International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Index Copernicus Value (2015): 78.96 | Impact Factor (2015): 6.391

Use of Solar Panel at Rural Areas in Bangladesh: Impacts, Financial Viability and Future Prospects

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Abstract: ***Electricity is the life blood of power for most of the country's economic activities. Solar panels may be a reliable and good source for supplying electricity throughout the country. The study was undertaken to determine the intensity of solar panel system is practiced in Bangladesh, the Net Present Value(NPV), Benefit -Cost Ratio(BCR) and IRR of the solar panel, the impact of solar panel on livelihoods, the future prospect of solar panel in Bangladesh; and the problems and constrains of the solar panel faced by the households. Sherpur upazila of Bogra district and Haluaghat upazila of Mymensingh district in Bangladesh were selected purposively because of the intensity of solar panel users and familiarity of the area. A total 140 households were selected through multi-stage cluster sampling technique and conducted direct face to face interview by using semi-structure questionnaire. Survey method was followed to collect data from the respondents. Data were collected by the researcher through personal interview and focus group discussion. Tabular technique was applied for the analysis of data and sustainable livelihood framework was used for the analysis of household assets. It was found that in Bogra district about 52.86% respondents used low capacity of solar panel, about 28.57% respondents used medium capacity of solar panel and 18.57% respondents used high capacity of solar panel. In case of Mymensingh district about 62.86% respondents used low capacity of solar panel, about 31.43% respondents used medium capacity of solar panel and 5.71% respondents used high capacity of solar panel. Financial analyses were done on the basis of investment decision making tools like Net Present Value (NPV), Benefit Cost Ratio (BCR), Internal Rate of Return (IRR) and Payback Period (PBP). NPV, BCR, IRR and PBP were Tk. 312, 1.01, 10.26% and 6.08 years, respectively in Bogra district and Tk. 1051, 1.04, 8.72% and 7.06 years, respectively in Mymensingh district. Most of the respondents reported that both their income, expenditure level as well as their livelihoods had increased after using the solar panels. After getting the solar panel purchased most of the livelihood assets were improved. But 34% and 13% of the respondents said that the land leased and cash in hand were unchanged in Bogra district and 11% and 23% respondents in Mymensingh district, respectively. The expected value of NBI was positive (45.87) means the project is preferable for continuing the business for the future in Bogra district and the value was also positive (127.58) in Mymensingh district. About 95% of the respondents reported shortage of sunlight in rainy day as problem in Bogra district and this figure was 92.85% in Mymensingh district. It may be conclude that Bangladesh has a great potentiality to adopt more solar panels especially in household level since it has positive impact on livelihoods.***

Keywords: Solar Panel, *Financial Viability, Future Prospects, Bangladesh*

1. Introduction

Electricity is the foremost source of power for the most part of the world's economic activities. Bangladesh's total installed electricity generation capacity (including captive power) was 15,379 MW as of February 2017. Recently Bangladesh started construction of 2.4 GW Rooppur Nuclear Power Plant expected to go into operation in 2023. But still the per capita energy consumption in Bangladesh is considered low. Bangladesh has small reserves of oil and coal, but very large natural gas resources. Commercial energy consumption is mostly natural gas (around 66%), followed by oil, hydropower and coal [1]. The Government has taken necessary initiatives to reform and restructure the power sector to make electricity available to all by 2021. In order to fulfill the vision and election manifesto target, the Government has planned to generate additional 24,000 MW electricity within 2021 [2]. In 2016, the total number of consumers connected to the grid is 21.8 million. Out of the 21.8 million 16 million are domestic connections (households), which would represent roughly 50% of all Bangladeshi households (30-40 million). Another 15% of the households have access to off-grid electricity. The government is estimating that more than 70% of Bangladeshi households now have access to electricity (76%, June 2016). The government plans to connect 98% of households mainly through grid extension by 2021[3].. Bangladesh gain 15 MW solar energy capacity from rural households and 1.9 MW wind power in Kutubdia and Feni. Bangladesh has planned to produce 10% of total power generation by 2020 from renewable energy sources. Government of Bangladesh has announced that 3MW electricity is going to be added to national grid from Shorisha bari solar power plant in Jamalpur district this year. Within five years 332MW electricity will be added from another five centers [4].

