Sociology & Cultural Research Review (SCRR)
Available Online: https://scrrjournal.com
Print ISSN: 3007-3103 Online ISSN: 3007-3111
Platform & Workflow by: Open Journal Systems

Socio-Economic impacts of Decentralized Solar Projects in Bajuar Agency, FATA

Ihsan Ullah
MS in Economics, University of International Business and Economics UIBE Beijing China
ihsanayubi70@gmail.com
Dr. Tasneem Akhter
Assistant Professor of Economics, Faculty of Management Sciences, University of Central Punjab, Lahore
tasneem.akhter@ucp.edu.pk
Dr. Fazal Karim
IDS, The University of Agriculture Peshawar
flarimiiui@gmail.com

ABSTRACT
This study assessed the current status and future prospects of solar energy adoption at the regional level using primary data collected from 100 respondents through a structured questionnaire. Descriptive statistical techniques, including frequency distributions and percentages, were used to summarize socioeconomic characteristics, while correlation and regression analyses were employed to examine the determinants of solar energy adoption. The findings indicate a positive and growing trend in solar energy usage; however, financial constraints significantly limit its widespread adoption. A large proportion of respondents belong to low- and middle-income groups, and poverty remains a major barrier to investing in solar systems for households and small businesses. While solar energy offers substantial environmental and economic benefits, its expansion depends heavily on effective government intervention. Policy measures such as subsidies, soft financing schemes, public investment in solar infrastructure, and the development of solar grid stations are essential to enhance accessibility and affordability. By promoting renewable energy adoption, governments can reduce load-shedding, decrease long-term energy costs, stimulate economic growth, and contribute positively to national GDP while ensuring environmental sustainability. Overall, solar energy presents a promising pathway toward energy security and sustainable development, provided that supportive institutional frameworks and financial mechanisms are effectively implemented.

Keywords: Socio-Economic, Decentralized Solar Projects, Bajuar Agency, FATA, *National GDP*

1. Introduction

Solar energy, transmitted from the sun as electromagnetic waves, is essential for life on Earth. These waves, including photoelectric and ultraviolet rays, can be converted into chemical or electrical energy using various devices. While the Earth receives only a small fraction of the sun's energy, this energy can be harnessed efficiently. A photon, the smallest unit of solar energy, travels at the speed of light, taking approximately 8.5 minutes to reach Earth. Upon interaction with atoms, photons excite electrons, enabling energy conversion into usable forms such as electricity or heat.

Solar energy systems typically include two main components: collectors and storage. Collectors—flat-plate, focusing, and passive—absorb radiation, while storage systems store excess energy for non-productive periods. Flat-plate collectors are widely used due to their simplicity and automated tracking of the sun. Focusing collectors concentrate sunlight on a specific point, achieving higher energy density but requiring temperature safeguards. Passive collectors naturally absorb solar radiation, converting it into heat without complex machinery.

Solar Energy and Its Importance

The sun is a massive star, approximately one million times the size of Earth, with a surface temperature of 6,000°C. Its core hosts nuclear fusion, where hydrogen nuclei fuse into helium, releasing tremendous energy. Solar energy, derived from the Latin word "sol," is utilized for multiple applications, including heating, electricity generation, and photosynthesis. Plants convert sunlight into chemical energy, which sustains all life on Earth.

Historical Background

The evolution of solar energy spans several centuries:

- **1767:** Horace-Benedict de Saussure created the first solar collector.
- **1839:** Edmond Becquerel discovered the photovoltaic effect.
- **1873–1876:** Willoughby Smith demonstrated selenium's photoconductivity, establishing the foundation for solar cells.
- **1891–1908:** Inventions included the first solar heater and copper collectors, improving efficiency.
- **1905–1916:** Albert Einstein’s theory of the photoelectric effect was experimentally confirmed by Robert Millikan.
- **Post-WWII:** Solar energy gained popularity in the U.S.
- **1958 onwards:** Solar power was deployed in space applications, followed by efficiency improvements in panels during the 1970s.
- **1980s–2000s:** Solar-powered aircraft, cars, and large-scale plants emerged globally.
- **2010s:** Record-breaking solar parks in China and India demonstrated the potential of utility-scale solar energy.

Solar Energy in Pakistan

Pakistan, located in the Sunny Belt, receives 1,500–3,000 hours of annual sunshine with high solar radiation, particularly in Baluchistan and Sindh. This makes solar energy a feasible alternative to conventional electricity. Government programs aim to electrify approximately 40,000 remote villages using solar systems. Key initiatives include:

- Import and installation of solar panels, water heaters, and pumping systems.
- The **first on-grid solar power station** inaugurated in Islamabad (2012) with 356.16 KW capacity, enabling net metering.
- **Quaid-e-Azam Solar Park** near Bahawalpur, a flagship 1,000 MW project on 6,500 acres, represents a major investment under CPEC.
- Solar energy deployment reduces reliance on conventional fuels, promotes renewable energy adoption, and has significant socio-economic benefits, including poverty alleviation and rural electrification.

Statement of the Problem

Pakistan faces chronic electricity shortages and rising consumption, particularly in rural regions. The growing reliance on alternative energy sources, such as generators and solar systems, highlights the importance of assessing solar energy's role in addressing load shedding and electricity gaps. Bajaur Agency, in FATA, exemplifies such a region with limited electricity access. In 2005, solar energy use was minimal, but by 2016, 16% of businesses had adopted solar panels. Solar systems have become a key substitute for hydroelectric power, contributing to poverty reduction, employment, and improved living standards.

Significance of the Study

Solar energy adoption in Pakistan, especially in Bajaur, has potential to:

- Reduce load shedding and electricity shortages.
- Promote sustainable energy production.
- Stimulate local economies through investment in solar infrastructure.
- Provide employment and business opportunities.

Objectives of the Study

1. Assess existing uses and satisfaction with solar energy.
2. Examine solar energy as a substitute for hydroelectricity.
3. Identify socio-economic factors influencing adoption.
4. Offer policy recommendations for improving solar energy deployment.

Hypotheses of the Study

- Solar energy plays a positive role in Pashat, Bajaur.
- Solar energy can substitute hydroelectric power in the area.
- Solar energy has a positive impact on local and national electricity supply and reduces load shedding.

Scope and Limitations of the study

The study focuses on Pashat, Bajaur, surveying 100 respondents from diverse occupations, including teachers, students, traders, and laborers. Data is analyzed using mean values, graphical and statistical methods. Results are context-specific and rely on the accuracy of respondents' information.

2. Literature Review

The existing body of literature provides strong evidence that renewable energy consumption, particularly solar energy, plays a crucial role in promoting economic growth while improving environmental quality. Numerous empirical studies demonstrate that renewable energy reduces carbon emissions, supports technological innovation, and generates employment opportunities across various sectors. Within this broader renewable energy framework, solar energy is consistently identified as the most abundant, reliable, and environmentally sustainable energy resource available. Originating from nuclear fusion reactions in the sun's core, solar radiation delivers an immense quantity of energy to Earth—far exceeding global energy demand. Although only a small fraction of total solar output reaches the planet, this amount is sufficient to meet present and future energy requirements if efficiently harnessed. The literature emphasizes that solar energy is not only central to electricity generation but also fundamental to sustaining life on Earth, regulating climate systems, supporting photosynthesis, and maintaining ecological balance.

Scientific explanations highlight that solar radiation travels as electromagnetic waves, reaching Earth within minutes and interacting with the atmosphere, land, and oceans. While part of this radiation is reflected back into space, the absorbed portion drives essential natural processes such as atmospheric circulation, the hydrological cycle, and agricultural productivity. Technological advancements have enabled the direct conversion of sunlight into electricity through photovoltaic (PV) systems and into thermal energy via solar collectors, making solar power one of the most versatile renewable energy technologies. Improvements in silicon-based solar cells have enhanced conversion efficiency and reduced production costs, significantly increasing commercial feasibility. Despite these advancements, only a very small percentage of available solar energy is currently utilized, highlighting enormous untapped potential. However, the literature also acknowledges intermittency challenges due to daily and seasonal variations, emphasizing the importance of complementary energy storage technologies and smart grid integration.

Globally, the transition toward renewable energy has accelerated due to rising energy demand, environmental degradation, and the gradual depletion of fossil fuel reserves. The world receives an estimated 160,000 terawatts of solar energy compared to global demand of roughly 16 terawatts, underscoring the vast surplus available. Countries such as Japan, the United States, Australia, and several European nations have implemented comprehensive solar roadmaps to achieve grid parity and reduce reliance on conventional fuels. Their experiences demonstrate that consistent policy frameworks, sustained investment, technological innovation, and institutional support are critical for scaling up solar deployment.

In the case of Pakistan, the literature presents a compelling argument for solar energy expansion. The country's electricity generation mix remains heavily dependent on thermal power based on imported fossil fuels, resulting in high production costs and vulnerability to external price shocks. Hydropower potential remains underexploited, while wind, biomass, and nuclear energy contribute relatively small shares to the overall energy mix. Consequently, Pakistan faces a persistent electricity deficit ranging between 3,000 and 7,000 megawatts, leading to widespread load-shedding, industrial slowdown, reduced agricultural productivity, and adverse social impacts. Studies estimate that energy shortages have caused annual GDP losses of approximately 3–4 percent, alongside rising unemployment, inflationary pressures, and weakened investor confidence.

Within this challenging environment, solar energy is widely recognized as the most feasible and sustainable solution. Pakistan's geographical location within the global solar belt provides high solar irradiation levels throughout the year, with substantial generation potential exceeding 100,000 megawatts, particularly in Sindh, Baluchistan, and southern Punjab. Both grid-connected and off-grid solar applications offer viable pathways to address energy shortages, especially in remote and underserved regions. Government initiatives—such as tax incentives, upfront tariffs, large-scale solar parks, and policy support from regulatory authorities—reflect growing recognition of solar energy's strategic importance. Nevertheless, progress has been slower than anticipated due to regulatory bottlenecks, financing constraints, limited local manufacturing capacity, and weak institutional coordination.

