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# Paradigm shift in socio-economic profile of users of domestic photovoltaic solar system in Punjab in relation to their awareness

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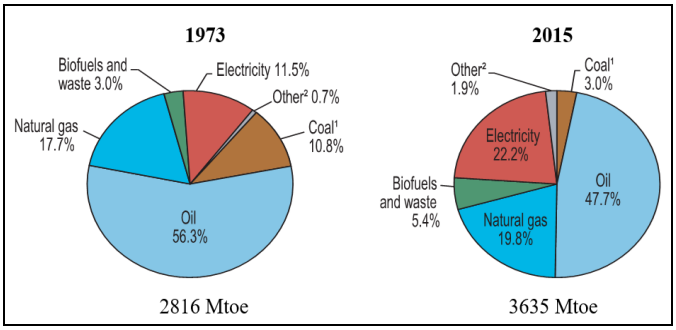
**Abstract**
Today the world is passing through a phase of scarcity of energy required for development on one hand and the near extinction of renewable sources of energy on the other. The sustainability of natural resources and switching to green energy is the only solution. This prospective study was carried out on users of domestic photovoltaic system residing in various cities of Punjab, India. A total of 300 respondents (both male and females) constitute the sample of the study. The study is descriptive in nature and primary data is used for this purpose. A self-constructed interview schedule was used to collect the data from the users of the solar photovoltaic (PV) system. A sample of 300 families from different cities of Punjab consisting 27 families from Jalandhar, 47 families from Patiala, 13 families from Mohali, 200 families from Ludhiana and 13 families from Amritsar who had installed photovoltaic systems in their residence in 2014-17 were selected for the study by proportionate random sampling technique. The present study is an attempt to study the socio-economic profile of users of solar photovoltaic system and to correlate it with their awareness of solar system so that the myth of attaching affluence with the affordability of domestic photovoltaic solar system be broken. It will help in correcting myopic perspective of users pertaining to solar photovoltaic system and contribute towards ecological sustainability without compromising the development.

**Keywords:** Net metering, renewable energy system, socio-economic status, solar photovoltaic system

## Introduction
Energy has been realized since long, as an important factor for economic development of a country with relation to increasing the quality of living of the people (Chavan 2014) [2] to the extent that it has become synonym to progress of a country and India, being on the path of economic and social development, is no exception to it. With the progressive energy demand by the people, the dependence on the non-renewable energy resources of fossil fuels like coal, oil, gases petroleum etc. has increased leading to the rapid depletion of these reserves. The estimated reserves of natural gas have decreased by 1.97% over the year 2016 (Energy Statistics, 2017) [7]. The same is the case with other energy sources which not only putting the threat of diminishing these resources sooner than later but also the emergence of critical issues with high costs as one aspect and ozone layer depletion, global warming and environment degradation as others (Anbuchezhian 2014) [1]. This calls for the shift to non-renewable energy for development making sustainable development a buzz word.
The pie chart below shows the change in the share of the fuels from 1973 to 2015 in fulfilling the energy demand of the world economy. The graph clearly shows a decrease in the share of oil from 56.3% to 47.7%, increase in share of natural gas from 17.7% to 19.8%, bio-fuels and waste increased from 3% to 5.4%, electricity from 11.5% to 22.2%, a high decrease in coal from 10.8% to 3%. This shows that the energy consumption is shifting from coal and oil to other sources of energy (IEA, 2017)




**Source:** World Energy Outlook 2017

**Fig 1:** Pie chart of world fuel consumption

India, with its ever growing population and aspiration to become economic power of the world, is also shifting though with slow pace, from renewable to non-renewable energy resources. The total potential for renewable power generation in the country as on 31.03.16 is estimated at 1198856 MW which includes wind power potential of 102788 MW (8.57%), wind power potential of 302235 MW (25.21%), SHP (small-hydro power) potential of 19749 MW (1.65%), biomass power of 17,538 MW (1.46%), 5000 MW (0.42%) from bagasse-based cogeneration in sugar mills, 2556 MW (0.21%) from waste to energy and solar power potential of 748990 MW (62.48. However out of the total installed generation capacity of renewable power as on 31-03-2016, wind power accounted for about 62.7%, followed by solar power (15.78%) and biomass power (11.46%) which indicates that the solar energy in India is grossly under used which otherwise is available in abundance due to the geographical location of the country with about 300 clear and sunny days in a year. Indian Government has taken strong initiatives and the country's solar installed capacity has reached 25.21 GW as on 31 December, 2018.

