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Cost Benefit Analysis and Diffusion Process of Solar Home System : A Study on Cumilla District of Bangladesh

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Abstract

Solar home system as a renewable energy solution for household could play an active role to mitigate the increasing energy demand and to reduce the dependency on fossil fuels in the rural part of Bangladesh. The intent of this study is to show the diffusion process of solar home system and to undertake a cost benefit analysis through NPV, BCR, and payback period. This study explores the efficacy of adopting the solar power technology in Cumilla district of Bangladesh. Results show that user'soral communication is driving the diffusion process of solar home system. NPV is found positive and varies from 5 to 528 taka; BCR is found higher than one which varies from 1.005 to 1.29; average value of payback period is found in the range of 15.4 to 19.8 years. Higher positive NPV and higher BCR indicate the economic attractiveness of using solar home system, while shortest payback period encourages the people for adopting solar home system. The government can, therefore, take necessary steps to promote the solar home system, in a wider range for mitigating the increasing energy demand of the country.

Key words: Solar Home System (SHS), Cost Benefit Analysis, Diffusion Process, Energy Demand, Cumilla.

1. Introduction

Energy is one of the most imperative factors for poverty alleviation, socio-economic and human development in any country. Fossil fuel like Natural gas, Coal and Oil is the most dependable energy source for the world right now even so it is being diminished at a higher rate. So a major transformation in the energy sector from fossil fuels to renewable energy sources is observed in the world.

Renewable energy is characterized as energy that comes from resources which are repeatedly overfilled by natural process such as sunlight, waves, tide, wind, rain and

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geothermal heats. About 18.2% of global ultimate energy consumption comes from renewable resources. This energy consumption is separated as 7.8% coming from traditional biomass, 4.1% as heat energy (modern biomass, geothermal and solar heat), 3.7% from hydropower, 0.9% from transport biofuels and 1.7% form other renewable sources including wind power and solar photovoltaic (PV). The share of renewables in global electricity generation is approximately 26% (REN21: Renewables now, 2018). Solar and wind has attained most popularity among all the renewable energy sources. However the fact is that countries like Bangladesh where the high winds accessible open land is less, there only selection is to depend on solar energy which is reachable everywhere indiscriminately. For large scale electricity production in Bangladesh, solar PV conversion is the most desirable and reliable pathway. Because of its simplicity and capability to generate low carbon electricity solar PV has also gained acceptance among the users.

Bangladesh sets targets for developing renewable energy resources to address 5% of the total power demand by 2015 and 10% by 2020 (Power Division, Ministry of Power, Energy and Mineral Resources, 2008). Bangladesh has already achieved some significant successes in the implementation of renewable energy technologies (RET). About 14% of the population of Bangladesh attained access to electricity through off-grid solar systems, where the electric grid does not reach or is unreliable (World Bank, 2018).

In Bangladesh, the access to electricity has reached at 76% (grid and off-grid), where urban accessis 94% & rural accessis 69 % (Tracking SDG7, 2018).Rapid urbanization, fueled by firm economic growth has formed a massive power demand in Bangladesh.

The government of Bangladesh has successfully increased electricity generation in the recent past; however grid electricity is not accessible in the remote areas of the country due to lack of infrastructure and longstanding distribution facilities.

The government has set an ambitious goal of fetching every rural household under electricity coverage. Renewable energy such as solar power can be the key factor of this ambitious goal. Covering 14% of the population, Bangladesh has implemented one of the world's largest domestic solar power programs. World Bank along with its development partners has installed solar home systems in more than 4 million households and shops in remote rural areas. In fact, more than 20 million people in rural Bangladesh get electricity by installing solar home system (LightCastle Analytics Wing, 2019).

Solar home system gained popularity among multiple people for various reasons. Solar home system that power rural households is environment friendly and economically feasible. There are sixteen upazila in Cumilla district. The northern part of Cumilla district covers the Muradnagar and Debidwar upazila, where electricity is not available.

Rural poor residents prefer solar system because the monthly amount spent for keroseneis more than the monthly installments for each set-up of solar home system to meet their power needs.