Solar energy is inexhaustible and pollution free. It is available everywhere; but the greatest amount is available between two broad bands encircling the earth between 15” and 35” latitude north and south. Fortunately, Bangladesh is situated between 20”43’ north and 26”38’ north latitude and as such Bangladesh is in a very favorable position in respect of the utilization of solar energy. Annual amount of radiation varies from 1840 to 1575 kwh/m^{2}which is 50-100% higher than in Europe. Taking an average solar radiation of 1900 kwh per square meter, total annual solar radiation in Bangladesh is equivalent to 1010 X 1018 J. present total yearly consumption of energy is about 700 X 1018J. this shows even if 0.07% of the incident radiation can be utilized, total requirement of energy in the country can be met. A study found the daily sunlight hours in Bangladesh to range from 10 to 7 hours; they further reduced this by 54% (to 4.6 hours) to account for rainfall, cloud, and fog [5]. So

this abundant solar energy have a large potential to be used in various sector in Bangladesh reducing the traditional fossil fuel based power consumption and ensuring a green environment for the future generation.

Solar panel refers to a panel designed to absorb the sun's rays as a source of energy for generating electricity. Electricity is the prime mover for the advancement of all economic and industrial activities. About 59% of total population live in rural and isolated areas and most of them have no electricity access. This scenario is more acute in the rural and isolated areas in Bangladesh where only about 25% have electricity access [6]. Bangladesh is a semi-tropical region lying in northeastern part of South Asia gets abundant sunlight year round. The average bright sunshine duration in Bangladesh in the dry season is about 7.6 hours a day, and in the monsoon season is about 4.7 hours, Solar energy can be harnessed. So, solar panel technology is advised. A total of 3,00,000 solar panels had been installed in more than 40,000 villages of 456 upazilas of all districts of Bangladesh. Daily on average 44 MW electricity is being produced by these solar panels [7]. Now a days solar panel is applied in different aspects such as solar based recharging station ,solar cooking etc.. It presents an attractive alternative to conventional electricity such as no monthly bills, no fuel cost, little repair and maintenance costs, easy to install any where etc. The solar panel technology is very effective to illuminate rural households and power other essential home appliances, such as lights, radios and small black and white televisions. Again, the main advantages of solar panels are that it is absolutely pollution free, inexhaustible and especially suitable for deserts and isolated places where other sources are not available. It is less expensive and only utilizing the proper use of it we can make our rural life developed like urban areas. That's why the necessity of solar panel is increasing day by day. Although, at present economy of Bangladesh is growing up and poverty rate is falling. To achieve more development of such situation and generation of electricity we need to realize the importance of solar panel.

In Bangladesh, the serious demand-supply gap of electricity is one of the largest bottlenecks for economic growth. As the capacity of power supply facilities is only around 4,000 MW compared to the peak electricity demand of 6,100 MW, they have no choice but to have scheduled load-shedding of electricity supply during the peak time [8]. Bangladesh is losing at least 3.5% of Gross Domestic product (GDP) due to the shortage of power supply according to a research report of Centre for Policy Dialogue (CPD) [9]. Bangladesh is deeply reliant on fossil fuel for its power production. As per Bangladesh Power Development Board data, out of total installed capacity of about 12000MW, 64% of the energy comes from natural gas, 2.0% comes from coal, 27% comes from diesel/furnace oil, 2% comes from hydro and remaining approximately 5% is imported [10]. With diminishing supply of gas, the power sector of Bangladesh is facing a severe peril and the diversification of primary source has become a essential.

Therefore, researcher focused on impact of solar panel of the users and to see whether the program could have positive impact on the respondents particularly in reducing poverty. This research was mainly aimed to determine the intensity of solar panel uses, investigate the impact of solar panel on livelihoods with financial analysis for the sustainability of the project, problems and constrains of the solar panel faced by the households and the future prospects.