The state of Punjab is one of the most affluent and progressive state of India. Though essentially an agrarian economy is now fast growing towards agro-based industrial development and power is the central axis of Punjab's economic development. Punjab Energy Development Agency is the state nodal agency for the promotion and development of renewable energy projects and energy conservation projects in Punjab.

**Table 1:** Source wise Estimated Potential and Installed Capacity of Renewable Power: Punjab (as on 31-01-2018) (Mws)

| S. No. | Energy Sources | Estimated Potential by 2022 | Installed Capacity as on 31/3/18 |
|---|---|---|---|
| 1 | Small Hydro Power | 100.00 | 156.15 |
| 2 | Biomass Power | 362.50 | 62.50 |
| 3 | Cogeneration Bagasse | 545.00 | 433.40 |
| 4 | Waste to Energy | 10.00 | 1.50 |
| 5 | Solar | 2097.00 | 898.00 |
| | Total | 3114.50 | 1551.55 |

**Source:** Punjab Energy Development Agency

At present the cumulative capacity of new and renewable sources of energy (NRSE) projects in the state is 1551.55 MW. It is estimated that the state of Punjab would further achieve an additional capacity of 3114.50 MW power through renewable sources of energy by the year 2022 (Table 1). The contribution would come from solar, biomass, cogeneration, hydel and waste to energy projects. The generation of power from above renewable sources of energy will also help in mitigating carbon dioxide emissions and combat climate change.

**Table 2:** Energy Statistics in Punjab as on December 2017

| RE (Renewable Energy) Technology | Potential (MW) | Achievement (MW) | Realization (%) |
|---|---|---|---|
| Solar | 2810 | 795 | 28.3% |
| Small hydro power (SHP) | 441 | 145.5 | 33% |
| Biomass+ Cogeneration | 3472 | 473.5 | 13.6% |
| Overall RE | 6723 | 1413.15 | 21% |

**Source:** MNRE and Ministry of statistics and programme implementation (MOSPI)

The Table 1 & 2 clearly shows that Punjab has vast potentiality for solar energy generation with as low as 28.3% realization of that potential till date.

Government of India in collaboration of Punjab government has taken the initiative to use solar power in agriculture sector at large scale 5000 solar pumps of capacity 3HP and 5HP are to be installed during the F.Y.2018-19 under the 150 provision of 58% subsidy by Punjab government and 22% subsidy by Government of India of the total cost of the pump. These 5000 pumps will save 20MW of electricity and about 80000 units per day and total saving in a year would be about 300 lacs units which will save about Rs. 14 crores of State Government being given as subsidy to the farmers.

Punjab has the World's Largest Single Rooftop solar plant located in Beas Dera with 11.5MW production capacity and the largest single location solar plant in Mansa district with 3.5MW capacity. Govt. of India has set Punjab a target of 40,000MW of power from renewable sources to be produced by the year 2022, of which solar will play a significant contribution and domestic front for solar energy utilization is the main focus because household is the major electricity consumption sector in India and it is constantly increasing due to ever increasing population. To motivate people to adopt solar system for domestic consumption, Punjab government has evolved its solar policy.

**The prominent features of Punjab Solar policy are**

- It has predominantly rooftop system with net metering facility with minimum sanctioned capacity 1 kWp and maximum of 1 MWp and utilization limit of 80% of sanctioned load of consumer.
- It provides self ownership option at COPEX model where entire investment comes from consumer as well as third party ownership at RESCO model where the entire system is owned by the developer and the consume pay a pre-determined tariff monthly.
- The billing mechanism is annual from October to September. The settlement of net energy including any banked energy be done at the end of each settlement period based on 90% of the consumption.
- The loan for solar system would be considered as a part of home loan and the loan upto 10 lacs be available under priority sector lending.

Roger (2003) [12] has presented a model (Fig. 2) for adoption of any innovation passes through various channels before being finally accepted. The knowledge of innovation is the first and prime factor in adoption of that innovation which in turn depends on the socio-economic characteristics, personality and communication behaviour of the individuals. The knowledge lead to the persuasion for the innovation and is based on five attributes of the innovation i.e. relative advantage, compatibility, complexity, trialability and observability that eventually determine the decision in favour or against implementation of that innovation.