The general objective of this research is to explore the effectiveness of adopting a solar home system (SHS) for household through benefit–cost approach. However, the specific objectives of the study are to (i) find out the diffusion process of solar home system; (ii) explore the financial feasibility of using solar system; and (iii) know the payback period of solar home system.

2. Literature Review

One of the first considerations we looked at whether or not solar was consistently cheaper than grid electricity, which is crucial to the feasibility of residential solar projects sustained growth. According to the National Renewable Energy Laboratory (2012), the level of carbon emissions has considerably increased, environmental turbulence all over the world prompting climate changes, poor air quality and unpredictable changes in energy cost.

According to the Barnes, et al., (2011) about 58% of villagers are power deprived and closely reliant on kerosene for illumination purpose in Bangladesh. As said by Iorkyaa et al., (2012) usual kerosene lamps supply light output as low as 0.3 lumen per watt, which is very pitiable in contrast with standard LED light bulbs. Mills (2012 & 2016) stated, house fires, kerosene burns and polluted indoor air quality connected with kerosene lighting in Bangladesh. The later (Mills, 2016) report tinted that infants in Bangladesh incur about 40% of the fuel-based lighting burns. The health hazards and related other risks of using kerosene fuel for lighting function are well recognized in many studies around the world (Chamania, et al., 2015; American Cancer Society, 2006; and Mashreky, et al., 2008).

Komatsu et al. (2011) revealed, approximately 50% household of rural Bangladesh keep on utilizing kerosene at a monthly of 0.92L decreased from 3.932L for illumination function only just even installing Solar Home System. However Pode (2013) stated that better standard of living is the main issue for user shifting from fossil fuel to solar PV solution.

The investigative study of Rahman et al., 2013 pinpointed the difficulties and motives for default of rural electrification amidst the conventional grid expansion in Bangladesh. These are lack of investment, bad terrain, poor operation and maintenance, low number of connections per unit of comprehensive grid and finally very low load demand per connection. Researchers (Rahman et al., 2013; Paul, 2011; Ziaur, 2012; and Alliance for Rural Electrification [ARE] 2008;) articulated their apprehension for the difficulties of rural electrification associated with institutional setup, financing and policy frameworks attributed to various geographical, economic and socio-political characteristics. Palit et al., (2016) reported nearly similar issues associated with grid expansion for rural electricity access in other South Asian countries.

Darghouth et al. (2016) have showed that the expenses of allocation, transmission and generation of electricity are recuperated through retail tariffs in many countries, levied on a volumetric basis. The expense of financing exerts a strong persuasion on the economic viability of solar PV projects. Intuitively, it follows those localities that propose monetary incentives experience increased rates of PV deployment, as confirmed by Crago and Chernyakhovskiy (2017). Households may have considerable reserve fund and like to pay for a PV system in cash, particularly when deposit interest rates are low. Others may be more likely to use debt finance, in which case loaning rates will decide the expenses of servicing that debt. It is also important to identify that households use diverse decision-making criteria for capital budgeting decisions contrast with commercial entities, and financial performance must be assessed accordingly. Payback period (PBP) is the determiner that holds the best way over homeowners' decision-making process while counting an investment in rooftop PV. Seven to ten years payback period is needed for households to move forward with rooftop PV investment.

Sidiras and Koukios (2005) have recommended that commercial users and residential users are eager to exercise payback times to define the estimation of a PV investment or other energy-saving investments. Private and business customers may accept that PV value in terms of inhabited monthly utility electric bills will fall down if they invest in PV and third-party owned PV business commonly promote PV products by means of bill savings metrics. Prospective commercial PV users may assume PV as a longer-term investment than residential user and may be more likely to describe PV value as a yearly return on investment (Chabot, 1998).

