Evaluation of Consumer Acceptance and Satisfaction from Solar Energy Products

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Abstract

As one of the largest energy consuming state, Punjab is facing environmental worsening, which occurs due to excess use of non-renewable conventional sources of energy such as coal. Solar photovoltaic (PV) energy is an indefinite and clean energy with minimum harmful impact on the environment. In the present study, we designed and conducted a survey in six districts of Punjab. Based on the primary data, we utilized basic statistical methods to observe respondents' knowledge, concerns, and attitudes towards PV adoption. The research aimed to recognize the drivers and dynamics that normally influence consumers to establish solar PV system in their homes. The results suggested that respondents' satisfaction differed across cities, and lack of financial support by the government is the major barrier that limits diffusion of solar energy.

Key words : **solar energy, diffusion, photovoltaic, semiconductor, barriers**

JEL Classification : O33, Q01, Q55

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Solar energy is the energy obtained from the sun during sunlight days. It is developed all the way through solar thermal generator (Collector) and solar photovoltaic (PV) modules (solar module) (Groot, 2008). Solar thermal generator utilizes solar power by converting the sun rays into heat (Mecnaney, 2010). Solar cells, likewise called as Photovoltaic (PV), convert sunlight straight into electricity (National Renewable Energy Laboratory, 2006). According to the Solar Energy Industries Association (2013), the solar photovoltaic tool produces electricity straightforwardly as of the sun. An electronic process that occurs with two naturally imprecise types of metals is called a semiconductor. Simply put, a solar panel works by allowing photons, or particles of light, to knock electrons free from atoms, generating a flow of electricity.

According to Sun Water Solar (2012), the solar thermal system uses the energy of the sun to heat water. Solar energy is pulled up by the collector which is, for the most part, intended to be on, fire up the fluids moved through the collector, and these warmth fluids transmit thermal energy to the water stored in the solar storage space tanks. Its long-term financial earnings is a decline in electricity bills, it is pollution free, and it minimizes our dependence on fossil fuel and energy. So, it assists in minimizing our carbon footprint.

The India Energy Portal estimated that approximately 12.5% of India's land mass, or 413,000 km^2, could be used for harnessing solar energy. India, likewise, has the possibility to considerably diminish power required during improved operation of solar water heaters (SWH). India has over 17 GW of installed renewable power generating capacity, with solar contributing only 15 MW(Roger, 1983). India was one of the worldwide leaders in

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installed renewable energy potential, with a total capacitance of 17,594 MW (utility and non-utility). MNRE seeks to get good-looking surroundings for investors, including incentives such as feed-in tariff. India's installed solar power capability was 15.2 MW at the end of June 2010.As of March 2014, India had 2631.9038 MW of grid attached solar power projects which were specially made under Jawaharlal Nehru National Solar Mission (JNNSM) (Roger, 1983).There are enormous opportunities to invest in efficient solar technologies in securing global solution to reduce the carbon footprint. Indian companies are responding to environmental threats as well as opportunities that lie ahead for carbon green development (Dutta & Roy, 2014). The Government of India launched the Jawaharlal Nehru National Solar Mission with an intention to be a global leader in solar energy. However, the high startup capital keeps the customers away from solar power. Thus, necessary measures need to be taken to bring down the cost of solar power to ensure its viability(Natarajan & Nalini, 2015).

Punjab receives an estimated 4-7 units/m^2 of solar insulation levels, suggesting that it holds the highest potential for solar power. The Punjab government is targeting solar power generation of 1,000 MW by 2017 and is targeting to operationalize 500 MW solar power projects by March 2016. It has currently operationalzed 117 MW of solar power projects (Harder, 2009). Punjab floated a tender in December 2014 for the second phase of allocations in the country for 250 MW of solar PV projects. Tasks were divided into three categories: category one was for a sum of 50 MW with project sizes between 1 MW and 4 MW ; category two was for 100 MW with project sizes between 5 MW and 24 MW ; and category three was for 100 MW with project sizes between 25 MW and 100 MW. It was mentioned that developers preferred larger projects (as category three projects were heavily oversubscribed) with comparatively lower transaction costs and more options for financial engineering (Peterson, 2010).

Literature Review

Faiers and Neame (2006) examined householders' attitude towards the adoption of solar energy and identified some of the barriers to its adoption. They used conjoint analysis and conducted a comparison of means of subgroups with the early adopters and the early majority and concluded that householders' felt optimistic towards a number of facets of solar technology, but they simply did not have an adequately helpful attitude towards it. Monetary aspects were the major barriers to its acceptance.