2. Materials and Methods

Sherpur upazila of Bogra district and Haluaghat upazila of Mymensingh district in Bangladesh were selected purposively because of the intensity of solar panel users and familiarity of the area. A total 140 households were selected through multi-stage cluster sampling technique and conducted direct face to face interview by using semi-structure questionnaire. Survey method was followed to collect primary data from the respondents. The period covered in this study was January to December/2016. Data were collected during the month of January to March, 2017. Repeated visits were made for collecting primary data. To determine the intensity of solar panel uses tabular analysis was used. To determine the NPV, BCR, IRR, PBP and NBI financial techniques were applied. To examine the impact of solar panel on livelihood of the households, DFID (2000) Sustainable Livelihoods Guidance Sheets framework was used for the analysis of households throughout several features using the household approach of identifying household assets within the vast social and economic transforming processes of community institutions and obligations, lawful framework and market structures [11]. To determine the future prospect of solar panel in Bangladesh econometric model was used.

2.1 Analytical Tools

The following models were used for the study.

Net Present Value (NPV):
NPV is the difference between the present value of cash inflow and present value of cash outflow. NPV study is sensitive to future cash inflow that an investment will yield [12].

$$\mathrm{NPV}\,(r, \mathrm{N}) = \sum_{t=0}^{N} \frac{R_t}{(1+r)^t} \qquad (1)$$

Where
t = the time of the cash flow
r = the (the that could be earned on an investment in the financial markets with similar risk); the opportunity cost of capital.

R_t= the net cash flow i.e. cash inflow – cash outflow, at time *t*. For educational purposes,
R_o is commonly placed to the left of the sum to emphasize its role as (minus) the investment.
N= The total number of periods

If NPV>0, that means positive, the project supposed to be accepted. However, if NPV<0 that is negative, the project should be rejected as cash flow will also be negative.

Benefit Cost Ratio (BCR):
The BCR is a relative measure, which is used to compare benefit per unit of cost. The BCR was estimated as a ratio of

total cash inflow and total cash outflow [13]. The formula of Calculating BCR (undiscounted) is:

$$BCR = \frac{\sum_{t=1}^{T} \frac{B_t}{(1+r)^t}}{\sum_{t=1}^{T} \frac{C_t}{(1+r)^t}} \quad (2)$$

Where, B_t is the benefit in time t and
C_t is the cost in time t.
If BCR>1, the project is accepted and beneficial.
If BCR=1, we interpret it as indifferent
If BCR<1, the project is rejected.

Internal Rate of Return (IRR):
Internal Rate of Return is a discount rate that makes the NPV of all cash flows from a particular project equal to zero. The IRR is the annual percentage rate of return that an investment real returns over the whole life of the investment. It is expressed in percentage(%) terms [14].

$$IRR = r_a + \frac{NPV_a\,(r_b - r_a)}{(NPV_a - NPV_b)}$$

r_a = lower discount rate
r_a = higher discount rate
NPV_a = NPV using the lower discount rate
NPV_b = NPV using the higher discount rate

(3)

If IRR is greater than cost of capital, then the project is accepted, Other than rejected.

Payback Period (PBP)
In simple terms, payback period is the length of time required to recover initial cash outlay on the project. If cash inflows are constant, then the payback period is calculated by dividing the initial outlay by the annual cash inflow [15].

$$PBP = \frac{TI}{NR} \quad (4)$$

Where, TI = Amount of total investment,
NR= Annual profit , which is annual gross income less annual operational cost.

When we consider the payback period, the shorter payback period is more attractive for the project. Farms using this principle to find out the tolerable payback period.

To determine the future prospect of solar panel in Bangladesh, the following model was used.
Net Benefit Increase (NBI) can be estimated as:

$$NBI = NPV * CRF_{t.i} \quad (5)$$

$$CRF_{t.i} = \frac{(1+i)^t . i}{(1+i)^t - 1}$$

Where,
CRF means capital returns factor
t = Expected lifetime of the digester
i = Discount rate

3. Results and Discussion

3.1. Determination of intensity of solar panel uses

Extent solar panel intensification was estimated by evaluating the power of the solar panel used by the households. Mainly village people used solar panels to do lighting, fan, mobile charging and playing music player. So, they mostly used solar panel ranging from (5-135) watt capacity. Small number of people use greater than 135 watt. The category was done according to used capacity of solar panel just for knowing the average capacity of panel they used. These were:

1) Solar panels containing (5- 50) watt, categorized as lower capacity panel.
2) Solar panels containing (51-100) watt, categorized as medium capacity panel.
3) Solar panels containing (101-above) watt, categorized as higher capacity panel.

