evident from historical data (AEDB, 2009). The currently installed photovoltaic has the capacity of about 1600 GW per year, which is almost equal to 3.5 PWh of electricity (this is nearly 41 times greater than the current power generation) (Harijan et al., 2009). In Pakistan, renewable energy accounts for 180 MW in the total energy mix. The potential of solar energy is estimated to be more than 100,000 MW. A study conducted by the national renewable energy laboratory (NREL) of USA in collaboration with USAID regarding solar mapping revealed that Pakistan has a potential of 2.9 million MW (NREL, 2012). The Fig. 1 shows direct normal solar radiation while Fig. 2 shows SUNY solar model for Pakistan.

Energy consumption in Pakistan has enhanced by almost 80% in a preceding couple of decades. In 1994–95, it was 34 million TOE, while it reached to 61 million TOE by 2009–10 (Sheikh, 2010). It is due to increase in population, development of industries and improvement in lifestyles (Farooq and Kumar, 2013). Conventional energy dominates the energy mix. The shares of different sources are Natural gas (45%), imported oil (35%), hydel power generation (12%), coal consumption (6%) and nuclear power (2%) (Sheikh, 2010). Given the limited available resources in the country and increasing prices of fossil fuels, the supply of electricity becomes lower and thus widening the gap between demand and supply. It is imperative for the government to look for alternative and

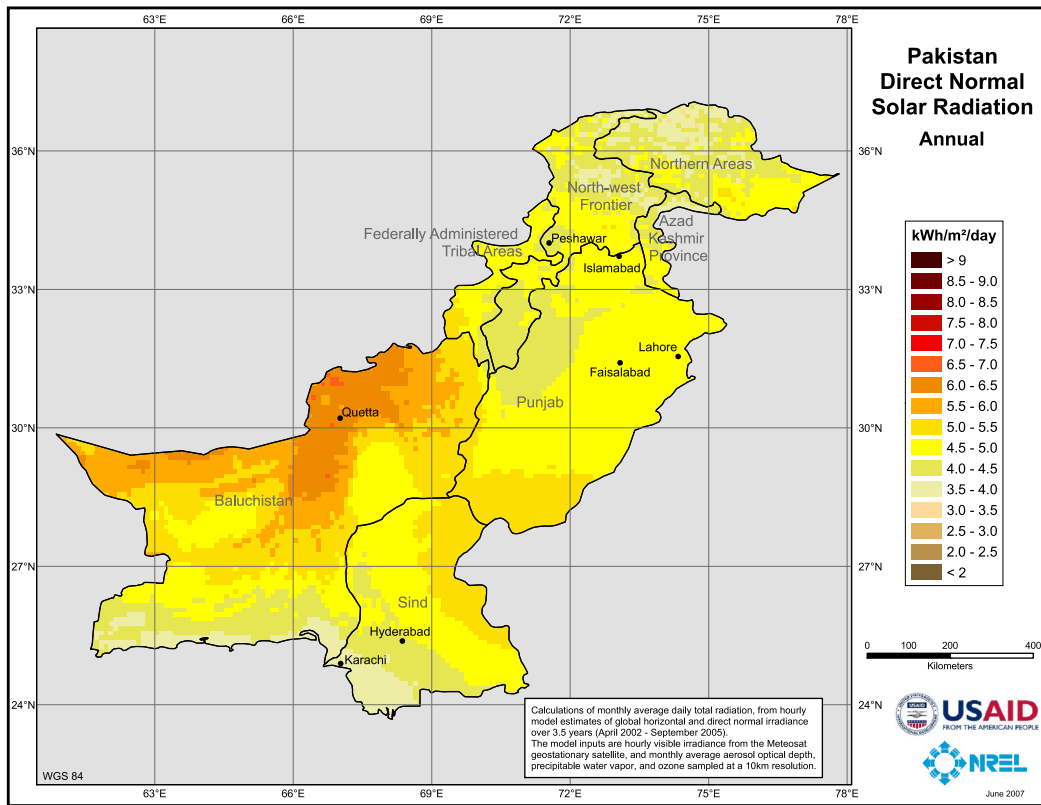


Fig. 1. Pakistan direct norm solar radiation (Annual) (Color print).
Source: NREL (2012).

