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Solar Energy in South Punjab/Pakistan: Domestic Users' Perceptions

Sara Batool Naqvi*

International Relations Analyst (IRA), Pakistan Atomic Energy Commission (PAEC), Islamabad 1114 and Ph.D. Scholar, National Defence University (NDU), Islamabad, Pakistan
Email: sara.batool.62000@gmail.com

Abstract

Keeping in view the significance of social receiving of energy systems, this study presents data by evaluating domestic users' perceptions regarding solar energy in Layyah and Bakhar (South Punjab/Pakistan). 120 domestic users were served with structured questionnaires by applying prevailing and inclined trends for solar energy. The findings of domestic users survey revealed that prevailing trend for solar energy is quite satisfactory as 60% of domestic users are already using solar as an alternative and the level of satisfaction is also 60%. General potential and inclined trends for solar energy found 82% in support of solar energy. Solar energy is expedient in a way to manage Pakistan's energy crisis by focusing on domestic user's perceptions.

Keywords: Domestic Users' Perceptions; Energy Autarky; Purposive Sampling; Solar Energy; South Punjab/Pakistan.

1. Introduction

Today, access to modern forms of energy, or rather secure, clean, affordable energy carriers fundamentally define modern economy. The importance of energy as it relates to the primary needs of all individuals, economic well-being, and personal living standards can be judged from the fact that the amount of energy each person should use is directly related to the quality of life, quantitatively measured in terms of Human Development Index (HDI) using three different categories: life expectancy, education, and Gross Domestic Product (GDP). Energy is key in this regard, as it is most compatible with the needs of the modern economy. Economic development consequently helps to enhance and improve quality of life. It means there is significant positive relationship between energy consumption and quality of human life.

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* Corresponding author.

For instance, Pasternak in a research of 60 most populated countries of the world found that level of human development stood at highest level when per capita electricity use was about 4,000 kWh. Although this is below the average per capita electricity consumption in developed countries, nonetheless, it is also way above the average per capita consumption in developing countries [1]. In Pakistan as of 2020, per capita energy consumption is only 448 kWh which is very low in comparison with its neighbor India (805kWh) [2]. The lower level of per capita energy consumption in Pakistan can be addressed through increased reliance on renewable energy resources, mainly solar energy. Solar energy is a renewable source of energy that comes from sunlight. Solar photovoltaic (PV) and solar thermal are two important variants of solar energy. Using solar cells—semi-conductor devices—electricity is produced through solar PV technology by directly converting sunlight into electricity; whereas solar thermal technology produces electricity indirectly from steam by first, utilizing solar collectors, converting energy from sun into heat energy which in turn is used for heating water into steam. Pakistan, particularly its province of Punjab owing to its geographical locale and climate conditions, has huge potential for solar energy. Major part of the country, except for the northern areas, receives annual mean sunlight period of 8-10 hours a day; 7-8 hours during winter (December to February), whereas, 9-10 hours in summer (May to August) [3]. On average, Pakistan receives 5-7 kWh/m^2/day solar irradiation [4]. The province of Punjab is of great significance as it is home to 53% [5] of the country's population. Not only is the solar insolation high in South Punjab but energy demand is also continuously increasing. 23,635 GWh energy was consumed in Punjab during 1994-95. This energy consumption reached 60,940 GWh in 2016-2017. The increase is even more than double during the time interval of 24 years [6]. Extensive and diverse scholarly work, both national as well as international, exists which significantly accentuates renewable energy sources, most importantly solar energy serving multiple purposes. Solar energy, according to Openshaw, can help reduce deforetation [7], while Biswas believes that NGOs and banks, through extending financial assistance and soft/ micro loans, can help electricfy the underdeveloped and economically underpriviledged rural areas by adoption of renewable technologies, particularly solar. However, he also accords a significant role to the government, business communities and education institutions in persuit of this goal [8]. Scientific dimension of solar energy has been the particular focus of various studies, both in national and international literature. Bhutto, Bazmi and Zahedi accord pivotal role to Research and Development (R&D) organizations in introduction of new technologies, hence, believing that scientists figure as the most important actor in the chain of solar technology promotion. In addition, through their R&D activities, scientists with their expert opinion can authoritatively and convincingly enlighten the users on relative utility of a particular technology [9]. The challenge of climate change has generated great interest among scientists for renewable technologies because of their environment friendly operation. These least environmental impacts, according to Haas and his colleagues have encouraged the utilization of solar energy. For economic reasons, they, however, state the technology will become more widespread among domestic users if it is subsidized [10]. There are also some studies which accord primacy to political dimension of Solar Energy. Such solar energy studies give vital role to government in developing, adopting and promoting solar energy [11] as it offers strong incentives to the government in terms of stimulating economic activities by creating jobs, achieving energy security through diversification and reduced reliance on fast depleting fossil fuel, while also saving valuable capital [12]. In a survey on solar energy in Malaysia carried out by Solangi and his colleagues most of the respondents, lacked elementary awareness on solar energy and hence opted for conventional source of energy. 70% of the respondents, however, opined that it was the