Table 1: Distribution of respondents according to capacity of solar panel they used

Category	Bogra		Mymensingh	
	Number	Percentage	Number	Percentage
Low capacity of panel(5-50) Watt	37	52.86	44	62.86
Medium capacity of panel (51-100)watt	20	28.57	22	31.43
High capacity of panel (101-above)watt	13	18.57	4	5.71

Source: Field Survey,2017

From the table 1, it is reveal that, in Bogra district about 52.86% respondents used low capacity of solar panel, about 28.57% respondents used medium capacity of solar panel and 18.57% respondents used high capacity of solar panel. In case of Mymensingh district about 62.86% respondents used low capacity of solar panel, about 31.43% respondents used medium capacity of solar panel and 5.71% respondents used high capacity of solar panel.

3.2 Determination of the NPV, BCR and IRR of the Solar Panel

For determining the NPV, BCR and IRR of the solar panel, cost of solar panels, benefits of solar panels and then economic viability of solar electricity production from solar panel was estimated. By analyzing the data we found that an average initial investment or cash outflow for the use of solar panel was Tk. 26555. Annual operation and maintenance (O&M) costs of solar panels were related to repairing and maintenance [16]. We also found that an average operation and maintenance cost were Tk.102 and it was increased on the basis of 8% inflation rate for the solar panel life time which was an average 14 years. Quantification of the benefits of a solar panel is a decisive step in the economic feasibility assessment of solar panel activities. The benefits accruing from establishing and operating a solar panel fall into two essential categories: monetary and environmental. The monetary benefits are the saved costs on energy substituted by electrical energy produced. It is vital to find an indirect technique to appraise the benefits, and the most realistic method is to place market values in term of substitute electricity for a given final use [17]. It was estimated for the data that an average cash inflow was Tk. 4357 and average salvage value was Tk.

1235 in Bogra district and an average cash inflow was Tk.3770 and salvage value was Tk. 1500 in Mymensingh district. The NPV, BCR and IRR was calculated on discount rate 10% and 12 % for Bogra district and 8% and 10% for Mymensingh district .We used those discount rates because of getting positive NPV and negative NPV value. At discount rate 10%, NPV was Tk. 312 and BCR was 1.01 and at discount rate 12%, NPV was Tk. -2121 in Bogra district and those values were Tk.1051, 1.04, Tk. -1877, respectively in Mymensingh district. Using the both discounting rates (Lower discounting rate 10% and upper discounting rate 12%) we found the IRR 10.26% which was greater than opportunity cost of capital (8%, lending rate of interest) [18], the project was economically viable in Bogra district. In case of Mymensingh district, Using the both discounting rates (Lower discounting rate 8% and upper discounting rate 10%) we found the IRR 8.72% which was greater than opportunity cost of capital (8%, lending rate of interest). We also calculated the payback period for both districts which were 6.08 years for Bogra and 7.06 years for Mymensingh district. Payback period of the project was less than average life time of solar panel. So, the project was economically viable and acceptable.

Table 2: Comparing between two districts

Tools	Bogra	Mymensingh
NPV (Tk.)	312	1051
BCR	1.01	1.04
IRR(%)	10.26	8.72
PBP (Years)	6.08	7.06

Source: Field Survey,2017

3.3 Impact of Solar Panel on Livelihoods

We analyzed the impact of solar panel on livelihoods on the basis of five assets like human, social, natural, physical and financial assets [11]. To think of human capital as a store of capability, which can contribute to yield a flow of services. Being able to work with contemporary equipment is individual productive capabilities. But these capabilities not only depend on knowledge but also comprise useful behavioral way of life as well as level of liveliness and physical and mental health. Social capital means the stock of belief, common thoughtful, common ethics, and communally held information that facilitates the social harmonization of economic activity [19]. Natural resources including their land (purchased), land (lease/mortgage) etc. Physical capital has two dimension one is natural another one is produced. Produced capital is that kind of physical assets that are generated by applying human fruitful activities to natural capital, and that are used to make available of goods or services. Financial capital is what allows all these useful activities to get going, in a financial system, in progress of the returns that will stream from them.