The literature further emphasizes the broader socio-economic benefits of solar energy investment. Beyond environmental gains through reduced greenhouse gas emissions and improved air quality, solar energy contributes to job creation in manufacturing, installation, operation, and maintenance. It reduces dependence on imported fuels, strengthens energy security, and expands electricity access in rural communities. Off-grid solar systems, in particular, have demonstrated effectiveness in improving access to education, healthcare, clean water, and communication services, thereby supporting poverty reduction and inclusive development. Although initial capital costs remain relatively high, declining technology prices and long-term operational savings have enhanced the economic competitiveness of solar power compared to conventional energy sources.

3. Research Methodology

This study is grounded in primary data collected through a structured questionnaire survey designed to gather both quantitative and qualitative information regarding solar energy usage, awareness, affordability, satisfaction levels, income, and living conditions of respondents. The research instrument included a combination of close-ended and open-ended questions to enable statistical analysis while also allowing respondents to express their views in detail. The questionnaires were administered personally to ensure clarity, reliability, and accuracy of responses. After collection, the data were systematically coded and entered into statistical software for analysis using descriptive, inferential, and econometric techniques to generate meaningful insights into the role and impact of solar energy in the study area.

A stratified random sampling technique was adopted to ensure fair representation of different socio-economic groups. The study was conducted in Tehsil Salarzai and Pashat city of Bajaur Agency (FATA), selected due to its status as a key commercial and administrative center with diverse economic activities, including retail businesses, educational institutions, healthcare services, transport operations, and solar enterprises. A total of 100 respondents were selected from various occupational categories, including laborers, students, teachers, doctors, solar traders, general storekeepers, drivers, and other professionals. This stratification enabled the research to capture varied perspectives on solar energy adoption and utilization.

The study employed a descriptive and analytical research design. Descriptive analysis was used to summarize demographic characteristics and patterns of solar energy usage, while analytical and econometric methods were applied to examine relationships among variables such as income, awareness, affordability, satisfaction, and energy consumption. Overall, the chosen methodology ensured systematic data collection, representative sampling, and rigorous statistical analysis, thereby enhancing the reliability and validity of the study's findings.

Model: $APSD = Y = C + \beta_1 X_1 + \beta_2 X_2 + \ldots\ldots\ldots \beta_n X_n + ei, \ (i = 1, 2 \ldots n)$

Where,

ei is the random error, α and βi‟s are the unknown parameters, C is the intercept and $\boldsymbol{\beta_1 + \beta_2 + \ldots. B_n}$ are the regression coefficients for variables $\boldsymbol{X_1, X_2 \ldots X_n}$ respectively.

In solar energy research, consumer behavior is comprehensively analyzed through four interconnected models: awareness (ASE), perception (PSE), satisfaction (SSE), and dependency (DSE) on solar energy. ASE is shaped by household expenditure, media awareness, solar dependency ratio, age, education, living conditions, gender composition, and family size, reflecting how these factors influence knowledge of solar energy. PSE examines how socio-economic characteristics such as consumption, expenditure, living conditions, dependency, age, education, and gender ratios affect perceptions toward solar energy. SSE identifies determinants of user satisfaction, including consumption, expenditure, media awareness, dependency, age, education, and gender ratios, while DSE highlights demographic and economic factors—living conditions, expenditure, dependency, age, family size, gender ratio, and media exposure that drive reliance on solar systems. Collectively, these models offer a holistic framework for understanding the multifaceted drivers of solar energy adoption, encompassing awareness, attitudes, satisfaction levels, and dependency patterns.

4. Result And Discussions

4.1 Respondent and Owner's Age Level.

4.1.1 Respondent Age Level

Age of the owner is also one of the important factors that influence the owner decision to consume solar energy. If there are younger people in the solar energy consumption, it may be taken as a transitional activity.

Table 4. 1: Age of the Respondent/ Employees

Age Group	Frequency	Percent%
15 25	36	36%
26 40	43	43%
41 50	13	13%
51 60	6	6%
60 and above	2	2%

SOURCE: OWN SURVEY 2016

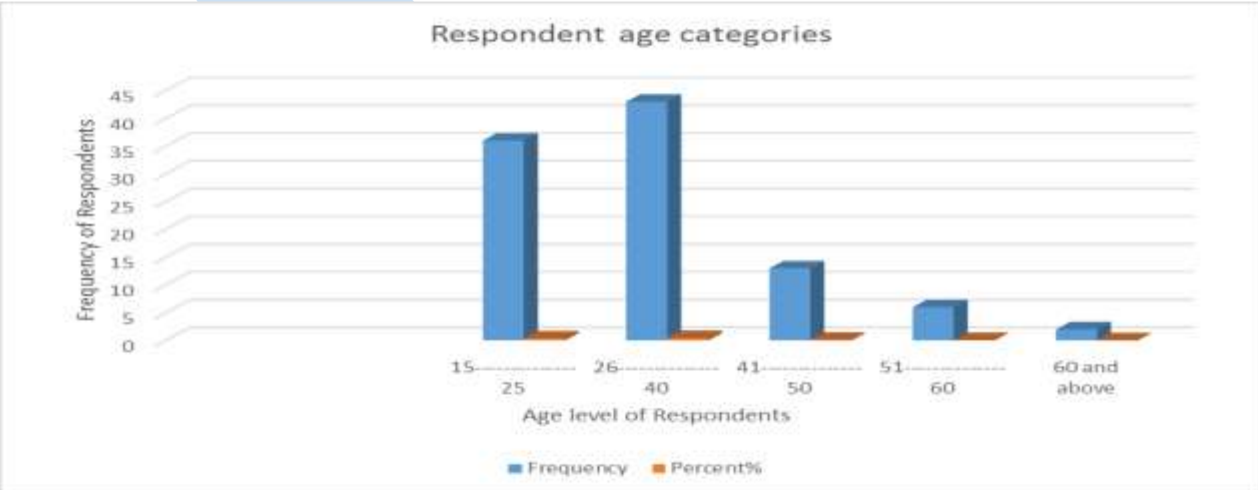


Figure 4. 1: Age of the Respondent

According to table No. 4.1, 36% respondent fall in the age of 15 to 25 and 43% respondent and consumer fall in the age of 26 to 40. Afterwards, 13% respondent fall between the age of 41 to 50 years, 6% respondent are between the ages of 51 to 60 year while 2% respondents fall in the age above 60 years. This result indicated that most of the respondents fall in the age of 26 to 40 years which show the concentration is found in young age respondent which further show that the consumption of solar energy is mostly permanent and preferred choice of the majority of the people. So the majority and well aware people of society want further consumption and investment in solar energy.

4.2 Sector Wise Age of the Respondent.

6 classes of respondents are included while the 7th class falls in category of „all others. The six classes are labors, teachers, students, doctors, solar traders, general store keepers and the seventh class is „all others‟.

Table 4. 2: Sector wise Age of the Respondents.

Respondents	Years	Frequency	Percent%
Labors	17---40	7	53.58%
	41---80	6	46.15%
Doctors	17---40	12	100%
	41---80	0	0%
General store	17---40	4	80%
	41---80	1	20%
Solar traders	17---40	6	85.71%
	41---80	1	14.28%
Teachers	17---40	10	62.5%
	41---80	6	37.5%
Students	17---40	15	100%
	41---80	0	0%
All others sectors	17---40	25	78.125%
	17---40	7	21.875%

SOURCE: OWN SURVEY 2016

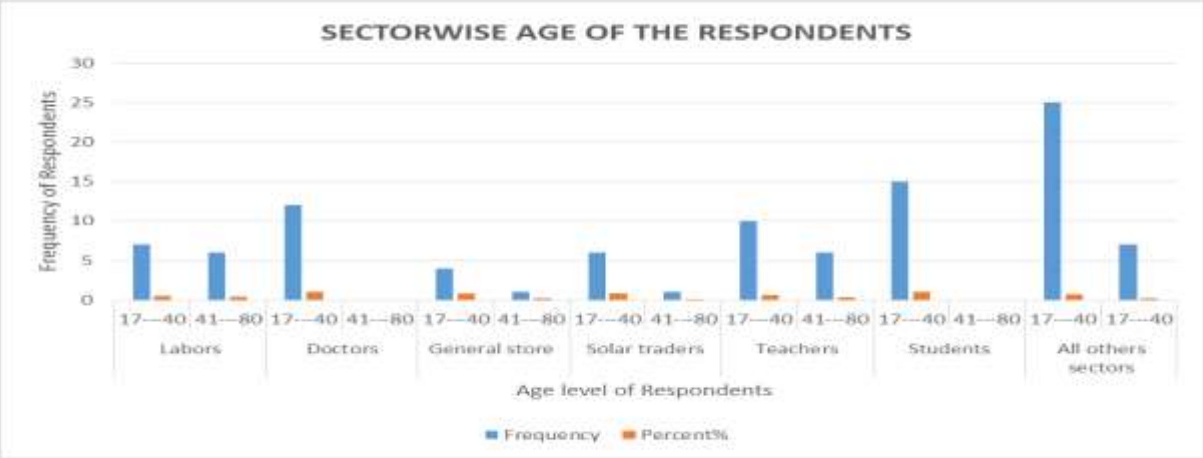


Figure 4. 2: Sector Wise Age of the RespondentThe above table No. 4.2 shows that in labor sector of respondents, 53% fall in age of 17 to 40 and 46% of labor respondents fall in the ages of 41 to 80 years. In second doctor sector, all of 100% respondents fall in the ages of 17 to 40 years. In third section of respondents of general store keepers, 80% fall in the ages of 17 to 40 while 20% fall in the ages of 41 to 80. In solar traders, 85% respondents fall in the ages of 17 to 40 while 15% fall in the ages of 41 to 80. In teachers, 62% of respondents fall in the ages of 17 to 40 while 37% respondents fall in the ages of 41 to 80. In most responsible section of students, 100% respondents fall in the ages of 17 to 40. In „all others‟ section which consists of most diverse sections of respondents, 78% fall in the ages of 17 to 40 while 21% fall in the ages of 40 to 80.