government as a lead actor that could help promote solar technology [13]. Ma, Chan, and Li concur with this instrumental role of government policy in the development of renewable energy [14]. Pimentel and his colleagues hold solar energy technology among all other renewable energy sources, as the most promising to meet growing energy demand in the United States and address environmental concerns; it, however, can materialize only with serious efforts of the government to develop and implement the technology [15]. Naqvi and Jabeen conducted political evaluation of Solar Energy in Pakistan. They emphasize on role of politicians for development of the solar technology. The study applied KAP (Knowledge, Attitude and Practice) analysis method [16]. Yet, other studies have stressed the business dimension of solar energy. Hosenuzzaman and his colleagues point out that while the scientist invents and the policymaker (government) regulates a technology, it is essentially the businessman who ultimately makes it accessible to the consumer. Thus, optimal utilization of a particular product is not possible for the scientist or the government alone absent business activities and the involvement of commercialization aspect. Besides, the constructive role of the businessmen is further amplified by facilitating the commercial development of any technology through investment [17]. Building on this argument, Mirza and his colleagues believe that wider promotion and consumption of solar energy need increased market penetration and expansion and the under-developed market serves as hurdle impeding solar energy consumption [18]. Bloyd and Bloyd expand the discussion by explaining certain major dynamics, including economic, technological and human resources, which impede the solar technologies' market penetration. They conclude with the consequential impact the market as well as prices have on expanded use of solar energy [19]. Some studies are found at international level on Solar Energy by using socioeconomic indicator. Wüstenhagen, Wolsink and Burer find that social acceptance of renewable energy could be a major hurdle in its promotion in certain nations, which are struggling with rebalancing their energy mix in favour of renewables. Socio-political, community and market acceptance are three subcategories of social acceptance [20]. Annina and his colleagues identify acquisition of land for large solar panels as a potential social hurdle. At national level, Jamil and Ahmad find an intimate relationship between consumer's income vs. price of the energy and electricity theft in Pakistan. A rise in price of the energy and/or reduction in income of the consumer would lead to increase in electricity theft. From their findings, therefore, it can be inferred that affordability and purchase limits of consumers play significant role in social acceptance of any source of energy [21]. In summary, the review of above literature on Solar Energy has focused largely on scientific or business indicators. Socioeconomic aspect of Solar Energy in Pakistan is a grey area in the available literature. The limited literature on this indicator includes socioeconomic evaluation of Solar Energy in the demographic locations of district Abbottabad and Gawadar port of Pakistan. In their detailed study on socio-economic prospects of Solar Energy in Abbottabad/ Pakistan, Jabeen and his colleagues find that a technology's socio-economic evaluation, e.g., in terms of its affordability increases the chances of its acceptance by the consumer, hence, socio-economic aspect is vital for the promotion of technology. Besides income level, they identify user friendliness as well as utilization level of alternative energy resources as some of the important socio-economic aspects that help promote Solar Energy [22]. Affordability, however, is not the only, or the defining factor in decision-making. In a study conducted in Gawadar/Pakistan, Jabeen finds that socio-cultural driving factor is the main variable in promotion of Solar Energy [23]. The present research intends to supplement the available literature on domestic user's perceptions regarding Solar Energy in Pakistan by conducting same study in South Punjab by replicating same questionnaire with formal permission of developer of the questionnaire used in this research [24].