Jung and Tyner (2014) inspect the possibility of solar being economical than grid electricity for all circumstances. A cost benefit analysis is conducted to verify the economics of implementing solar PV arrangements in Indiana depended on policy instruments that could boost implementation of solar PV arrangements first under the existing policy and then under prospective policy options. By investigating the expenses allocation of solar PV arrangements corresponding to grid electricity in homes and estimating the probability that solar can be cheaper than grids under these diverse policy mixtures, the results are important for government policy makers to determine how effective alternative policies are for encouraging solar PV use. A cost-benefit analysis is exercised to appraise the economics of solar PV arrangements in Indiana with a key factor of economic viability being the comparison of a breakeven cost of electricity of a residential solar PV solution with the expected annualized cost of electricity supplied from the grid ($/kWh). The study concludes that under current policies of federal tax credit, financing, and net metering in Indiana, there is simply fifty-fifty option of solar being cheaper than electricity from grids. However, with implementation of potential policies such as a carbon tax, solar PV solution may be cheaper than grid electricity. These results are beneficial in showing that even with all the current incentives, the cost of solar can be lowered by considering other policy incentives.

The extensive diffusion of Solar Home System has permitted researchers to evaluate the financial viability of the ownership model (Mondal, 2010). He interviewed 56 households and 10 microenterprises that possessed a SHS and completed a financial analysis of six case studies. His financial analysis figured out the payback period, net present value (NPV) and internal rate of return (IRR) for the SHS investments. The four households and businesses that use the SHS for commercial or income generating purposes enjoyed the payback periods of less than three years, a positive NPV and an IRR of over 39%, making the SHS a very good investment.

A good number of studies have been completed in the development of solar home system. The existing research typically shows the comparative analysis of solar technology and also shows the cost and benefit of using solar home system. But no one shows the cost effectiveness of using solar home system in rural areas of Cumilla district of Bangladesh. This research has found out the cost effectiveness of using SHS in Cumilla district and the financial viability of the solar home system. This analysis also assessed why households wanted to buy the solar home system.

3. Research Design and Methods

3.1 Study area: The main focal point of this study is to determine the appropriate social impact that has outcome from the use of SHS in Cumilla region. The survey was conducted in the rural area of Muradnagar and Debidwar upazila, which is located in the northern part of Cumilla district. Debidwar is positioned at 23.6000° N and 90.9917°E. It has 101,809 households covering a total area of 340.73sq. km. Average literacy rate 50.39%. Main sources of livelihood: 54.17% agriculture, 14.04% commerce, 11.82% service, 4.57% transport and communication, 2.90% rent and remittance, 1.74% non-agricultural laborer, 1.22% construction, 1.02% industry,0.33% religious service and 8.19% others (Bangladesh Bureau of Statistics [BBS], 2015). Muradnagar is positioned at 23.6385°N and 90.9325°E. It has 55,619 households and a total area of 238.36 sq. km. Average literacy rate 38.43%. Main sources of livelihood: 50.24% agriculture, 16.25% commerce, 8.47% service, 4.80% rent and remittance, 2.72% transport and communication, 2.55% non-agricultural laborer, 1.34% industry, 1.09% construction, 0.42% religious service and 12.12% others (BBS, 2015). It was visualized that under investigation the collected data would definitively outline socio-economic conditions and provides are presentative example of rural Bangladesh. These upazilas have been chosen because a good number of villages and households use the solar home system. These areas, could afford SHS as they are economically better than the other areas.

3.2Sampling Frame: Four villages-Poshchimsonulla and Sonapor from Muradnag or upazila, Barashalghor and Yousufpur from Debidwar upazila were selected for data collection based on the users of solar home system (SHS). The survey was executed in those households that owned solar home systems. In each village, all households are not using the solar home system (SHS) as the source of energy for electricity. The name of the property owner and the installation year of SHS were collected from household owners of the selected villages. The sampling distribution is given in table 3.1.

Table 3.1: Region wise Sampling Distribution

Name of villages	Sample size
Poshchimsonulla	15
Sonapor	15
Barashalghar	10
Yousufpur	10
Total	50

3.3 Data Collection tools: In the study, both qualitative and quantitative data were collected through questionnaire survey. Data were collected through face-to-face interview using structured questionnaire. The population of the study was unknown. Purposive sample method was used to conduct this survey. Since the research data was not available, researcher took 50 samples purposively for analysis. The collected data relates to personal information, income of household, how they learned about solar technology, purpose of using solar home system, and the costs and benefits involved while using solar system by households. The questionnaire contained 30 questions. After data collection, a revision of the prior study was completed to make out the difference amid the impact of past and present outcome. This helped to present an efficient outline of the investigative work.