Finally all these sections mostly consist of first age of respondents 17 to 40 which show that 70% to 80% people of all fields of life have awareness about solar energy, have full satisfaction with it, most of people have perception about solar energy in age of 17 to 40 and dependency on solar energy is increasing in the ages of 17 to 40 among young stars.

4.3 Respondents Education and Non Education Class.

Table 4. 3: Respondents Education And Non Education Class.

Educated	**Percent%**	**Non Educated**	**Percent%**
86	86%	14	**1**4%

SOURCE: OWN SURVEY 2016

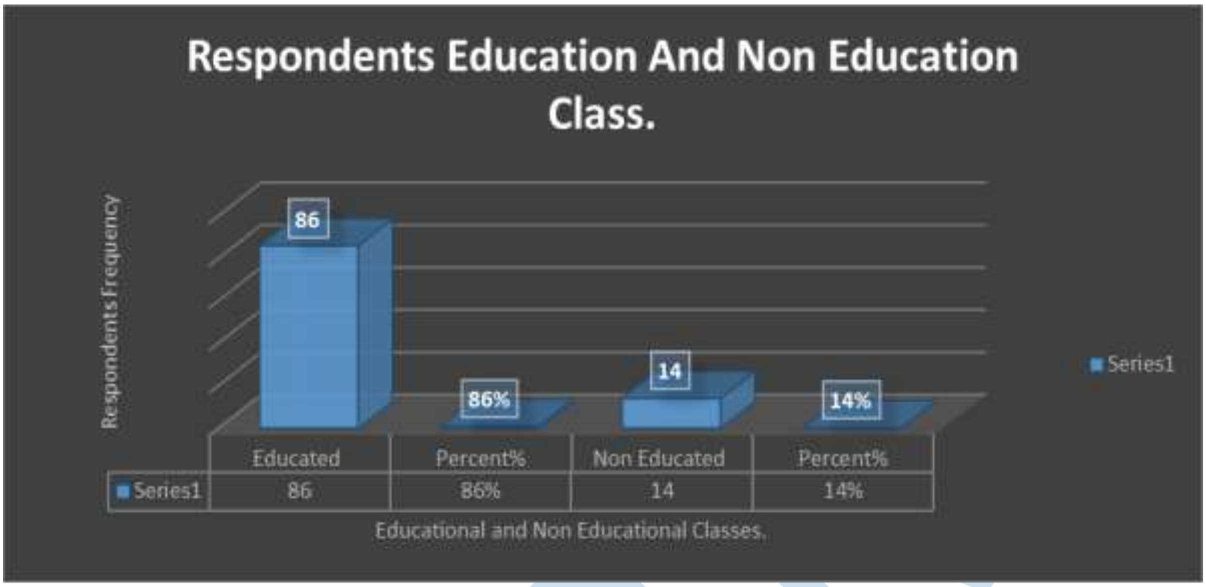


Figure 4. 3: Respondents Education and Non Education Class

The above table No.4.1/2 shows that 14% respondents were illiterate who used solar energy and gained satisfaction with it.86% had the following educational records.

4.4 Respondent Level of Education.

Quality education also plays a vital role in consumption, awareness and introduction of solar energy in the area. Following are different classes of education which show the educational level of respondents.

Table 4. 4: Education of the Respondents.

Education level	**Frequency**	**Percent%**
Primary Level	11	12.79%
Middle Level	17	19.76%
High level	8	9.30%
College level	12	13.95%
University level	38	44.18%

SOURCE: OWN SURVEY 2016

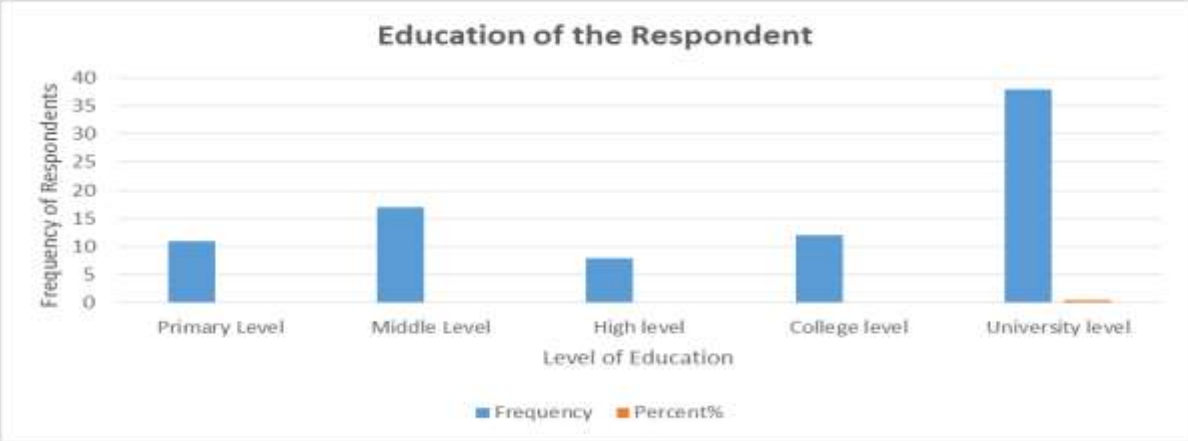


Figure 4. 4: Respondent Level of Education

Table 4. 5: Poverty Is The Main Reason Behind People Not Using Solar Energy

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly agree	10	10.0	10.0	10.0
Agree		84	84.0	84.0	94.0
Don"t know		1	1.0	1.0	95.0
Disagree		4	4.0	4.0	99.0
S.D.A		1	1.0	1.0	
Total		100	100.0	100.0	

SOURCE: OWN SURVEY 2016

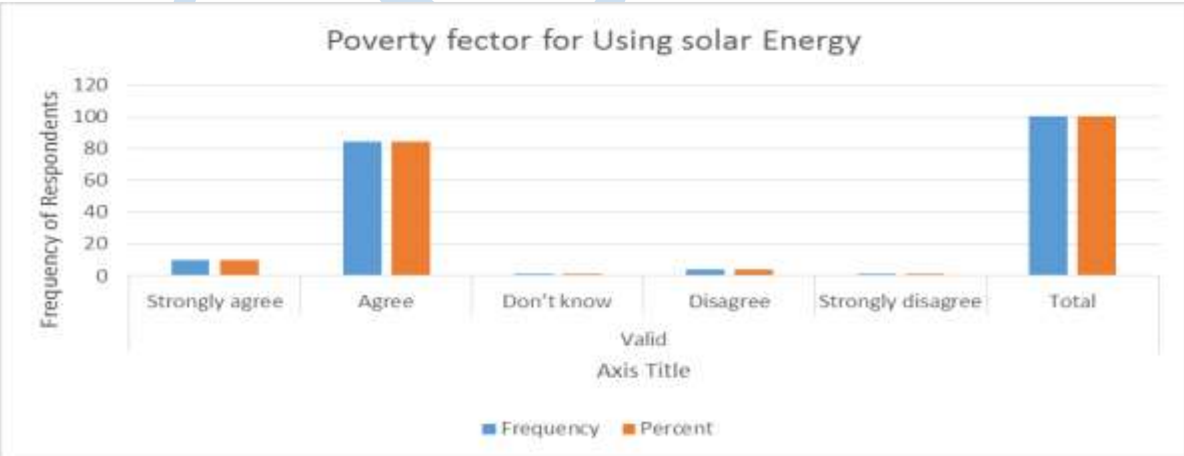


Figure 4. 5: Poverty factor for Using Solar Energy

Table 4. 6: Education And Awareness Are The Main Reasons Behind People Not Using Solar Energy Sources.

	Frequency	Percent	Valid Percent	Cumulative Percent

Valid Strongly agree	1	1.0	1.0	1.0
Agree	13	13.0	13.0	14.0
Don‟t know	4	4.0	4.0	18.0
Disagree	82	82.0	82.0	100.0
Total	100	100.0	100.0	

SOURCE: OWN SURVEY 2016

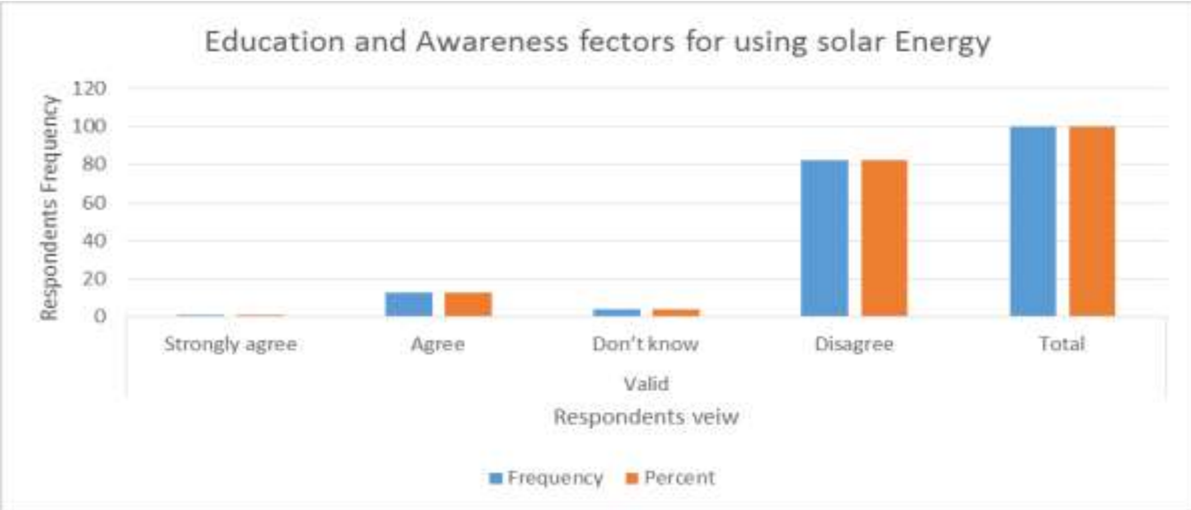


Figure 4. 6: Education and Awareness Factor for Using Solar Energy Sources

The results indicate that respondents with different educational backgrounds demonstrate varying levels of awareness, perception, satisfaction, and dependency regarding solar energy, with the highest proportion (38%) holding graduate-level or higher qualifications, followed by smaller shares at primary (11%), middle (17%), high school (8%), and college levels (12%). Only a negligible percentage (1.1%) reported having no knowledge of solar energy, suggesting that general awareness is relatively widespread. However, further analysis shows that poverty—not lack of education or awareness—is the primary barrier to solar energy adoption. An overwhelming majority (94%) agreed that financial constraints prevent households from installing solar systems, while only 14% considered lack of education and awareness as the main obstacle, with most respondents rejecting this view.