2. Methodology

This research was triggered by the scarcity of literature on the role of domestic users' perceptions in acceptance of a technology. While the existing literature accords ample importance to the scientific details or technological aspects in acceptance of solar technology, the directing principle was that these two variables do not solely define it rather, the domestic user's perception, is equally, if not more, consequential. The scientific or technological aspects, as discussed in available works are, thus, not enough as far as domestic user's perceptions are concerned.

- Solar energy= Independent variable
- Energy Autarky= Dependent variable
- Domestic Users' Perceptions= Mediating variable

2.1. Methods of data collection

The study attempts to assess the acceptance of solar energy in South Punjab founded on its domestic users' perceptions. The area of study was chosen on the basis of suitable solar irradiance and prevailing power outages.120 domestic users were selected to attain data as per purposive sampling. The survey research was organized and commenced from May to August 2017 and included questionnaire. The questionnaire was planned as per the perceptions of domestic users and by using simple and precise queries.

2.2. Questionnaire for domestic users

The purposive sampling was used to establish the link between energy autarky and social receiving of solar energy. These domestic users were served with structured questionnaires as an instrument, including the items of market competitiveness, user comfort, and cost effectiveness. Socioeconomic evaluation of Solar Energy is already done in the demographic location of district Abbottabad and Gwadar port of Pakistan [25]. The questionnaires were issued to gauge the current and inclined tendencies for solar energy. The domestic users were asked to determine social receiving of solar energy in the selected area.

2.3. Data analysis

Statistics were judged by dilating frequency distribution to tabulate average as mode of each section, while data values are calculated by SPSS (24).

It attempts the *question*;

'In what way can solar energy support in achieving energy autarky in the backdrop of reference to its domestic user's perceptions? The receiving of solar energy as the most appropriate selection to eradicate energy insufficiency will help in establishing energy autarky in the country.

Purpose of the paper

The purpose of this paper is to assess domestic user's perceptions regarding solar energy to retain energy autarky in Pakistan.

Following are the specific *objectives* of this study

- To highlight the viability of solar energy by focusing on its domestic user's perspective.
- To depict domestic user's perspectives of solar energy in South Punjab/ Pakistan.

Hypothesis

- Energy outages can be decreased by using solar energy, if the satisfaction of the domestic user is safeguarded by fulfilling the requirements of price & accessibility to market, cost effectiveness and user friendliness.

3. Findings and analysis

3.1. Average monthly income of the domestic users

If income increases, consumption also increases. An income-consumption phenomenon is very interesting. When the income increases, demand for the inferior goods decreases whereas the consumer then moves to superior yet more efficient goods and vice versa. Here the objective to get data of the income of the domestic users is to determine their purchasing power and, based on the prices, determine whether the price is affordable or not.

Table 1: Average monthly income

N	120
Minimum salary	9000
Maximum salary	75000
Mean salary	21966
Std. deviation	12154

Table 1 shows the average monthly income of 120 domestic users stood at 21,966 whereas the maximum was 75,000 and minimum 9,000 with a standard deviation of 12,154. People in rural areas are mostly dependent on agriculture; therefore, the average monthly income is low.