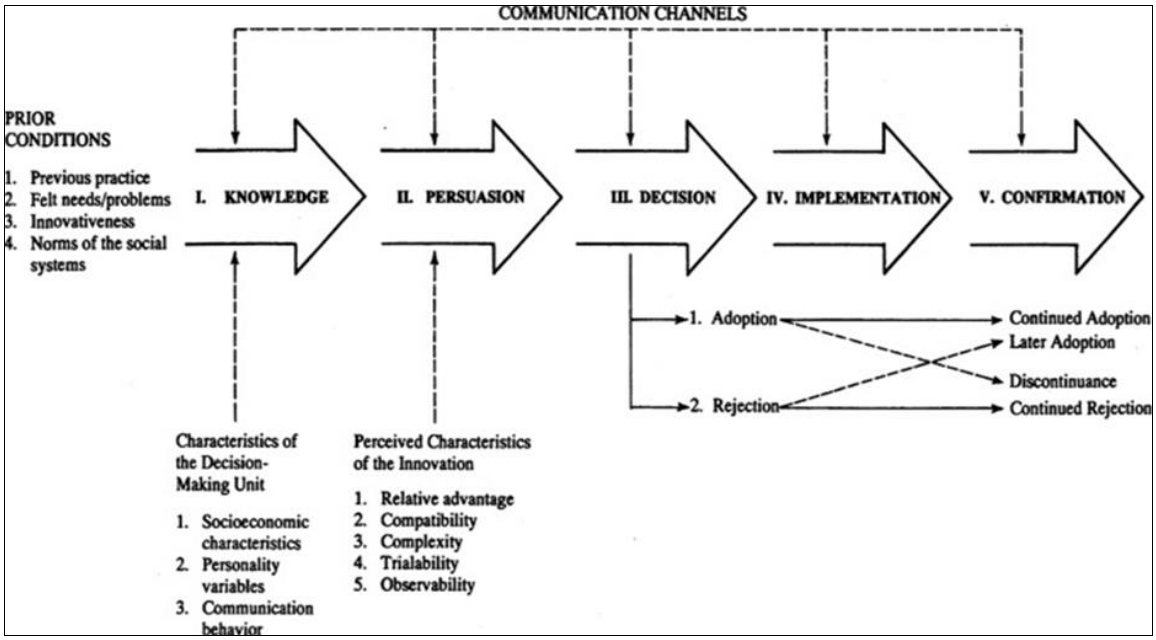



**Fig 2:** Source: Rogers EM, Elements of diffusion. Diffusion of innovations (2003)

The present study focuses on the awareness of domestic photovoltaic system in Punjab among its users and their socio-economic profile which is the foremost factor underlying its adoption.

## Material and Methods

This prospective study was carried out on users of domestic photovoltaic system residing in various cities of Punjab, India. A total of 300 adults (both male and females) constitute the sample of the study. The study is descriptive in nature and primary data is used for this purpose.

Socio-economic status scale developed by Meenakshi (2010) was used to collect the data from the users of the solar PV system. A sample of 300 families from different cities of Punjab consisting 27 families from Jalandhar, 47 families from Patiala, 13 families from Mohali, 200 families from Ludhiana and 13 families from Amritsar who had installed photovoltaic systems in their residence in 2014-17 were selected for the study. The scale consists of seven different aspects, viz. education, profession, monthly income, total wealth, property, surrounding locality and social status.

A self-structured interview schedule was designed to elicit the specific information related to users of domestic photovoltaic system in Punjab regarding awareness associated with solar photovoltaic system.

The statistical technique of Pearson Product Moment correlation techniques was employed between the scores of socio-economic status and the awareness.

## Results and Discussions

**Table 3:** Socio-economic profile of users of domestic photovoltaic system (n=300)

| Level | Education | family occupation | wealth | property | location | social status | Income | Overall Socio-economic Status |
|---|---|---|---|---|---|---|---|---|
| High | 39 (13%) | 32(11%) | 56(19%) | 83(28%) | 72(24%) | 98(33%) | 64(21%) | 57(19%) |
| Average | 163(54%) | 237(79%) | 153(51%) | 186(62%) | 203(68%) | 152(51%) | 179(60%) | 195(65%) |
| Low | 59(20%) | 31(10%) | 91(30%) | 31(10%) | 25(8%) | 50(17%) | 57(19%) | 48(15%) |
| Total | 300(100%) | 300(100%) | 300(100%) | 300(100%) | 300(100%) | 300(100%) | 300(100%) | 300(100%) |