4.5 Household Monthly Income

Table 4. 7: Household Monthly Income

Level of income	**Frequency**	**Percent%**
10000 30000	26	26%
31000 60000	50	50%
61000 100000	15	15%
100000 150000	2	2%

Above 150000	6	6%

SOURCE: OWN SURVEY 2016

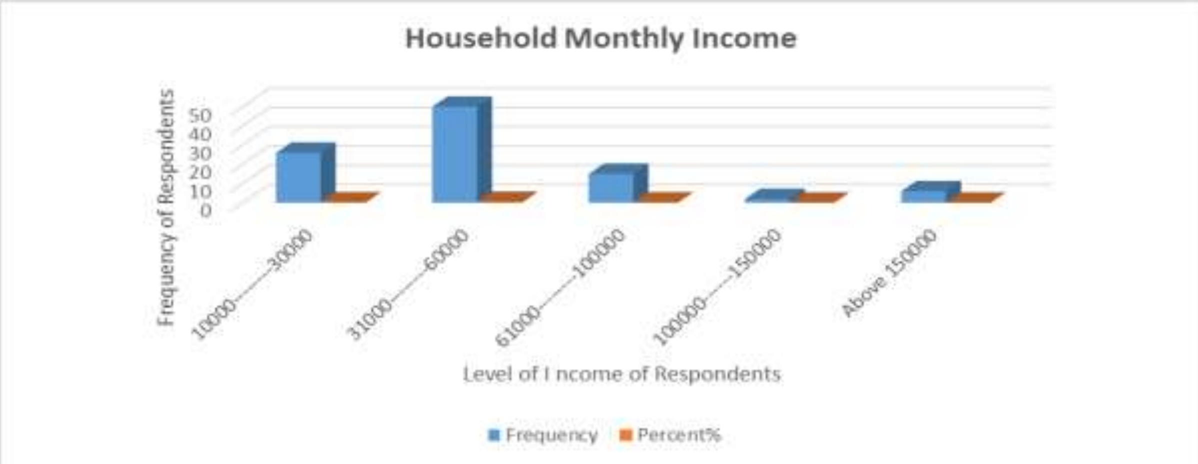


Figure 4. 7: Household Monthly Income

In the above table No. 4.6, 26% respondents have income level from 10000 to 30000 and 50% respondents have income level from 31000 to 60000 while 15% respondents have income level from 61000 to 100000 monthly. Out of 100 sample, 2% respondents have income level from 100000 to 150000 and 6% respondents have income level above 150000. Therefore, most respondents belong to middle class and most of respondents have purchasing power of solar system.

Table 4. 8: Main Source of Family Income

Figures.	**Source**	**Frequency**	**Percent%**	**Cumulative%**
A	Agriculture/Farming	30	30%	11.15%
B	Livestock	6	6%	2.23%
C	Agricultural Labor	9	9%	3.34%
D	Self Employed	91	91%	33.83%
E	Remittances	18	18%	6.68%
F	Employment (Private)	19	19%	7.06%
G	Employment (Govt.)	36	36%	13.36%
H	Labor Work	36	36%	13.36%
I	Aid (official and unofficial)	3	3%	1.11%
J	Zakat	0	0%	0%
K	Rent	10	10%	3.71%
L	Others (Specify)	11	11%	4.08%
ALL	TOTAL	269	269%	100%

SOURCE: OWN SURVEY 2016

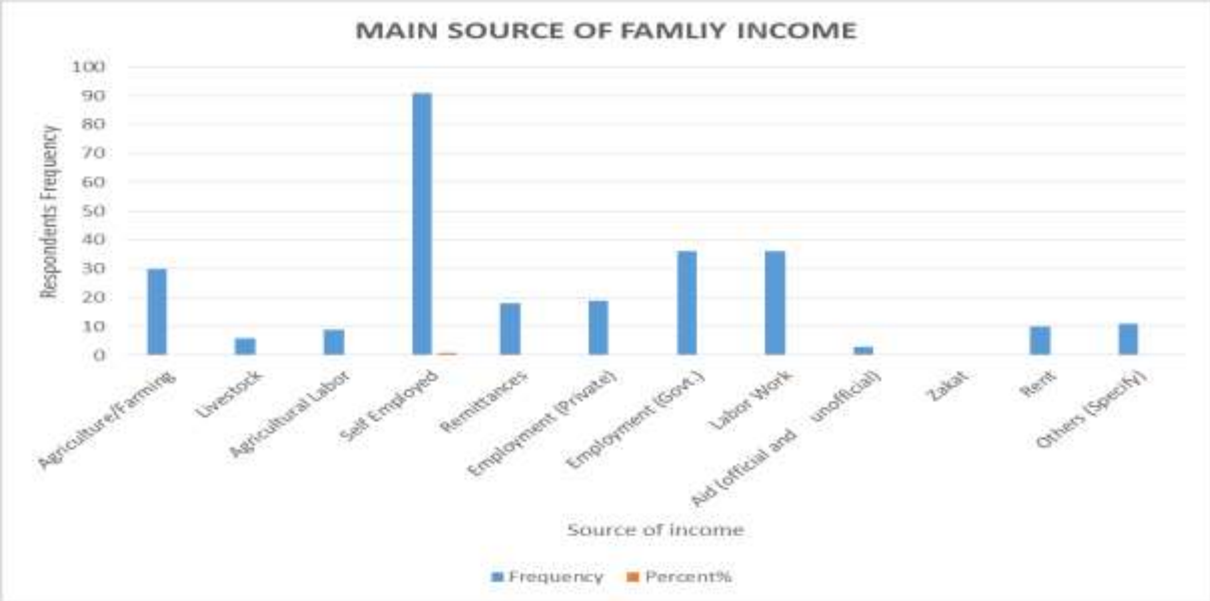


Figure 4. 8: Main Source of Family Income

According to the above table No 4.7, 11.15% respondents have agriculture as the main source of income, 2.23% have livestock as the main source of income, 3.34% are attached with agriculture labor, 33.83% are self-employed, 6.68% obtain their income from remittances, 7.06% have private employment, 36.36% have Govt employment, 13.36% earn their income from labor work, 1.11% receive aid from Govt and private organizations, 3.71% have rent as the main source of income, 4.08% obtain income from others sources.

Respondents Household Monthly Expenditure.

Table 4. 9: Respondent Household Monthly Expenditure

Rupees Monthly Expenditure	**Frequency**	**Percent%**
10000 20000	16	16%
21000 40000	34	34%
41000 60000	36	36%
61000 80000	9	9%
81000 100000	2	2%
101000 120000	2	2%
121000 above	1	1%
TOTAL	100	100%

SOURCE: OWN SURVEY 2016

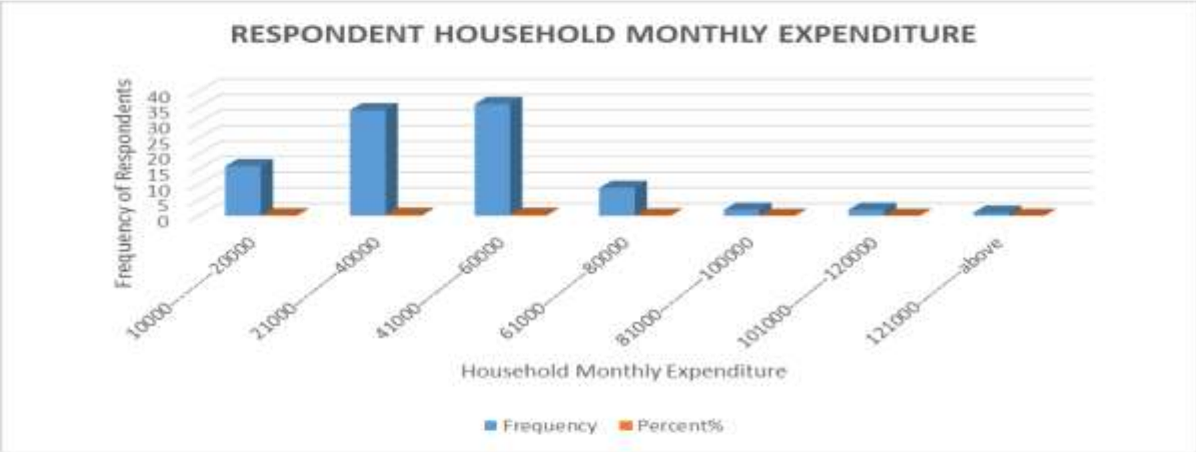


Figure 4. 9: Respondent Household Monthly Expenditure

Questions were asked in the survey from the owners about their household monthly expenditures. According to the table No 4.8, 16 % of Owners‟ household expenditure is 10000/- to 20000/- rupees per month, 34% of Owners‟ household monthly expenditure is from 21000/- to t 40000/- rupees, 36% have monthly expenditure from 41000/- to 60000/- rupees, 9% have monthly expenditure from 61000/- to 80000/- , 2% have monthly expenditure from 81000/- to 100000/-, 2% of respondents have monthly expenditure from 101000/- to 120000/- and finally 1% respondent has monthly expenditure more than Rs. 121000/.