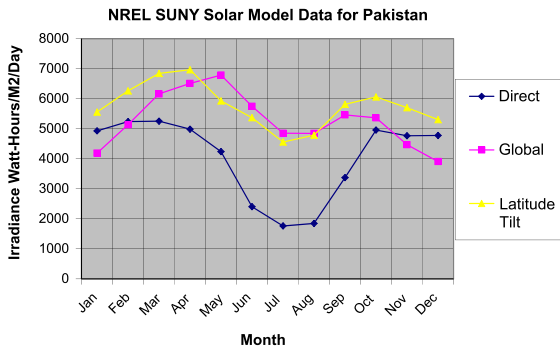


Fig. 2. SUNY solar model data for Pakistan (Color print).
Source: NREL (2012).

domestic resources under such circumstances. The total capacity of renewable energy in Pakistan was 168 GW during 2010, which is almost eight times greater than total demand of electricity of which renewable energy was just less than 1% of total capacity installed (Farooq and Kumar, 2013). It is expected that Pakistan energy needs will increase by three-fold until 2050 (Asif, 2009).

Mainly, Pakistan depends on conventional energy sources and there is not so much effort to utilize renewable energy for generation of electricity (Sheikh, 2010). Despite the acknowledgment, that renewable energy is an alternative and important source of energy, Pakistan has yet to exert efforts to develop this form of energy. However, it was present in all previous policies and plans; but has been given low priority. It was provided with little incentives to become a full-fledged industry based on the available technology (GOP, 2015). Still, the government of Pakistan did take some practical measures to promote solar technology in the country. She established organizations for this purpose. The national institute of silicon technology (NIST) was established in 1981. This

organization was busy in research, development and commercialization of solar energy with a special focus on photovoltaic (PV). The Pakistan council for appropriate technology (PCAT) was established in 1985 to focus on mini-hydro power, biogas plants, solar cookers and small wind system for energy conversion. In 2001, the government of Pakistan merged the two aforementioned organizations namely, the national institute of silicon technology (NIST) and Pakistan council for appropriate technology (PCAT) to a more vibrant organization, Pakistan council for renewable energy technology (PCRET). It has the responsibility of conducting research to promote renewable energy in the country (PCRET, 2009). PCRET started some pilot projects like wind turbines, solar water heaters, photovoltaic (PV) cells, solar cookers, solar dryers, solar biomass plant on a small scale to check their performance in the local context (Sheikh, 2010). PCRET also provided training facility for maintenance and operation of this technology. The government of Pakistan established alternative energy development board (AEDB) in 2003. The main purpose of this organization was to play a central role in renewable energy sector by implementing various policies, programs and project (AEDB, 2009). AEDB also facilitates private sector and foreign investment by providing one-window facility to ensure smooth and steady implementation of RE projects for electricity generation (AEDB, 2009). Still, Pakistan is facing similar type of impediments in successful implementation of solar energy system like other developing countries such as lack of sincere effort by the government, lack of funds, lack of technological resources, lack of incentives and support by the government and mistrust of the financial sector (PCRET, 2009).

Resolving the energy crisis of Pakistan is not that much simple, it requires a substantial investment both in generation as well as in distribution and transmission. The government is hopeful to add 20 GW of electricity to the system by 2020 as mentioned in the “Vision 2020 Program” with an estimated cost of about USD 32 billion—an annual average investment of USD 3.2 billion. Given the limited

fiscal space of the government, the private sector has to invest a significant portion of required investment. However, the private sector is also facing risk from both the country and the electricity sector and is hesitant to invest. The private investor will remain unwilling to invest until they get an assurance that government will not expropriate the private investment explicitly or implicitly. Therefore, it is suggested to lower the discretionary power of the government that deals with power sector (Kessides, 2013).

3. Research methodology

This study is designed as an exploratory investigation because limited knowledge is available regarding the social acceptance of SHS in Pakistan. This methodology is also utilized by Solangi et al. (2015). Further knowledge can boost the utilization of SHS. This study utilizes both primary and secondary type of data. The survey method was employed to collect primary data from the respondents. For this purpose, a survey questionnaire was distributed among the local inhabitants in the northern part of Pakistan in schools, colleges, shopping plazas, supermarkets, and factories. Information was collected from both rural and urban areas. The survey was completed between April and May 2016. The language of the questionnaire was kept simple and only limited number of technical terms had been included in it so that respondents with a different background, education and exposure to SHS can easily understand this. In the sample design of the survey, three criteria were considered important. First, the respondent should be a permanent resident of district Malakand. Second, they should be mature i.e. 18 and above years of age. Third, both rural and urban respondents will be included in the study. Before collecting information, respondents were asked some general questions related to renewable energy (RE) such as information about global warming, familiarity with renewable energy technologies, interest in environmental issues and interest in SHS. Hence, those respondents who replied somehow positively or negatively to the aforementioned questions were considered for survey questionnaire. The method of convenience sampling technique was utilized to collect data. The size of the sample was taken only 350. Our study aims to contribute positively to literature by providing perspective and acceptability of SHS disregarding, income class, ethnicity, and caste. Moreover, the survey is not a representative of the entire nation and its scope is only limited to northern part of Pakistan (Malakand).