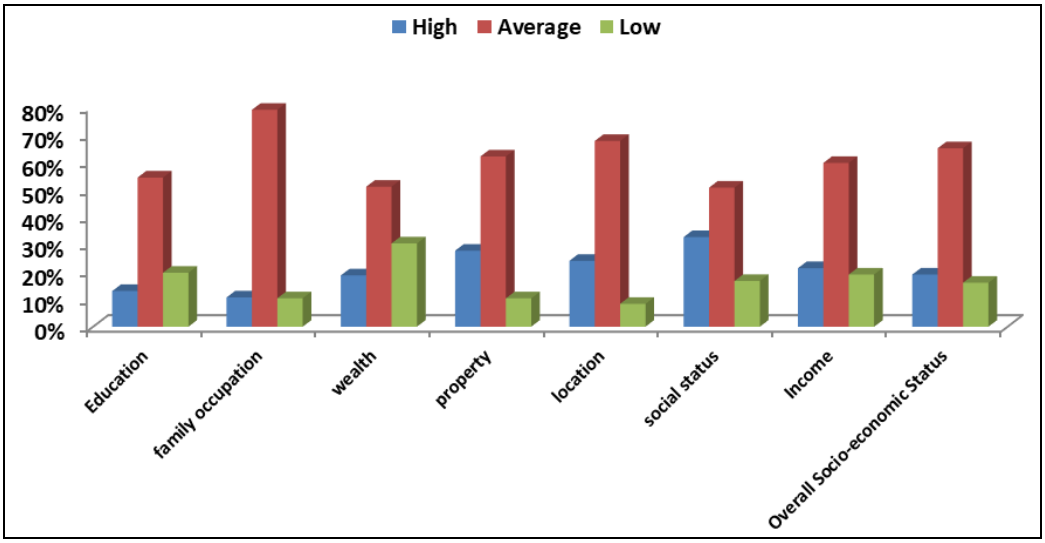



**Fig 3:** Socio-economic profile of users of domestic photovoltaic system (n=300)

Table 3 indicates that nearly half of the respondents were of average education level whereas one-fifth of the respondents were of low education level; nearly four-fifth of the respondents were of average family occupation level and remaining respondents were equally distributed on high and low family occupation level; half of the respondents were of average wealth status whereas one-third of the respondents were of average wealth status; 10% of the respondents were of low property status with more than half of the respondents were of average property level and property of one-third respondents were of high level; 33% of the respondents were of high social status and 17% were of low social status; nearly one-fifth of the respondents belong to low income level. The overall socio-economic status of 15% respondents was found to be low and only 19% respondents were of high socio-economic status.

The result agreed with the findings of Stefan (2004) [9], Kotler (2006) [3] and Nelson *et al*. (2011) which opined that the educational, economic, social and cultural factors contributed significantly in purchase of solar photovoltaic system. This indicates the paradigm shift in the socio-economic status of users of solar photovoltaic system contrary to the conventional belief that only the persons of high socio-economic status use solar photovoltaic system.

**Table 4:** Awareness of respondents about basic features of solar photovoltaic system (n=300)

| S. No. | Basic Information | | | | f | Percentage |
|---|---|---|---|---|---|---|
| 1 | Different solar photovoltaic systems available in market | On-grid | Yes | | 300 | 100.00 |
| | | Off-grid | Yes | | 300 | 100.00 |
| 2 | IS specification | Yes | | | 300 | 100 |
| 3 | Working principle | Yes | | | 300 | 100 |
| 4 | Life | 25 years | | | 300 | 100.00 |
| 5 | Place of Installation* | At the roof of residential and commercial complex | | | 110 | 36.67 |
| | | Housing societies / commercial establishments like malls | | | 70 | 23.33 |
| | | Community centres | | | 64 | 21.33 |
| | | Government organizations | | | 64 | 21.33 |
| | | Private institutions | | | 63 | 21.00 |
| | | All the above | | | 248 | 82.67 |
| 6 | Investment | Rs. 55,000 to Rs. 65,000 | | | 20 | 6.67 |
| | | Rs. 65,000 to Rs. 75,000 | | | 214 | 71.33 |
| | | Rs. 75,000 to Rs. 85,000 | | | 66 | 22.00 |
| 7 | Roof area required | 10 Sq.m./Kwp (app) | | | 239 | 79.67 |
| 8 | Knowledge of net metering | Yes | | | 291 | 97.00 |
| | | No | | | 9 | 3.00 |
| 9 | Panels getting required amount of sunlight | Yes | | | 297 | 99.00 |
| | | No | | | 3 | 1.00 |
| 10 | System fulfilling required amount of electricity | Yes | | | 297 | 99.00 |
| | | No | | | 3 | 1.00 |