4.6 Sex of the Respondents.

Table 4. 10: Sex of The Respondents.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Male	95	95.0	95.0	95.0
Female		5	5.0	5.0	100.0
Total		100	100.0	100.0	
Total		100	100.0	100.0	

SOURCE: SURVEY 2016

Figure No: 4.9

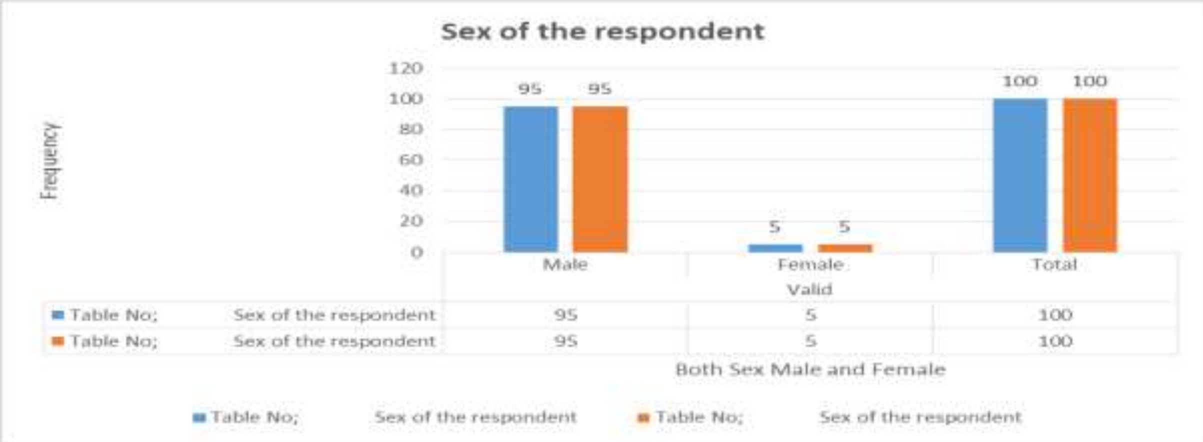


Figure 4. 10: Sex of The Respondents

The table No 4.9, above shows that both male and female participated in answering questionnaires about solar energy. Total respondents are 100 out of which male participation is 95 and their percentage becomes 95% while female participation is 5 and their percentage becomes 5% of all samples.

4.7 Marital Status of the Respondents.

Table 4. 11: Marital Status of the Respondents.

		Frequency	**Percent**	**Valid Percent**	**Cumulative Percent**
Valid	Single	19	19.0	19.0	19.0
Married		80	80.0	80.0	99.0
Widowed		1	1.0	1.0	100.0
Total		100	100.0	100.0	
Total		100	100.0	100.0	

SOURCE: OWN SURVEY 2016

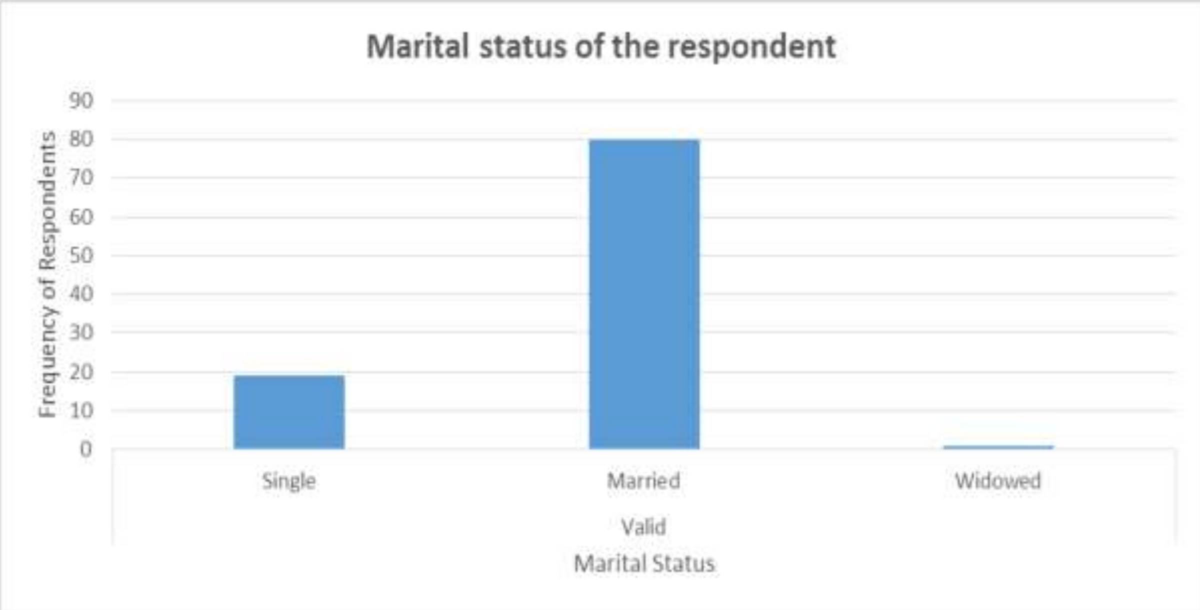


Figure 4. 11: Marital Status of the Respondents.

The above table No 4.10, shows that all respondents, male and female are 100 out of these 19 have no marital status and they become 19% of all respondents while 80 are married and they become 80% of the observations. 1 respondent is widowed.

Family Type of Respondents.

Table 4. 12: Family Type of the Respondents

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Joint	61	61.0	61.0	61.0
Nuclear		39	39.0	39.0	100.0
Total		100	100.0	100.0	

SOURCE: OWN SURVEY 2016

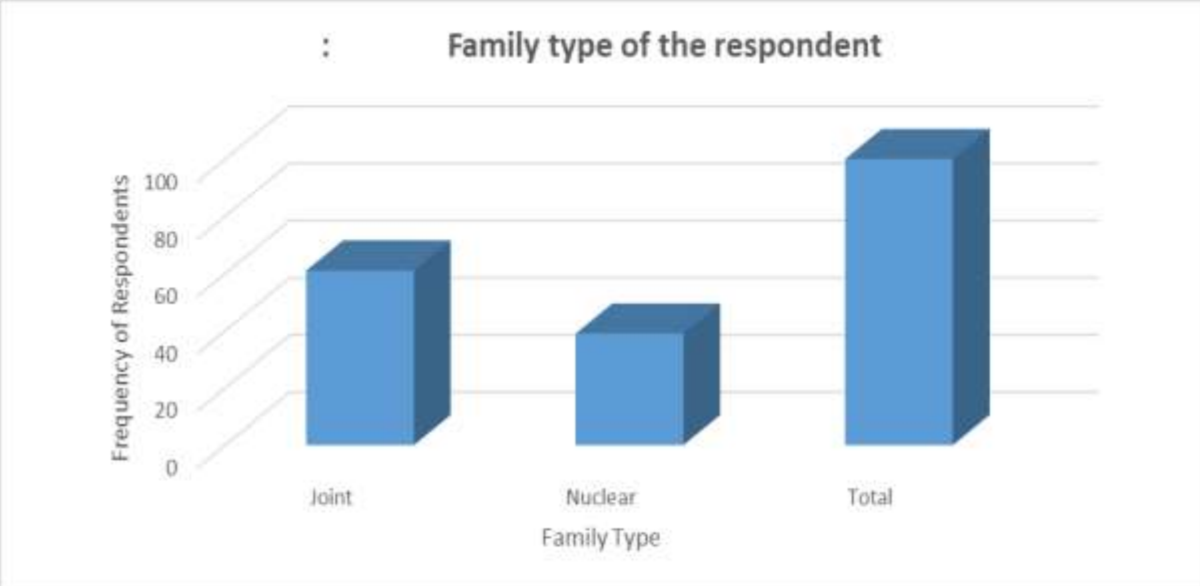


Figure 4. 12: Family Type of Respondents

In the above table No 4.11, we determined the total number of respondents who live in nuclear family and total number of respondents who live in joint family. All respondents who live in nuclear families are 39 and their percentage becomes 39% while 61 respondents live with joint families and their percentage become 61%. All are equal to 100 and their percent become 100%.

4.8 Home Ownership and Condition of Respondents.

Table 4. 13: Home Ownership of the Respondents.

		Frequency	**Percent**	**Valid Percent**	**Cumulative Percent**
Valid	Other	22	22.0	22.0	22.0
Owned		78	78.0	78.0	100.0
Total		100		100.0	

SOURCE: OWN SURVEY 2016

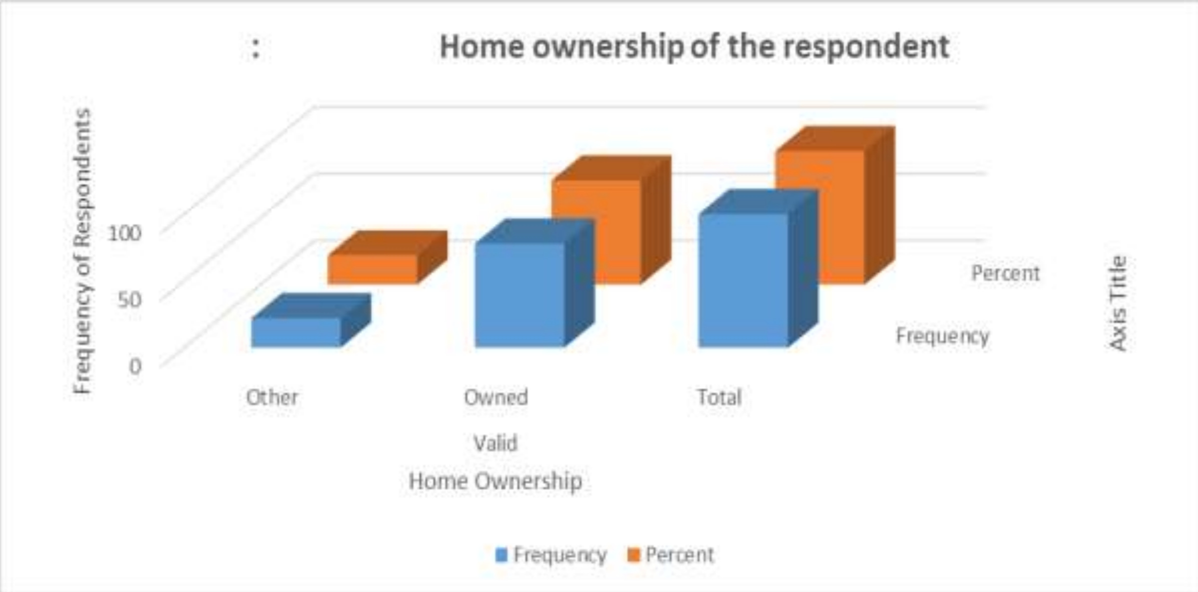


Figure 4. 13: Home Ownership and Condition of Respondents

The above table No 4.12, explains and shows the home ownership of the respondents and condition of their homes. All are 100 observations in which 78 respondents have their own homes and their percentage becomes 78% while 22 do not have their own homes and their percentage becomes 22% of all respondents. Affordability of Solar System for Each Respondent.