Vasseur and Kemp (2015) exposed the effect analysis into the acceptance & non acceptance of solar PV in Dutch homes. They deliberated and evaluated the description of adopters and non-adopters of solar PV by means of factor analysis and cluster analysis.

Zhai and Williams (2010) aspired to look into the role of the consumer receipt model and its result on housing photovoltaic (PV) adoption. The example is experienced in built-up PV adoption from a survey of homeowners in Arizona, United States. They also used descriptive statistics of observation variable and demonstrated major dissimilarity between adopters and non-adopters.

Dutta (2012) considered that India has swiftly built up its solar power sector. Not entirely has the country already reached its targets of 1 Giga Watt (GW) of installed solar capacity this year, but the monetary value of domestic solar power is now at par with the price of electricity from new coal-fired power plants. Greater reliance on solar power will encourage the country's energy security and lessen its heavy (and costly) dependence on coal. Cheaper solar power will serve thousands of Indian homes and they will be able to gain access to electricity for the first time.

Comparable costs for solar power and conventional generation could lead to an increase in solar power's share in India's power generation portfolio. The awareness, perception, and ease of using technology & behavioral control are important facts that affected respondents' intention to adopt renewable energy (Prasadh & Suresh, 2016). The Indian banking industry and the hospitality industry are investing in renewable energy to bring about sustainable development in the society (see De Souza & Pai, 2013 ; Tara & Singh, 2014).

Objectives of the Study

(1) To identify major barriers limiting acceptance of solar products.

(2) To study the motives influencing consumer acceptance of solar energy based products.

(3) To compare consumer satisfaction from solar energy based products across cities.

(4) To propose a theoretical model on the basis of the findings of the present study.

Methodology

The purpose of this study is three fold. First, it aims to examine the satisfaction level of users. Second, this study investigates the barriers limiting the diffusion of solar energy. Third, the study aims to know the motives to purchase solar based products. This study uses both primary and secondary data in the investigation. Data was collected by using a survey questionnaire from the residents of Pathankot, Gurdaspur, Jalandhar, Kapurthala, Ludhiana, and Bathinda in Punjab. The survey was conducted between July - December 2015.

The terminology employed in the questionnaire was simple and understandable, with just a few technical terms because the respondents might be from different backgrounds with varying levels of exposure in this area. Nevertheless, respondents with a basic understanding of renewable energy were preferred. In the sample design of the study, two measures were required for the participation in the study. The foremost requirement was that the respondents must be the citizens of Punjab. The second demand was that the participants must be the head of the household. At the time of conducting the survey, some general questions were asked from the respondents - such as interest in an environmental issue, information about global warming, familiarity with renewable energy technologies, which renewable energy is best for Punjab, interest in solar energy, and so forth. The respondents who replied to the above questions with relevant information were only selected for the questionnaire survey.

The study was conducted through stratified convenience sampling. In this research, some questions were compared with relevant literature. The study aims to explore the perspectives and acceptance of the participants towards solar energy without any discrimination to their spiritual and cultural backgrounds. The study scope was limited to urbanized participants only.

Analysis and Results

The survey results focused on the characteristics of the respondents, their attitude towards solar-energy utilization, public views on the difficulties in consuming solar energy, and public expectations of enhancing solar-energy utilization in Punjab. A sum of 300 respondents was selected from 10 distributors from each city followed by another five respondents per distributor. Irrespective of ethnicity, income levels, instruction degree, residential areas, and genders, the respondents of this survey were, at least, interested in using solar energy. A survey was conducted by personal interaction with the respondents, and relevant consistency was maintained.

↳ **General Characteristics of the Respondents :** The general characteristics of the respondents is as follows. Men comprised of 93.2 % of the total respondents and women comprised of 6.8% of the total respondents ; 98.5% of the respondents were married and 1.5% were unmarried. With reference to educational qualification : 4.5% of the respondents were matriculate ; 18.1 % were intermediate ; 16.8% were graduates ; and 15.6% were postgraduates. Government employees and private employees were same : 20.8% each ; 50.6% of the respondents were engaged in own business, and 7.9% of the respondents were retired persons. Respondents having income levels up to ₹ 50,000 were 41.5%, between ₹ 50,000 - ₹ 1,00000 were 36.6 %,

₹ 100000 - ₹ 500000 were 19.2%, and ₹ 500000 and above were 2.7%. The division of the respondents on the basis of city is as follows : Pathankot : 18.5%, Kapurthala : 5.3% , Jalandhar : 19.2%, Bathinda : 17.7%, Gurdaspur : 20.4%, and Ludhiana : 18.9%.

One-way independent ANOVA was performed to test the hypothesis that satisfaction of the respondents from the use of solar energy based products did not differ significantly across cities. The results of the test have been given in Table 1, Table 2, and Figure 1, respectively.