Above all five kinds of assets were given in the table 3.

Table 3: Change of different type of assets

Assets	**Items**	Bogra			Mymensingh		
		Increased	Unchanged	Decreased	Increased	Unchanged	Decreased
Human assets	Education	52(74.28)	14(20)	4(5.71)	50(71.43)	13(18.57)	7(10)
	Health status	45(64.29)	21(30)	4(5.71)	48(68.57)	15(21.43)	7(10)
	Skills and Knowledge	47(67.14)	19(27.14)	4(5.71)	45(64.29)	13(18.57)	12(17.14)
Social assets	Patronage	49(70)	15(21.43)	6(8.57)	45(64.29)	17(24.29)	8(11.43)
	Neighborhoods	29(41.43)	29(41.43)	12(17.14)	35(50)	21(30)	14(20)
	Kinship	40(57.14)	21(30)	9(12.86)	38(54.29)	18(25.71)	14(20)
Natural assets	Land leased	33(47.14)	24(34.29)	13(18.57)	43(61.43)	11(15.71)	16(22.86)
	Trees and Forest	29(41.43)	19(27.14)	22(31.43)	30(42.86)	19(27.14)	20(28.57)
	Water and aquatic resources	35(50)	22(31.43)	13(12.86)	40(57.14)	14(20)	15(21.43)
Physical assets	Bed	42(60)	26(37.14)	2(2.86)	38(54.29)	14(20)	18(25.71)
	Chair	39(55.71)	21(30)	9(12.86)	42(60)	21(30)	7(10)
	Table	43(61.43)	26(37.14)	1(1.43)	35(50)	23(32.86)	12(17.14)
	Cupboard	40(57.14)	24(34.29)	6(8.57)	48(68.57)	13(18.57)	9(12.87)
	Showcase	49(70)	12(17.14)	9(12.86)	55(78.57)	4(5.71)	11(15.71)
	Television	27(38.57)	32(45.71)	11(15.71)	15(21.43)	45(64.29)	10(14.29)
Financial assets	Cash in hand	53(75.71)	13(18.57)	4(5.14)	37(52.86)	23(32.86)	10(14.29)
	Deposit in the bank	48(68.57)	15(21.43)	7(10)	31(44.29)	28(40)	11(15.71)
	Poultry	35(50)	19(27.14)	16(22.86)	35(50)	15(21.71)	20(28.57)

(Figures in parentheses indicate percentages), Source: Field Survey, 2017

Table 3 shows that most of the assets were positively changed after using solar panel except land (lease/mortgage) 47.43% user thought increased and 34.29% thought unchanged of land leased in Bogra district. Again, 61.43% user though increases and only 15.71% thought unchanged of land leased in Mymensingh district.41.43% user though increases and 31.43% thought decreased of Trees and Forest in Bogra district. Again, 42.86% user though increases and only 28.56% thought decreased of Trees and Forest in Mymensingh district.

3.4 Determination of Future Prospects of Solar Panel in Bangladesh

Bangladesh holds the possible to reasonably meet a considerable portion of its future electricity require through the use of solar panel, probably adding up as much renewable competence as the existing electric power capacity of Bangladesh. Many parts of the country have suitable solar environment and there are many potentially lucrative applications. Recently, scientists of Bangladesh are trying to develop second generation solar cell, actually they are about to success. Bangladesh must have contemporary

policy outline that allows and attract private investors to develop solar energy projects in order to realize the massive prospective of renewable energy. The expected value of NBI was positive (45.87) means the project is preferable for continuing the business for the future in Bogra district and the value was also positive (127.58) in Mymensingh district

3.5 Problems faced by the Solar Panel User

The problem reported in this section was based on the opinions of the respondents. The most common and serious problems is summarized below and presented in following figures 1 and 2.