4. Results and discussions

The SHS development has been surveyed on the basis of the aforementioned background. In this section, we present, the demographic characteristics of the respondents, the attitude and interest of public towards utilization of SHS, public opinion on the difficulties they face in SHS usage, expectations of the public about SHS promotion in Pakistan and public views on the implementation of new SHS projects. The survey was conducted between April and May 2016 employing the convenience method of sampling in the northern area of Pakistan. The number of questionnaires distributed was 500 and we receive 350 responses. The survey was completed without discrimination in gender, ethnicity and residential areas of respondents. The age of all respondents were 18 and above. Moreover, the survey was completed by personal interaction with the respondents. The analysis of the data was carried out using SPSS 18 software.

Table 1
Demographics of the participants ($n = 350$).

Respondent's characteristics	Frequency	Percentage
Gender		
Male	269	76.9
Female	81	23.1
Age		
Less than 18–20	38	10.9
20–29	164	46.9
30–39	94	26.9
40–49	32	9.1
50 and above	22	6.3
Education		
Primary	42	12
High school	36	10.3
College	86	24.6
Graduate	172	49.1
Diploma	14	4
Area		
Urban	174	49.7
Rural	176	50.3
Occupation		
Shopkeeper	35	10
Businessman	60	17.1
University student	116	33.1
Farmer	4	1.1
Govt servant	74	21.1
Daily wager	34	9.7
House wife	27	7.7

Table 2
The interest of public in solar home system.

Public interest in solar home system	Frequency	Percentage
Agree	284	81.1
Disagree	20	5.7
Neutral	46	13.1
Total	350	100

4.1. Demographic information of the respondents

The general demographic characteristics of the respondents are as follows. Almost 77% of the respondents are male, while only 23% are female. Nearly half of the respondents aged between 20 and 29 years. In terms of education, about 49% have graduation, 12% have primary schooling, 10.3% have a high school, 24% have college and only 4% have diplomas. The respondents are approximately equally distributed between urban (49.7%) and rural (50.3%) areas. Most of the respondents were university graduates (33.1%). The demographic characteristics of selected respondents are shown in Table 1.

4.2. The interest and attitude of public towards utilization of SHS

The survey was conducted to determine the attitude of the public towards utilization of SHS. Table 2 shows the interest of the public in SHS. The result indicates that around 81% of the respondents are interested overwhelmingly, whereas 5.7% are not interested and about 13.1% are neutral. Therefore, a high level of interest is observed among the respondents, which shows a high potential for the usage of SHS.

According to the energy policy of Pakistan, the focus has been on the development of RE to ensure energy security. Keeping in mind the aforementioned background, the survey was completed to investigate the interest of public in purchasing solar panels and in using electricity generated from solar power for their homes. Specifically, they were asked two questions about this. One is for the purchase of solar panels if 50% of the cost is covered by the government in the form of subsidy, second is regarding the purchase of solar-generated electricity if the cost of it is the same as the fossil fuel generated electricity. Table 3 revealed that almost

Table 3
Public interest in purchase of solar and fossil fuel generated electricity ($n = 350$).

Public interest in solar home system	Yes		No		Unsure	
	Freq	%	Freq	%	Freq	%
The possibility of buying solar panels if the total cost is subsidized by 50% by the government	269	76.9	35	10	46	13.1
The possibility of using solar generated electricity if the price is same to that of fossil fuel generated electricity	108	30.9	146	41.7	96	27.4

77% of the respondents agreed to buy the SHS if half of the price is subsidized by the government. Nearly, 10% of the respondents showed disagreement to the buying of the SHS, whereas 13% are unsure. This clearly shows the interest of the people in the buying of the SHS but only if government subsidies 50% of its cost. The result of the second question implies that almost 31% of the respondents are interested in using electricity generated from solar panels if the cost is equal to fossil fuel generated electricity. Nearly, 42% of the respondents were not interested and the rest were unsure about its use. Therefore, the development of SHS and its targets will only be achieved if the government subsidies 50% of the cost of solar panels.