To test the homogeneity of variance, Levene test was performed. Levene test is significant which means that variances among groups are not same, therefore, robust tests of equality of means (Welch and Brown-Forsythe) were used to compare the groups. The results show that the satisfaction levels among the respondents from the use of solar energy based products differed significantly across cities, so the null hypothesis is rejected, F (5, 136.765) = 3.200, $p < .05$.

It can be observed from the Figure 1 that satisfaction of respondents of Ludhiana from solar energy products was the highest followed by respondents based in Kapurthala, Jalandhar, and Pathankot. Gurdaspur followed by Bathinda showed the least satisfaction from solar energy products.

The Table 2 shows individual comparisons of cities with each other calculated through the Games-Howell method. The results of the test depict that the respondents of Ludhiana were more satisfied by using solar energy products than their counterparts in Gurdaspur ($p < 0.05$).

Table 1. Descriptive Statistics and ANOVA Results for Satisfaction from Solar Energy Based Products

Statements	*N*	Mean	*SD*	Lev. Stat.	Sig.	*F*	Sig.
Pathankot	50	1.86	.606	2.719	.020	3.200 (W)	.009
Kapurthala	49	2.02	.595			3.121 (B)	.009
Jalandhar	51	1.90	.640				
Bathinda	47	1.72	.649				
Gurdaspur	54	1.69	.609				
Ludhiana	49	2.06	.556				
Total	**300**	**1.87**	**.621**				

Figure 1. Satisfaction of Respondents from Use of Solar Energy Based Products

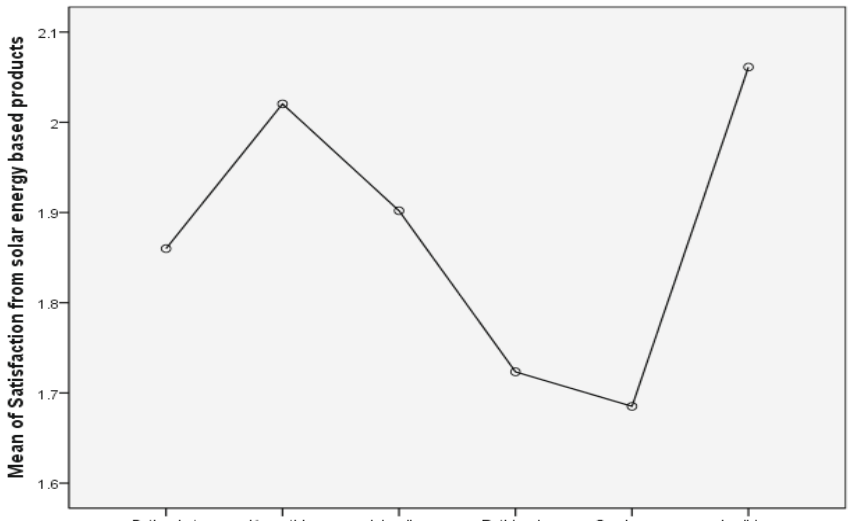


Table 2. Post Hoc Contrasts (Games-Howell) for Satisfaction from Solar Energy Based Products

		Mean Difference	Sig.
Pathankot	Kapurthala	-.160	.780
	Jalandhar	-.042	.999
	Bathinada	.137	.880
	Gurdaspur	.175	.690
	Ludhiana	-.201	.572
Kapurthla	Jalandhar	.118	.927
	Bathinada	.297	.165
	Gurdaspur	.335	.063
	Ludhiana	-.041	.999
Jalandhar	Bathinda	.179	.698
	Gurdaspur	.217	.454
	Ludhiana	-.159	.782
Bathinada	Gurdaspur	.038	1.000
	Ludhiana	-.338	.076
Gurdaspur	Ludhiana	-.376	.024

Table 3. Barriers Limiting the Diffusion of Solar Energy

S. No.	Barriers Limiting the diffusion of solar energy	Yes	No	Yes %
1.	Lack of financial support by government	142	158	47.3
2.	Lack of promotion by the government	141	159	47.0
3.	Special installation requirements	66	234	22.0
4.	Technical complexities	93	207	31.0
5.	The threat of poor quality products sold in the market	94	206	31.3
6.	Lack of research and testing by firms	51	249	17.0
7.	Inadequate standards	92	208	30.7
8.	Long payback period	104	196	34.7
9.	Cost involved in changing battery periodically	99	201	33.0
10.	Higher maintenance and repair cost	67	233	22.3
11.	Higher initial cost as compared to conventional sources	115	185	38.3

The Table 3 shows that lack of financial support and promotion by the government are the major barriers that limit the diffusion of solar energy followed by high initial cost, long payback period, cost involved in changing battery periodically, and threat of poor quality products sold in the market. Lack of research and testing by firms is the least influencing diffusion barrier followed by special installation requirements, high maintenance and repair cost, and inadequate standards.