Most of the solar panel users reported that, when it is rainy days, they face the shortage of power. Again, if more power was used at day period they face shortage because it gets charged only at sunlight. So it was also a major problem. Some users indicated that the power productivity of the panel should be longer than it contained at present. Due to the lower productivity they faced shortage of power for using electric tools. Some users said that, the power storage capacity was relatively lower. Many users complained that the initial cost of solar panel was higher. It was not under the nose of all people especially for poor people. That's why People thought that Government should give solar panels to the poor at free of cost, although government had already started this project. It was not possible to repair the panel by the users when get problems, having no training or knowledge on solar panel they cannot maintain it properly. Only a little numbers of NGOs were providing credit on solar panel. Sometimes it was seen that, the NGOs are taking more money as price than real .They set installments without any basic calculation which is higher than market price. For this most of the areas kept out of solar panel credit as well as solar electricity facilities. The credit programs were not available to almost all the areas. The users who buy panels on credit complain that interest rate was very high. Even the people who buy the panels on cash indicated that they rejected credit due to having high interest rate. The users did not have any training to operate solar panel. For this reason many people did not buy solar panel in fear to operate properly. Even, the people working as installer or technician were not well trained or higher degree owners. Some people marked battery capacity as lower. Battery can receive less charge from the sun. For this they get less power to use. So, they hope that the battery capacity should be enriched. Some users faced the problems of choosing of proper place and angel to place the solar panel. Because, village area is mostly covered with trees or bamboo bushes. So they found hardly a proper place to settle the panel. Many users' commented that unsealed battery contains toxic metal and metal salts, and release gas while charging. Some users said that they changed battery water for toxic problems. It was very common that users faced the problem of strong wind and sand storms. Many users told me that they have to change the switch and regulator several times**.** That means the quality of switch and regulator was very poor.