4.3. The difficulties public face in consumption of SHS

The purpose of this study is to explore the acceptance of SHS in Pakistan. This study investigates the difficulties faced by the public in consumption of SHS; in addition, it also tries to find the reasons which ultimately hinder potential consumer from the usage of SHS. The result of the survey shows several potential hindrances that have affected the consumer decision to purchase and install SHS. The initial cost of the SHS is the major hurdle faced by the consumers as indicated in Fig. 3. Respondents were provided with four options to choose from. Almost 78% of the respondents claimed this aspect to be the most important. Furthermore, about 53% of the respondents considered the best possible price as a yardstick to purchase and install SHS. The respondents were unwilling to install SHS until they find the best possible price. Moreover, trust in solar system provider is a major obstacle. Almost 41% considered this aspect to be the most important whereas more than 50% claimed it to be important. Information also plays a crucial role in the purchase decision of SHS such information comprised of how this system works, how much the bill of electricity is reduced and what are the experiences of other users. Besides the aforementioned barriers, others include more information about the system, need of technical assistance, lack of knowledge and low trust on solar system provider, lack of information about environmental issues and poor brand image. This result shows that SHS can be promoted in Pakistan if the initial cost is controlled as well as if the consumers were provided solar panels from a reliable source. Therefore, by incorporating these suggestions the usage of SHS will boost in Pakistan and will likely overcome the sufferings of the common masses due the problem of load shedding.

4.4. The opinion of public towards the development of SHS in Pakistan

The opinion of public is important in meeting the objectives of the government regarding SHS policies. The aim of this study is to determine the expectations of public regarding SHS usage in Pakistan by taking into account the opinion and attitude towards new SHS policy implementation. Moreover, this study investigates public views on the role of an organization that could lead the development of SHS. Fig. 4 revealed the opinions of public that may enhance the usage of SHS. The result of the survey indicates that almost 94% of the respondents claimed that government subsidy is the best way to enhance usage of SHS all over the country. In addition, nearly, 66% believe that finding a trustworthy contractor

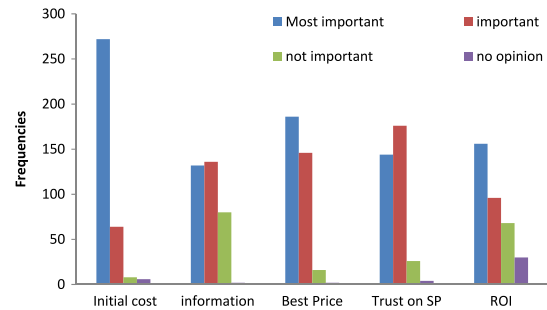


Fig. 3. The responses of public regarding the difficulties in consumption of SHS (Color print).

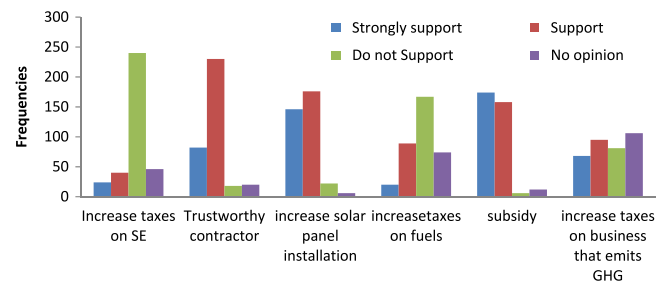


Fig. 4. The opinion of public on ways to enhance the usage of SHS (Color print).

is a good idea, whereas more than 50% supports the increase in installation of solar panels to meet the energy requirements. The results show that majority of the respondents considered government to be the main responsible body for the promotion of SHS usage.

Fig. 5 shows the attitude of public towards the new SHS policy implementation. The result revealed that almost 60% of the respondents supported the installation of solar power plants all over the country in order to enhance the development of SHS. About 46% considered it necessary to have access to full information, nearly 54% suggested that huge amount of funding for the purpose of independent research. Almost 47% of the respondents supported the notion of increasing the installation of solar panels and 63% recommended and considered it most important to provide low-cost panels nationwide. The result of the survey shows that government can enhance the development of SHS by providing various incentives (subsidies) and increasing taxes on firms that use conventional energy. In addition, this study also recommends that government should provide full information to the general public, research funding for SHS and should initiate projects that increase the installation and usage of SHS. Finally, this study investigates the opinion of the public on the role of an organization that may lead and enhance the development of SHS in Pakistan. Fig. 6 indicates that almost 90% of the respondents recommend the governmental organization to take the lead in the dissemination of SHS, about 40% considered research institutions, and only 17% believe that academia should be given top priority. The result about mass media is unexpected as only 20% of the respondents believe that it should be given top priority despite the fact that media has the power to spread awareness among inhabitants and increases the knowledge related to SHS development. In addition, 26% of the respondents believe