Motives for using solar energy based products are shown in the Table 4. No power cuts is the major motivator for using solar energy products followed by decreasing usage of fossil fuels, maintenance free energy, promotes ecological balance, and removes negative effects of greenhouse gases. The Table 5 depicts that majority of the respondents did not prefer to buy solar energy based products if these were slightly expensive than other sources of energy.

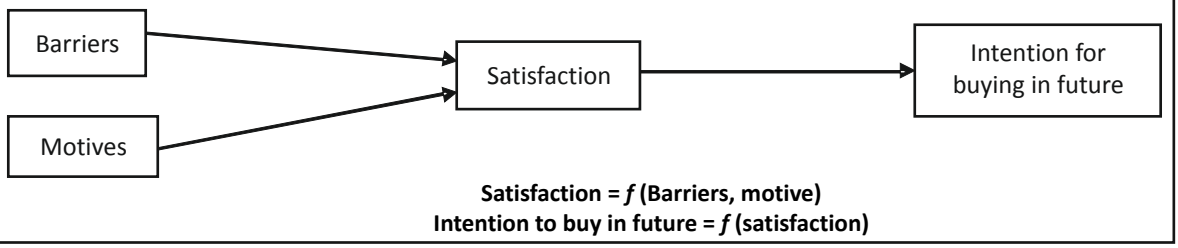
Table 4. Motives for Using Solar Energy Based Products

S. No.	Motives for using solar energy based products	Yes	No	Yes %
1.	Less dependence utility on conventional sources	83	217	27.7
2.	No power cut	199	101	66.3
3.	Solar energy systems are virtually maintenance free	89	211	29.7
4.	For ecological balance, solar energy resources should be promoted	64	236	21.3
5.	Using solar energy resources would remove the negative effects of the greenhouse gases	63	237	21.0
6.	Using solar energy resources will decrease the usage of fossil fuels, which are the biggest cause of global warming	101	199	33.7

Table 5. Consider Buying a Solar Energy Based Product if it was Slightly Expensive to Another Source

S. No.	Response	Frequency	%
1.	Yes	88	29.3
2.	No	170	56.7
3.	May Be	42	14.0

Figure 2. Model Proposed for Increasing Acceptance of Solar Energy Products



Considering the motives and overcoming the barriers as reported above leads to satisfaction of users from solar energy products which further determines their intention to buy solar energy products in the future. The Figure 2 shows this relationship in the form of an acceptance model. Barriers and motives of solar energy based products are the two drivers which lead to satisfaction from solar energy based products. The satisfaction levels with solar energy based products creates future demand for the same.

Managerial/Policy Implications

This study will help the Government as well manufacturers of solar-energy products. It would help the government to make a policy based on the results of present study, which will help to increase the acceptance of solar products in low awareness areas. The manufacturers can identify the potential barriers of solar-energy diffusion pointed out by the present study and devise their strategies accordingly that will help them to remove the significant barriers, which, in turn, will result in increased satisfaction and generation of higher sales in the future.

Conclusion

The satisfaction level of users differed significantly across cities. Respondents of Ludhiana were more satisfied with solar energy products than were the respondents of Gurdaspur. Lack of financial support and promotion by

the government are the major barriers that limit the diffusion of solar energy followed by high initial cost, long payback period, and the cost involved in changing the battery periodically. No power cuts is the major motivator for using solar energy products followed by decreasing usage of fossil fuels, maintenance free energy, promote ecological balance, and remove negative effects of greenhouse gases.

As per our study, there was no significant difference in satisfaction levels in different cities. But there was a vast difference in the satisfaction levels with reference to Ludhiana and Gurdaspur. Hence, the government policies have to create awareness about solar products in low awareness areas like Gurdaspur district.

The main barriers limiting the diffusion of solar energy are the lack of financial support and promotion by the government. To promote solar energy, the government is providing bank loans and subsidy for solar energy. The government also provides tax benefits to solar energy users.

Limitations of the Study and Scope for Further Research

The results of the present study are based on the samples taken from six cities of Punjab state only. The results of the study may be different in other areas due to geographical size, location of the population, socio-cultural, & economics differences. The study is more likely to reflect the middle class and urban areas and may not be applicable to other income classes and rural areas.

For generalization of the results, the study may be replicated at national and worldwide levels. A model may be constructed based on the diffusion scale given by E. Rogers, and variables that affect respondents' intention to use solar energy products may be identified.

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