3.4. Methods of Data Analysis: The Statistical Package for Social Sciences (SPSS) was used for data analysis. Mean, frequencies and percentages were used to summarize and categorize the information gathered. Bar charts were used to show the system size, the learning process about SHS, users of SHS, percentages of the users, mean value of monetary savings and percentages of users for influencing others to use the solar home system (SHS).

The benefit–cost analysis is used to find out the alternative for the adoption of solar home system for households. Various parameters such as payback period, net present value, and benefit-cost ratio had considered to critically examine the economics of solar home system. For accuracy and exactness of this cost benefit model, it is important to determine the present values of the solar home system and compare the costs and benefits across different time periods. The study used contemporary data for example current energy prices for household, solar system costs from different agencies, costs of power components, labor costs from solar and roofing contractors. The NPV of each household with system size, the difference between the present value of the cash inflows (Benefits) and cash outflows (costs) can help determine which purchase scheme of SHS is the better option. Furthermore, the study scrutinized the cost and benefit apparatus of the solar system-

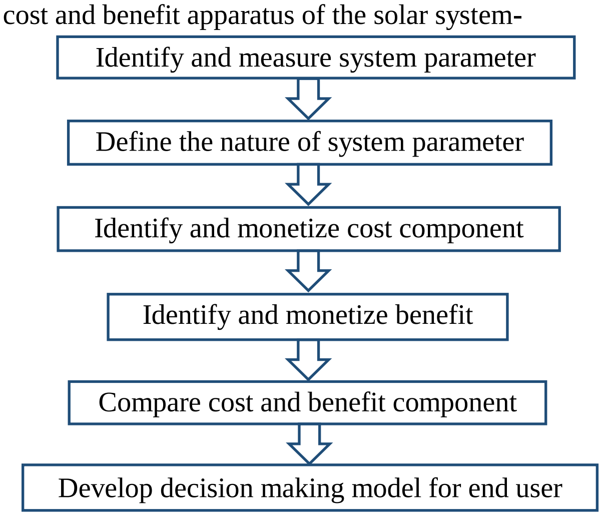

Fig 3.1: Cost–Benefit process (Source: Snell, 2011)

To calculate the financial parameters, the study used following equations-

1. NPV= $\frac{Benefit-cost}{(1+discountrate)^{t}}$ here, t: Lifetime of system (1, 2, 3…….20)

2. BCR= $\frac{Benefit}{Cost}$

3. Payback period = $\frac{Capitalcost}{Anualsavings}$

The economic investigation of SHS based on different financial parameters such as simple Payback period, Net present value (NPV), and Benefit to cost ratio (BCR). Payback period is the period of time that recoups the initial investment. NPV was calculated by bringing all the costs and benefits to the year zero. BCR was calculated by dividing total benefit to total cost throughout the project life. A short payback period, higher NPV and BCR are necessary to ensure that the purchase of SHS is quickly recovered and a risk-free investment.

4. Results and Discussion

4.1. Characteristics of the respondent:

The socioeconomic characteristics of respondents were collected. These included gender, age, profession, family members, and monthly income of respondent. In this study, 74% respondents are male and 26% respondents are female. The age of the respondent varies between 24 years to 65 years. And that of the family members varies between 4 to10. People use solar energy for many purposes such as for household, for commercial, street light, etc. But in this study hundred percent respondents uses solar energy in their houses that is solar home system. In this study, we have found that 30%of respondents are businessmen, 10% are govt. job-holder, 14% serve in private companies, 8% respondent are farmers and 38% of respondents have other occupations. 32% of respondents who use SHS in their houses have a monthly income of more than 25000 Tk., 26% respondents have 20000-25000 Tk., 30% respondents have 15000-20000 Tk. and 12% respondents have 10000-15000 Tk. as monthly income.

4.2 Diffusion process of SHS

4.2.1 Learning about SHS: Before using the solar home system the consumer must know about the existing technology and believe that it is superior to other types of energy. To accomplish this, different households were asked how they learned about the technology. The respondents of Muradnagar and Debid war came to know about the solar system from their relatives, neighbors, field workers and from other sources.