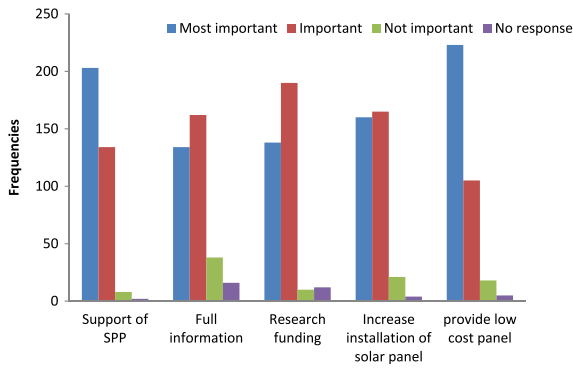


Fig. 5. The attitude of public towards new SHS projects implementation (Color print).

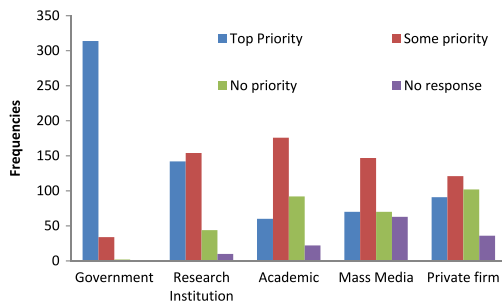


Fig. 6. The views of public on the role of organization in SHS development (Color print).

that private firm can play a crucial role in the development of SHS in northern Pakistan.

Policies based on the survey conducted

1. A few solar panels have been installed on schools and mosque's roofs despite the abundant availability of solar energy in the northern area of Pakistan. The major hurdle in the enhancement of SHS is the lack of incentives from the government side. They need to overcome this to encourage the participation of public in SHS technology.
2. The government needs to overcome the barriers faced by the consumers in SHS usage. The survey indicates that other barriers include the need for technical assistance, poor brand image, trust in the solar provider, lack of knowledge and time. Awareness about the benefits of SHS can be spread through media e.g. television, magazines, seminars and workshops.
3. The development of SHS needs effective financial support. The government needs to provide such support in the form of subsidy (Consumer subsidies, product subsidies and investment subsidies) and policies of pricing. The government incentives will stimulate the consumption and would lead towards the expansion of the market. As we know from the survey result that about 77% of the respondents agree to purchase solar panels if the government subsidizes 50% of its cost. Therefore, subsidies have a great potential to encourage consumers towards SHS.
4. A public–private partnership (PPP) approach is suitable to develop R&D infrastructure in the country.

5. Conclusion

Balancing the energy demand and supply is very important for the economic as well as social development of a country. The situation of Pakistan with respect to energy is not very impressive. The country is facing a severe shortage of electricity. Therefore, the

government emphasized to diversify the energy mix to overcome the shortage of energy in the country. Solar energy is deemed an appropriate source of energy as Pakistan lies in the sunny belt and has an abundant amount of sunshine throughout the year. The purpose of this study is to investigate the social acceptance and willingness to pay for SHS in northern areas of Pakistan. The study explores the acceptance of SHS by examining the interest of public in SHS, public opinion on the difficulties they face in consumption of SHS, and the expectations of public on enhancing the usage of SHS in Pakistan. The result of the study indicates that people are interested in purchasing SHS only if the government subsidizes a part of its cost. In addition, the important hindrances identified in the development of SHS are initial cost; trust in solar system provider, obtaining best possible price and information about SHS. Moreover, the respondents view government to take the lead in SHS development.

Key conclusions and findings are given below

1. Most of the respondents (i.e. 81%) are very interested in SHS in northern Pakistan.
2. Approximately 77% of the respondents are willing to purchase solar panels if 50% of the cost is subsidies by the government.
3. The major hurdle in the usage of SHS is its initial cost. Some of the respondents claimed that the lack of trustworthy solar panel providers also hinders them from using SHS.
4. The best way for the development of solar power plant is through governmental support. Moreover, the respondents claim that provision of low-cost panels to consumers is also important.
5. Most of the respondents expect government to lead the development of SHS usage. Some other organization includes academic, research institutions, mass media, and private firms.
6. The government needs to provide support in the form of subsidy (Consumer subsidies, product subsidies and investment subsidies) and policies of pricing.

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