Table 4. 14: Every Household in The area Can Afford Solar Energy.

		Frequency	Percen t	Valid Percent	Cumulative Percent
Valid	Strongly agree	3	3.0	3.0	3.0
Agree		16	16.0	16.0	19.0
Don‟t know		3	3.0	3.0	22.0
Disagree		77	77.0	77.0	99.0
S.D.A		1	1.0	1.0	100.0
Total		100	100.0	100.0	

SOURCE: OWN SURVEY 2016

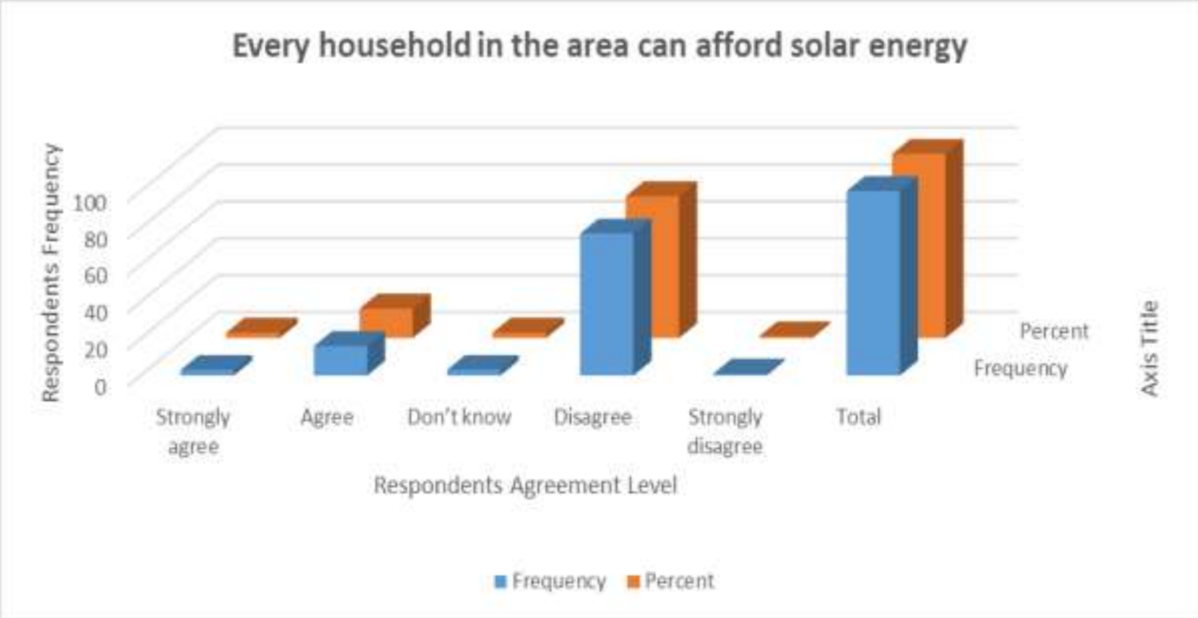


Figure 4. 14: Every Household in The area Can Afford Solar Energy

In the above table No 4.13, all details have been given about the affordability of solar energy for each household in the area. The respondents have different points of view about the affordability. 3 respondents out of 100 think that every household in the area has the ability to purchase a solar system and they strongly agree with that opinion. 16 respondents are only agree that every household in the area could afford solar system and their aggregate becomes 16%. 3% of respondents opined about solar affordability. On the other hand, 77 respondents disagree with the affordability of solar system for each household in the area and their aggregate become 77%. 1% respondent strongly disagrees with the affordability of solar energy for each household in the area.

Finally we concluded that poverty is a big issue for any household in the area not being able to install solar system. In the light of 77% number of respondents, all having the same views, I think every person in the area has no affordability to purchase solar system for his home.

4.9 Aggregate Requirements of Household Fulfill By Both Energy Solar and Hydro Power.

Table 4. 15: Descriptive Statistics

	N	**Minimum**	**Maximum**	**Mean**	**Std. Deviation**
	100	6000	150000	3.11E4	21138.323
Threshold level of income for solar energy affordability.	100	0	80	13.85	18.010
What percent of household energy needs are fulfilled by hydro power electricity?	100	20	100	52.22	19.551
What percent of household energy needs are fulfilled by solar energy?	100	20	100	52.22	19.551

Valid N (list wise)

SOURCE: OWN SURVEY 2016

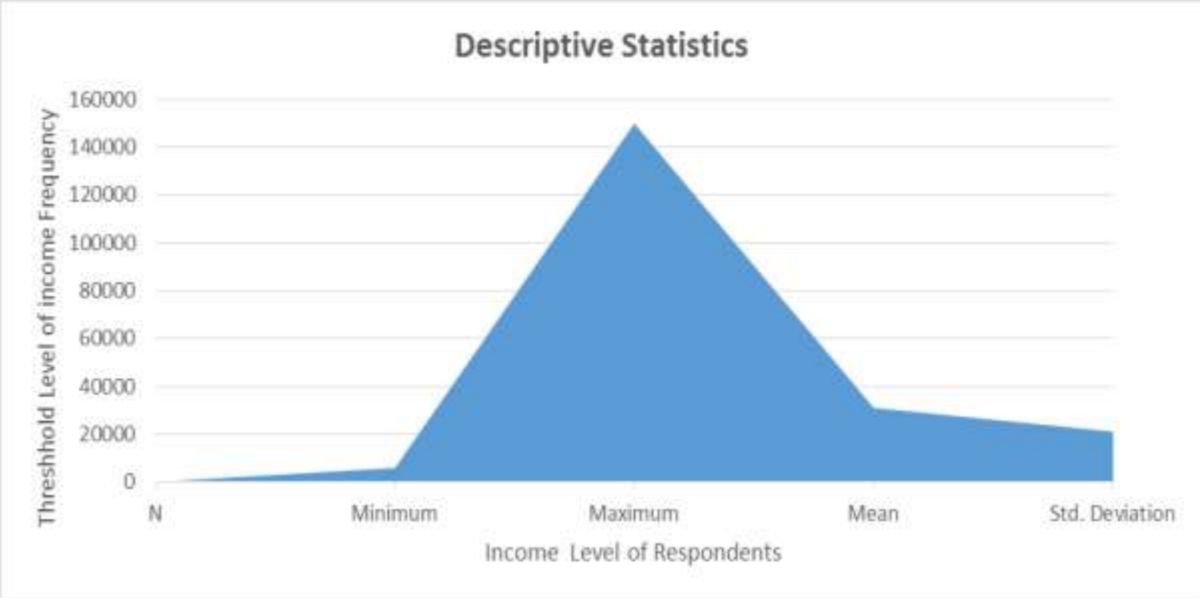


Figure 4. 15: Descriptive StatisticsIn the above table No 4.14 model, 100 respondents specified their threshold level of income for the affordability of solar energy in Pashat, Bajaur area. In these observations, the minimum threshold level of income is Rs. 6000/- and the maximum level of income specified by respondent is Rs. 150000/- cumulative Mean is 3.11E4, and standard Deviation is 21138.323. Aggregated percentage by the respondents to fulfill their electricity needs by hydro power electricity in 100 observations is minimum 0 and maximum 80, their Mean 13.85 and Standard Deviation is 18.010 fulfilled by hydropower. Percentage of households fulfilling their energy needs by solar in 100 observations is 20 Minimum and 100 Maximum while their Mean is 52.22 and Standard Deviation is 19.551. Respondents Solar Installation Information.

This section includes respondents‟/traders‟ information about solar system installation, their level of satisfaction with solar system at homes/ shops and their monthly income from all possible resources.

Table 4. 16: Respondents Year of Establishment Installation Solar System.

Year of Installation	Frequency	Percent%
2004	0	0%
2005	1	1%
2006	2	2%
2007	1	1%
2008	2	2%
2009	8	8%

2010	7	7%
2011	11	11%
2012	19	19%
2013	25	25%
2014	13	13%
2015	6	6%
2016	4	4%

SOURCE: OWN SURVEY 2016

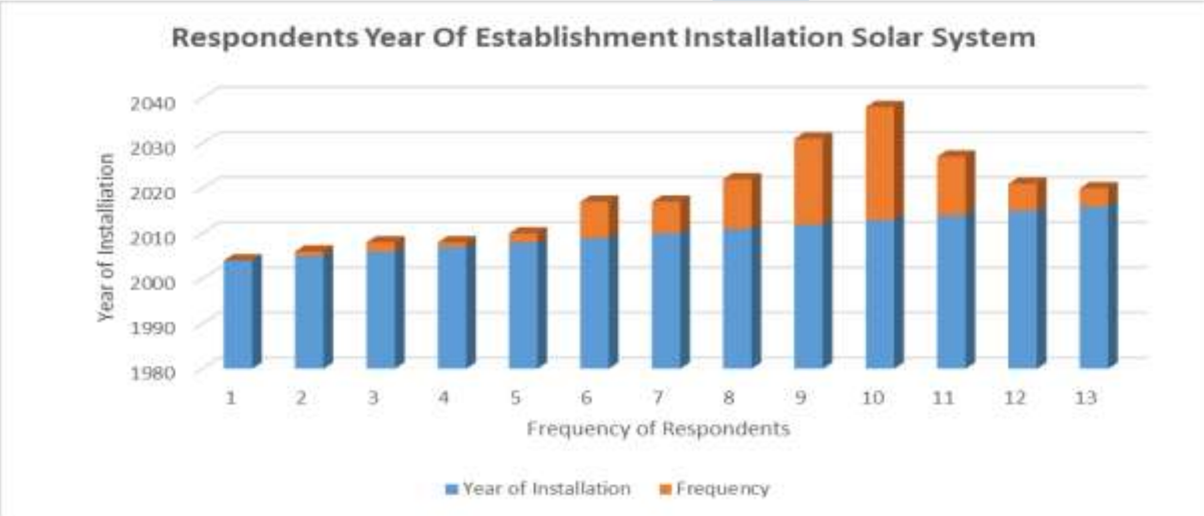


Figure 4. 16: Respondents Year Of Establishment Installation Solar System.