3.2. General Potential for Solar energy

Table 2: General potential for solar energy

Responses	Frequency	Percentage
Yes	119	99.9
No	1	0.8
Total	120	100.0

In order to measure general potential of Solar Energy, respondents were asked if they would like to use solar

energy technology to get electricity in case of power shortage. The outcome is very encouraging. Out of 120, only one answered "No" whereas 119 responded positively, showing their intentions to opt for solar technology. Domestic users in Pakistan consume more than 50% share of total electricity [26]. Furthermore, 63.62% [27] of the total population lives in rural areas where grid supply is already an issue. Therefore, solar technology which provides the facility of off-grid electricity generation could be a viable solution to this problem. In order to measure the existing trends for alternate energy, consumers were asked three questions in this part.

3.3. Prevailing Alternative Energy Source

Table 3: Prevailing alternative energy source

Alternate resources	Frequency	Percentage
UPS	44	36.7
Generator	2	1.7
Solar	73	60.8
Total	119	99.2
Missing system	1	0.8
Total	120	100.0

Whether urban areas or rural, electricity has become an essential commodity. In summer most of the rural areas, and especially south Punjab, are too warm, therefore, electricity supply is necessary. However, these areas experience load shedding for 14-16 hours a day. This is why they were asked what alternative type of energy they were using. The questionnaire included only UPS and generator; however, when the survey was being conducted responses came that they were using solar panels also. So the frequency for solar panels was also recorded. Out of 120, forty-four responded that they were using UPS and only 2 answered with Generator. Interestingly, 73 domestic users responded that they are using solar panels. Most of them were using only one solar panel to keep electric fan running during the daytime. Two possible reasons for not using the UPS or generator are: first, the UPS or generator is expensive and out of reach of most people in rural areas; secondly, load shedding duration of 16 hours or sometime even more does not allow recharging the UPS fully, so UPS backup is not enough to fill the load shedding duration. This leaves most of the people opting for one or two solar panels so that they can get electricity at least during daytime. Furthermore, respondents added that transmission structure is very poor. In case of rain or storm, electricity remains completely shut for days. If there is any fault in the transformer, villagers have to remain at their own. Hence, the findings of this solar energy showing the highest level of the existing trend for Solar Energy.

3.4. Satisfaction with Prevailing Alternative Energy Source

Table 4: Satisfaction with prevailing alternative energy source

Response	Frequency	Percentage
Yes	73	60.8
No	31	25.8
To some extent	16	13.3
Total	120	100.0

Table 4 shows the responses regarding satisfaction with the existing alternative energy source. The findings of table 4 are also justified in light of findings of table 3. Here, 60.8% of domestic users are satisfied with the existing alternative energy source that is solar technology as it is discussed above in the findings of table 3 where 60.8% of domestic users are using solar as an alternative energy source.

3.5. Average Monthly Billing of Domestic Respondents

Table 5: Average monthly billing of domestic respondents

Choices (Rs.)	Frequency	Percentage
<500	2	1.7
500-1000	62	51.7
1000-3000	42	35.0
>3000	14	11.7
Total	120	100.0

Data of the monthly billing would give us an idea of how much the villagers are spending monthly on their electricity needs. Based on the results it could be compared to the cost of solar energy and to determine feasibility for solar energy technology. Results reveal that 51.5 % average monthly bill remained between PKR 500-1000 whereas 35% remained between PKR 1000-3000, and 11.7 % higher than PKR 3000. It should be noticed that this is an average monthly bill with 14-16 hours load shedding a day. With 24-hour supply, the monthly bill would be much higher. It reflects the high cost of national grid electricity, especially for the rural area where monthly income is low. It provides cost comparativeness for solar technology.

3.6. Affordability for Solar energy

Table 6: Affordability for solar energy

Responses	Frequency	Percentage
Yes	120	100
No	0	0
Total	120	100.0

In order to judge the inclined trends for alternate energy three questions were asked. Table 6 displays the answers, regarding affordability for Solar Energy. Respondents were asked whether they can afford solar energy technology to get electricity or not. The result is highly encouraging. All of them responded positively.