*Multiple responses

Table 4 revealed that all the respondents (100.00%) were aware of on-grid as well as off-grid solar photovoltaic systems and its working principle and have their solar photovoltaic system as per IS specifications. All the respondents (100%) knew exactly about how long the PV modules would last. More than four-fifth of the respondents (82.70%) had the knowledge of all the possible places where the solar photovoltaic system could be installed. More than one-third of the respondents (36.70%) believed that the solar photovoltaic system could be installed at roof of residential and commercial complex; nearly than one-fourth of the respondents (23.30%) knew only about housing societies / commercial establishments like malls and equal number of respondents (21.33%) knew only about community centers and government organizations and 21 per cent respondents knew only about private institutions as the places possible to install solar photovoltaic system. Nearly three-fourth of the respondents (71.30%) opined that the average cost of solar photovoltaic system lies between Rs. 65,000 to Rs. 75,000 per Kwp whereas twenty two per cent respondents paid the average cost of solar photovoltaic system between Rs. 75,000 to Rs. 85,000 per Kwp and only 6.70 per cent of respondents opined that the average cost of solar photovoltaic system lies between Rs. 55,000 to Rs. 65,000 per Kwp. Nearly four-fifth of the respondent (79.67%) exactly know about the exact area is required to set up the solar photovoltaic system whereas the remaining one-fifth (20.33%) respondents could not give the right answer. A very high majority of respondents (97%) claimed to have knowledge regarding net metering system of solar photovoltaic system. Only three per cent agreed that they didn't know about net metering. Those respondents actually opted for off-grid system which operate on batteries and did not need net metering. A very high majority of ninety nine per cent respondents accepted that their solar photovoltaic panels were getting adequate amount of sunlight and equal proportion of respondents accepted that their solar photovoltaic system were fulfilling the required amount of electricity. The remaining one per cent disagreed on both the issues.

The above discussion clearly indicate that the respondents were well informed and well aware of solar photovoltaic system which is quite natural for any Indian buyer who had the tendency to get information about the object from all the possible sources before spending money on it. A very small proportion of respondents showed lack of information and awareness.

**Table 5:** Correlation between awareness and socio-economic profile of users of solar photovoltaic systems

| Socio-economic status indicators | Awareness of socio-economic profile |
|---|---|
| Education | 0.39** |
| Occupation | 0.19** |
| Wealth | 0.52** |
| Property | 0.25** |
| Surrounding Locality | 0.21** |
| Social Status | 0.18** |
| Socio-economic Status | 0.40** |

**Significant at .01 level

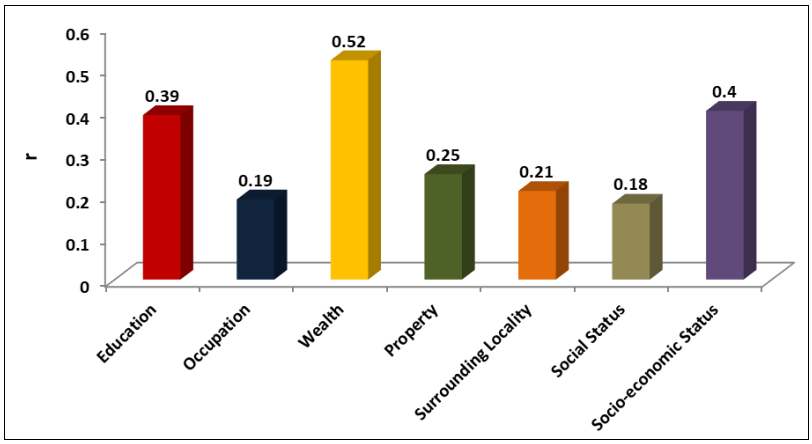



**Fig 4:** Correlation between awareness and socio-economic profile of users of solar photovoltaic systems

The perusal of data shown in Table 5 indicate that the awareness of respondents pertaining to the various components of solar photovoltaic systems was positively and significantly correlated with their level of education, their occupation, wealth, property, surrounding locality, social status as well as their overall socio-economic status which in turn illustrated that the respondents with higher level of family education, occupation, wealth, property, good surrounding locality, high social status as well as high overall socio-economic status were more aware about solar photovoltaic system as compared to their counterpart with low level of family education, occupation, wealth, property, good surrounding locality, low social status as well as low overall socio-economic status.

## Conclusion

The overview of the results illustrated in Table 3 very clearly and vividly represented that the users of socio-economic profile of users of solar photovoltaic system is undergoing paradigm shift from the conventional belief that only the persons of high socio-economic status use solar photovoltaic system. More and more people from average and even low socio-economic strata are coming in the net of solar photovoltaic system users. The result is supported by a study undertaken by Sommerfeld (2017) [14] which revealed that the financial capacity, education status and home ownership had in the past been found to be important pre-requisites in the uptake of solar PV but currently these factors no longer remain the dominant ones.

The result supports the conventional belief that high socio-economic status of users ensures the high level of awareness pertaining to basic features and functioning of solar photovoltaic system.

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