The above table No 4.15, shows that majority of people installed the solar energy system at their homes /shops in the year 2013 which becomes 25% of all respondents. Secondly, in the year 2012, 19% of respondents installed solar system at their homes. In the year 2014, 13% of respondents installed solar at their homes. In the year 2011, 11% of respondents installed solar energy at their homes/ shops. In 2010, they were 7%, in 2009 they became 8%, in 2008, 2%, in 2007, they were

1%, in 2006, they were 2%, in 2005, 1%, and in 2004, there was no idea about solar system in Pashat, Bajaur area. In 2004, rare case could know about solar energy.

4.10 Affordability of Solar Energy.

Table 4. 17: Monthly a Threshold Level of Income for Installation Solar Energy.

Level of Income	**Frequency**	**Percentage%**
10000-----30000	71	71%
31000-----60000	24	24%
61000-----90000	2	2%
91000-----120000	2	2%

Above from 120000	1	1%

SOURCE: OWN SURVEY 2016

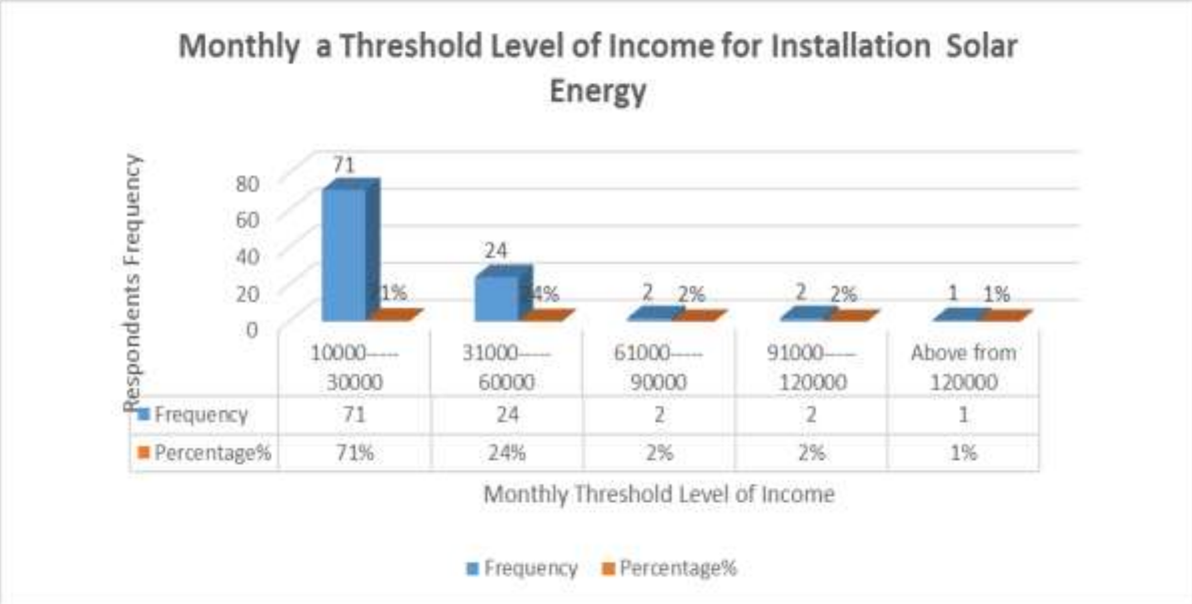


Figure 4. 17: Monthly a Threshold Level of Income for Installation Solar Energy.

The above table No 4.16, shows the affordability level of solar energy .The table shows that 71% of respondents have view that monthly income level of consumer from 10000/ to 30000/- could afford solar energy easily while in second section, 24% of respondents have the view that income from 31000/- to 60000/- could afford solar system easily so they are two considerable points of view which show that a consumer having monthly income from 10000/- to 50000/- could easily install normal solar system at his home.

4.11 Model No. 1. For Estimating Respondent Level of Awareness about Solar Energy. (ASE)

According to the result, respondent‟s awareness about solar energy (ASE), respondent‟s level of satisfaction with solar energy (SSE), perception of respondents about solar energy (PSE), dependency on solar energy of respondents (DSE) are all dependent variables while there are various independent variables in all the above depend on it. Living condition of respondent(LC), total expenses of the respondents(TE), media awareness of the respondents(AM) ,family size of respondents(FS), dependent ratio of the respondent on solar energy (DR), male female ratio in research(MFR), age of the respondent(AR), education level of the respondents(ER) are all independent variables.

In ASE model, there are following independents variables: living condition of respondents LC, total expenses of the respondents TE, media awareness of the respondents AM, dependency ratio on solar energy DR, age of the respondents RA, Education level of the respondents ER, MFR male female ratio of respondents in solar energy, family size of the respondents FS are the major determinants which influence the awareness of solar energy.

4.11.1 Model No 1: ASE=f (LC, TE, AM, FS, DR, MFR, AR, ER, Ei)

ASE = awareness of respondent about solar energy

LC= living condition of solar energy, TE= total expenses of respondents, AM=Media awareness, FS= Family size of respondents, DR= dependency ratio on solar energy, MFR= Male female participation, AR= Age of the respondents, ER= education level age the respondents, Ei= error term.

The Econometrics form of the above mathematical MODEL will be as follows.

4.11.2 ASE =f (B_1LC+B_2TE+B_3AM+B_4FS+B_5DR+B_6MFR+B_7AR+B_8ER+ εi)

Where

ASE, the awareness of solar for respondents, LC is the living condition of the respondents, TE is the total expenses of the respondents, AM is the Media awareness of the respondent, FS is the family size of the respondents, DR is the dependency ratio on solar energy, MFR is the male female ratio of the respondents, AR is the age of the respondents, ER is education level of the respondents, Ei is error term.

And ASE is awareness of respondents (In figure)

B_1, B_2……………………..B_n Are the slopes of the corresponding parameters of independent variables.

(Is living condition, total expenses, media awareness, family size, dependency ratio, etc)

Ei…….Disturbance term or error term. It represents all those factors that affected the level of current awareness but were not taken into account.

4.12 Estimating Model No.1: (ASE)

The tool used for estimating model is EView8.0 computer application for applied economics. Following are the empirical results obtained by using regression analysis least square method.

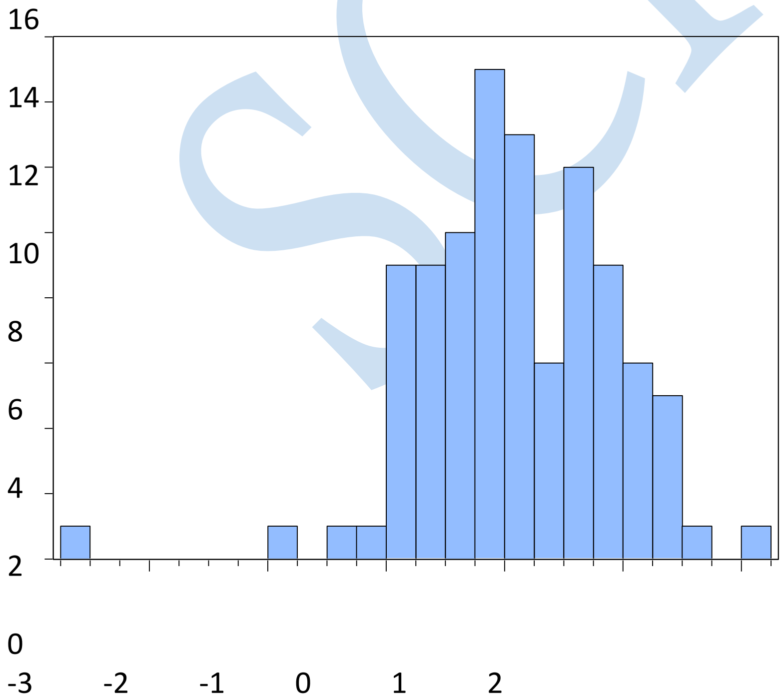
Table 4. 18: Awareness About Solar Energy. (ASE)

Dependent Variable:		**Awareness About Solar Energy**		**(ASE)**
Method	Date	Time	Sample	Included Observations
Least Squares	08/24/16	11:07	1 100	100
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Probability**
TE	5.15E-06	4.69E-06	1.097794	0.2752
AM	0.178675	0.059891	2.983326	0.0037
DR	1.469524	0.514987	2.853516	0.0053
RA	0.034796	0.006841	5.086162	0.0000
ER	0.002820	0.018962	0.148728	0.8821
LC	0.261199	0.071966	3.629498	0.0005
MFR	0.057854	0.115129	0.502513	0.6165
FS	0.022481	0.014139	1.590023	0.1153

The results of Model No. 1, which examines the determinants of Awareness about Solar Energy (ASE), indicate that most explanatory variables have a positive relationship with awareness, though their levels of statistical significance vary. Total expenses (TE) show a positive coefficient (5.15), suggesting that higher household expenditure increases awareness; however, the relationship is statistically insignificant at the 99 percent confidence level and therefore cannot be strongly supported. Media awareness (AM) demonstrates a positive and statistically significant effect, with a coefficient of 0.178, indicating that greater exposure to media substantially enhances awareness of solar energy. Similarly, the dependency ratio on solar energy (DR) has a positive and significant coefficient (1.46), implying that households more dependent on solar systems tend to exhibit higher awareness. Respondent age (RA) also shows a positive and statistically significant relationship (0.034), suggesting that awareness slightly increases with age. In contrast, education level (ER), despite having a positive coefficient (0.0028), is statistically insignificant and thus not a strong predictor of awareness at the 99 percent confidence level. Living conditions (LC) present a positive and statistically significant coefficient (0.2611), highlighting that improved socio-economic conditions contribute to greater awareness of solar energy.