3.7. Inclination towards Solar energy

Table 7: Inclination towards solar energy

Responses	Frequency	Percentage
Yes	119	99.2
No	1	0.8
Total	120	100.0

Table 7 displays the responses considering proclivity towards Solar Energy. Respondents were asked whether they would use solar energy technology to get electricity, as it is clean energy. The result is very encouraging. Out of 120, only one answered no whereas 119 responded positively, showing their intentions to go for solar energy.

3.8. Knowledge of the level of availability for Solar energy

Table 8: Knowledge of the availability for solar energy

Responses	Frequency	Percentage
Yes	93	77.5
No	27	22.5
Total	120	100.0

Table 8 displays the replies considering awareness among respondents regarding availability of solar appliances in market. Out of 120 total, 93 domestic users had some idea about availability of solar appliances in the market while 27 did not have any knowledge. Thus overall 77% positive while 22% negative responses were received.

3.9. Initial Spending to Utilize Solar Electricity

Table 9: Initial spending to Utilize Solar Electricity

N	120
Minimum	11000
Maximum	150000
Mean	41550
Sd. deviation	41087

One of the drawbacks of solar energy technology is that it requires initial investment and then it keeps producing electricity for years with no cost of solar panels. Initial spending is a major issue especially in the rural areas where the income of the people is already low. Average initial spending stood at PKR 41,440 with a minimum of PKR 11,000 and a maximum of PKR 150,000. Most of the people had already spent what they could afford. Level of solar utilization was found high. However, the low income was observed as a major hurdle in this regard. People cannot afford to utilize solar energy for 24 hours. Most of the people utilize it only during daytime because they are not financially strong to purchase batteries for the backup. Besides, right now, it is being used only for electric fans and none of the other appliances. Results indicate low initial spending capacity, therefore, it is suggested that the government either provide subsidy or provide interest-free loans.

3.10. Average Maintenance Cost of Solar energy

Table 10: Average Maintenance Cost of Solar energy

Options (PKR).	Frequency	Percentage
10000	109	90.8
20000	11	9.2
30000	0	0
Total	120	100.0

Average annual spending capacity of operational cost of 90.8% was PKR 10,000 while PKR 20,000 for the remaining 9.2%. Both the domestic users and businessmen said that solar panels do not have any operational cost. Operational cost is to maintain backup when there is no sunlight. The market survey revealed, and also testified by domestic users, that the price of the batteries is quite high. If the price is brought down, it would be within reach of the lower income citizen and utilization of the solar technology would increase.

4. Conclusions

The findings of domestic users survey revealed that existing trend for Solar Energy in South Punjab is quite satisfactory as 60% of domestic users are already using solar as an alternative and the level of satisfaction is also 60%. General potential and inclined trends for Solar Energy was found 82% in support of Solar Energy, much higher than the findings of the same study (65% inclination towards Solar Energy) conducted in Abbottabad [28]. While the proclivity for Solar Energy was found 99%, again higher in comparison with the results of the same study conducted in Gwadar Port city (70%) [29]. This demonstrates a much higher acceptance of Solar Energy in South Punjab.

5. Recommendation

As discussed earlier that similar studies are already done in Abbotabad (Province: Khyber Pakhtunkhwa) and Gwadar Port City (Province: Bolochistan) and the current study is conducted in South Punjab (Province: Punjab) of Pakistan. The survey results from area of study in these three provinces of the country indicate that

the respondents have shown higher interest in Solar Energy. Secondly, this research is a part of Ph.D program, due to time constraints, 120 domestic respondents were selected and approached. It is therefore recommended that Domestic Users' Perceptions regarding Solar Energy might be calculated based on large sample sizes and extended to other provinces of Pakistan as well in order to get variant findings.

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