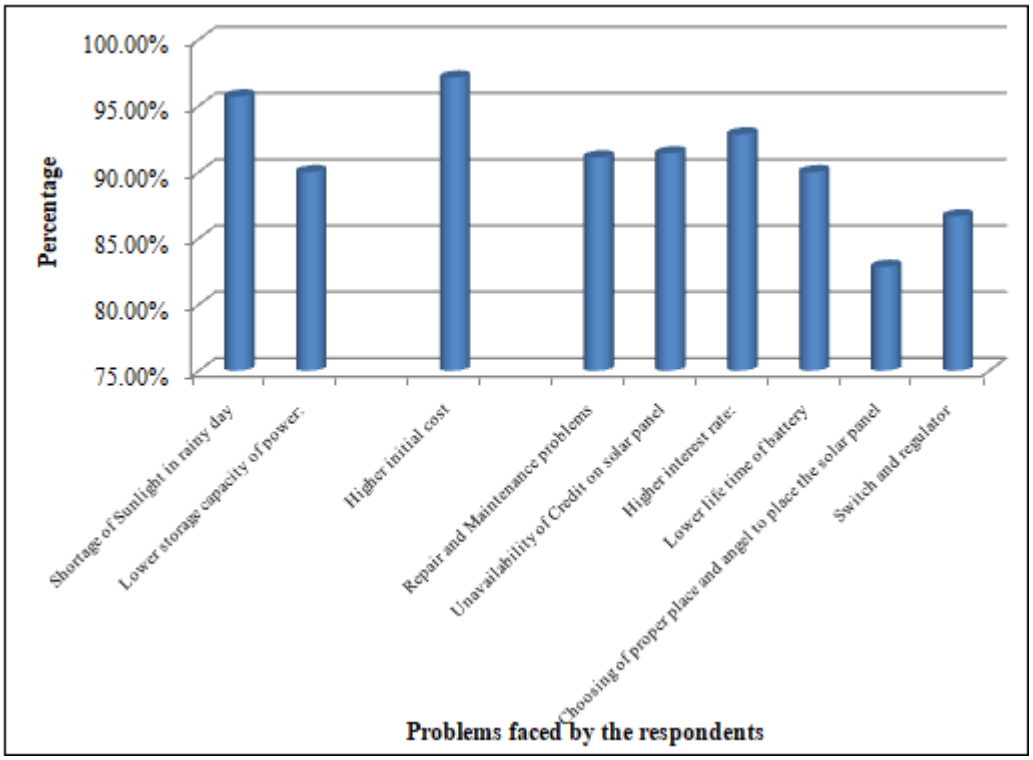

Figure 1: Problems and constraints faced by the respondents of Bogra district

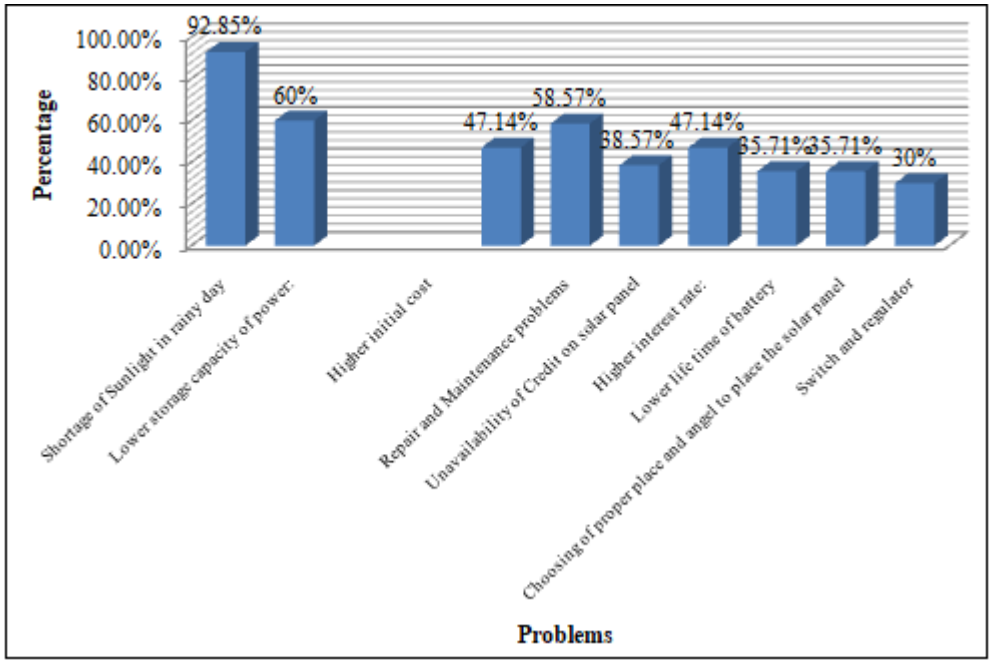

Figure 2: Problems and constraints faced by the respondents of Mymensingh district

4. Conclusion

Economy of Bangladesh is growing up slowly. As vision "2041" Bangladesh will be a developed country by 2041, for achieving this vision Bangladesh needs rapid economic growth, but for this, increased power demand must be ensured. As Bangladesh is rural based agrarian country, the grid electrification in many rural areas difficult and very expensive. As an alternative and very convenience, solar panel is very popular with both the consumers and suppliers and the use of solar panel is increasing day-by-day rapidly all over the country [20]. But proper financial provision, including payment of installments, service fee, subsidy, technical and permissible support for organizations dealing to set up in the solar sector is important [14].Technician support should be ensured for mounting local technical support, which can contribute to make the project sustainable. Participation of rural people especially rural women should be encourage for training, as they are the most crucial stakeholders of the systems and can able to do some of the safeguarding. To achieve the sustainable development goals especially goal number one eradicate poverty along with improvement of rural livelihoods, solar panel is an useful tool. "Bangladesh is really goes in front in solar home systems. The program is making a difference in the lives and livelihoods of rural people by alleviating poverty. It has fabulous potential for scaling-up and also replication in other countries under comparable conditions or necessary adaptations" [21]. The findings of the present study indicate that the capacity of solar panel used in the rural Bangladesh is very low ranging from (5-135), financial sustainability also poor due to high operation and maintenance cost. If the solar panel technology can be improved and training for the solar panel users can be ensured, it will be financially viable and help to develop living standards of the people. Even solar panel users are facing some problems but results indicates that future prospects of solar panel use in Bangladesh is very good.

5. Acknowledgements

The first author gratefully acknowledges the Ministry of Science and Technology, Government of the People's Republic of Bangladesh for funding this research work.

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