In Model No. 1, both the male–female ratio (MFR) and family size (FS) exhibit positive relationships with Awareness about Solar Energy (ASE), but their effects are statistically insignificant at the 99 percent confidence level. The coefficient for MFR (0.057) indicates that a one-unit increase in the male–female ratio leads to a 0.057-unit increase in awareness; however, the insignificant t-statistic and probability values suggest that this relationship is not strong enough to be accepted. Similarly, family size (FS) shows a positive coefficient of 0.022, implying that larger households may have slightly higher awareness of solar energy, yet this effect is also statistically insignificant. Overall, although both demographic variables demonstrate positive associations with solar energy awareness, they do not significantly influence ASE within the study framework.

4.13 Normality Test of Model No. 1 (ASE)



Series: Residuals
Sample 1 100

Observations 100

Mean	0.089827
Median	0.034697
Maximum	2.086112
Minimum	-3.676040
Std. Dev.	0.824111
Skewness	-0.796417
Kurtosis	
Jarque-Bera	50.22192
Probability	0.000000

Figure 4. 18: Normality Test of Model No. 1 (ASE)

4.14 Interpretation of Normality Test in Model No. 1. (ASE)

In the above figure, all variables tested their normality total observations 100, their mean is 0.089827, Median is 0.034697, Maximum 2.086112, Minimum -3.676040, Standard Deviation is 0.824111, Skewness is -0.796417, Kurtoses is 6.084824, Jarque-Bera 50.22192 and finally probability is 0.000000. It is resulted that if J-b test value of probability is greater than 0.1, the test statistics conclusion is thatRegression Residual is normally distributed, if not, then Regression Residual is not Normally Distributed.

RESULT: So in above Colum J-B test statistics have probability value less (<) than 0.1 so the Regression Residual is not normally distributed.

4.15 Heteroskedasticity Test of Model No. 1. (ASE)

Table 4. 19: Heteroskedasticity Test of Model No. 1. (ASE)

Heteroskedasticity Test: White.

F-statistic	0.405502	Probability. F(36,63)	0.9978
Obs*R-squared	18.81241	Probability. Chi-Square(36)	0.9919
Scaled explained SS	37.18824	Probability. Chi-Square(36)	0.4141

4.16 Interpretation of Heteroskedasticity of Model No. 1(ASE)

In above table, the result is given by heteroskedasticity white test, Obs*R-squared is computed LM value and if the probability value associated with LM statistics is smaller than 0.01, then this is indicated that heteroskedasticity is in existence in this Test. If Obs*R-squared is computed LM value then probability value associated with LM statistics is greater than 0.01, then it is indicated that heteroskedasticity is not in existence.

Result: In above case, the Obs*R-squared probability value is 0.9919 which is greater (>) than 0.01 that indicates that heteroskedasticity does not exist in this test.

4.17 Specipecation Test of the Model No. 1. (ASE)

Table 4. 20: Specipecation Test of the Model No. 1. (ASE)

Ramsey RESET Test

Equation:				UNTITLED				
Specification:(ASE)	TE	AM	DR	RA	ER	LC	MFR	FS
Omitted Variables:				Squares of fitted values				
	Value			Differences		Probability		
t-statistic	8.432147			91		0.0000		
F-statistic	71.10110			(1, 91)		0.0000		

4.18 Interpretation of Specipecation Test of the Model No. 1. (ASE)

In the above model, we generally used Ramsey test for the elimination of misspecification from a case. In above test, ASE, TE, AM, DR, RA, ER, LC, MFR, and FS are specification variables. In this type of case if probability value of F-statistics is greater than (>) 0.1, we could expect that improvement in model is impossible. If the probability value of F-Statistics is less (<) than 0.1, then we could expect that improvement in model is possible.

Result: In the above test, the probability value of F-Statistics is 0.000 which is less (<) than 0.1 so the improvement in model is possible and we reject H_0.

5 Conclusion and Policy Recommendations

5.1 Conclusion

Solar energy consumption in Bajaur Agency, particularly in the Pashat area, has emerged as a vital alternative to conventional electricity, effectively meeting daily household needs and contributing to economic and social development. The study, based on 100 respondents across six occupational categories—including doctors, students, teachers, store keepers, solar traders, and laborers—reveals high satisfaction with solar energy systems, driven by reliability and accessibility. Most respondents fall within the 17–40 age group, with nearly half being graduates, and household expenditures predominantly ranging between Rs. 21,000 and 60,000. While a threshold income of Rs. 10,000–30,000 is considered necessary to adopt solar technology, poverty remains the main barrier, cited by the majority of respondents, whereas education and awareness play a minor role. The survey also highlights that most households operate their own businesses, live in joint family setups, and predominantly own homes in basic condition. Since 2013, solar system installation in homes and shops has steadily increased, reflecting growing acceptance and market expansion, while solar traders have expanded their presence from 4% in 2004 to 16% in 2016. Respondents strongly support government intervention, with 70% favoring investment in solar projects, 80% advocating for solar grid stations to mitigate electricity shortfalls, and 60% preferring solar power initiatives over hydroelectricity. Overall, solar energy reduces dependency on electricity, creates employment opportunities, and plays a significant role in poverty alleviation.

Based on these findings, policy recommendations emphasize enhancing adoption and sustainability of solar energy in the region. The government should provide subsidies and interest-free loans, regulate pricing, and invest in both small- and large-scale solar projects to reduce reliance on conventional energy and create economic opportunities. Establishing large solar grid stations would stabilize electricity supply while generating national revenue. Training and research centers should be developed to build technical expertise, supported by education and awareness campaigns to increase public understanding and adoption. Introduction of daily-use solar instruments, government supervision of installations, and provision of technological and marketing support to users and traders are recommended to ensure proper implementation and growth of the solar sector. Dedicated national solar projects, coupled with specific budget allocations, would strengthen the energy sector, promote economic growth, and provide a sustainable solution to persistent electricity shortages.

References

Bureau of Statistics. (n.d.). *Planning and development department, government of Khyber Pakhtunkhwa*. http://www.kpbos.gov.pk

Ministry of Finance. (n.d.). http://www.finance.gov.pk

District Profile of Bajaur Agency. (2014). *Pakistan Bureau of Statistics*. http://www.pbs.gov.pk
Chinnzmmi, S. (2013). An economic analysis of energy. *Journal of Clean Energy Technology*, 1, 18.
Fayeez, A. T. I., Gannapathy, V. R., Ida, S., Isa, M. K. N., & Azyze, N. L. (2015). Literature review of battery-powered and solar-powered wireless sensor node. *ARPN Journal of Engineering and Applied Science*, 10, 671–672.
Hydrocarbon Development Institute of Pakistan. (n.d.). Planning Commission of Pakistan.
Pakistan Electric Power Company (PEPCO). (n.d.).
Water and Power Development Authority (WAPDA). (n.d.).
Shahzad, A., & Anjum, N. (2012). Energy crises in Pakistan: Reception and adoption of energy saving campaign. *Pakistan Journal of Social Sciences (PJSS)*, 32(1), 194–195.
Macpherson, D., Ph.D. (2009). The positive economic impact of solar energy on the Sunshine State. *Center for Competitive Florida, Florida Council of Economics Advisor at Florida Tax Watch*, 1, 2.
International Renewable Energy Agency (IRENA). (n.d.). *Renewable energy*.
Yamamoto, H., Fujino, J., & Yamaji, K. (2001). Evaluation of bioenergy potential with a multi-regional global-land-use-and-energy model. *Biomass and Bioenergy*, 21, 185–203.
Srinivasan, P., Chen, D., Chen, M., Tu, V., & Zhou, J. (2014). Commercializing solar power: The efficiency of price and quantity instruments in incentivizing private investment. 1, 7.
The NEED Project. (2015). 8408 Kao Circle, Manassas, VA 20110. http://www.NEED.org
U.S. Department of Energy, Energy Efficiency and Renewable Energy. (n.d.).
FATA Development Authority (FDA). (2013). *Annual report*. http://www.fda.gov.pk
Mirza, U. K., Maroto-Valer, M. M., & Ahmad, N. (2003). Status and outlook of solar energy use in Pakistan. *Renewable and Sustainable Energy Reviews*, 7, 501–514. http://www.elsevier.com/locate/rser
Indian Department of Education, Energy Environment & Economics. (n.d.). *The issue of renewable energy: Overview of Unit 3*.
Perera, S. (2006). Does where people live change their interest and appreciation of solar panel? *Solar Energy*, 1, 3–5.
Romanach, L., Contreras, Z., & Ashworth, P. (2013). Australian householders' interest in the distributed energy market. *Earth Science and Resource Engineering/Energy Flagship* (Report No. EP133598), 8, 56–80. http://www.csiro.au
Ministry of Natural Resources and Energy (MNRE). (2013). Government of Swaziland.
Beacon House National University. (2011). *Pakistan energy sector challenges & opportunities: State of the economy – Emerging from crisis 2008*. Pakistan Economic Survey, 2009.
Renewable Energy Data Book. (2009).
Wolde-Rufael, Y. (2005). Energy demand and economic growth: The African experience of 19 countries. *Journal of Policy Modelling*, 27, 891–903.
Khan, M. A., & Ahmed, U. (2010). Energy demand in Pakistan: A disaggregate analysis. *Pakistan Institute of Development Economics*, 6.