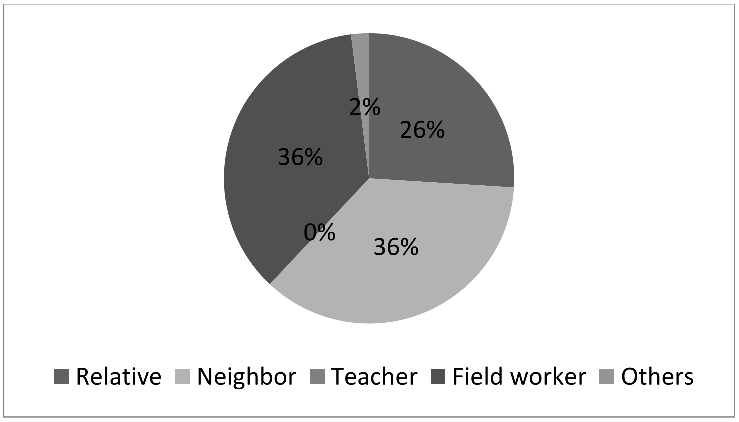

Fig 4.1: How the respondents learned about solar system.

Figure 4.1 shows that 36% of households have come to know from their neighbors, 26% from relatives, 36% from field-workers and the rest 2% from other sources. They have influenced the respondents to purchase this system and have helped them to acquire knowledge about the system. Therefore, the role of oral communication in spreading the information about SHS emphasized its significance in the process of diffusion.

4.2.2 Purchasing solar home system: The study shows that the users buy the solar system either in cash or in installments.

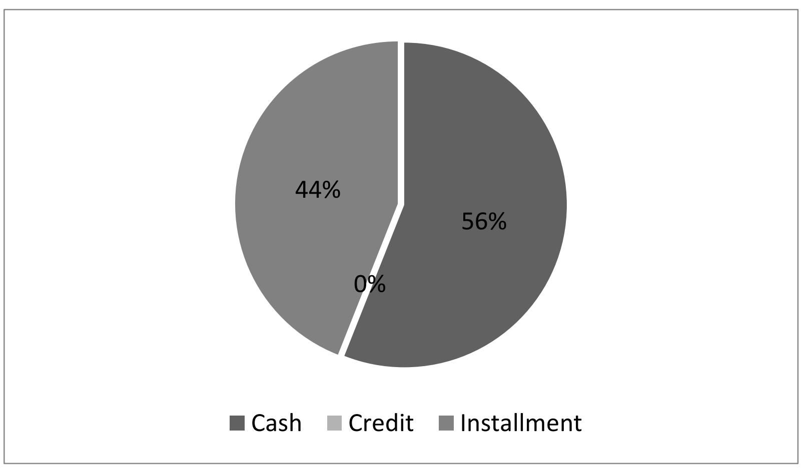

Fig 4.2: How the respondents purchase solar system.

Of the respondents, 56% have bought this solar system in cash and the remaining 44% have bought this system in installments. Since they can purchase it by installments, it becomes easier for them to afford this.

4.2.3 Size of solar home system and percentage of users: Different size of the solar system exists in the market. Normally most of the households uses 20Wto 85W solar system in rural areas. Energy requirements for various sizes also vary. The following figure shows the different size of the solar system and response of the respondents of Debidwar and Muradnagar upazila.

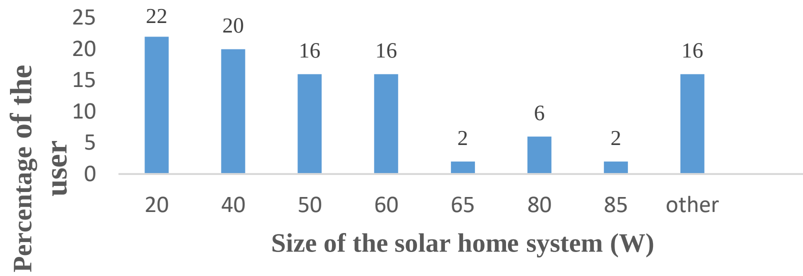

Fig 4.3: Size of solar home system with percentage of user.

Here 22% of the respondent use 20W solar systems, 20% use 40W, 16 % use 50W, 16% use 60W, 2% use 65W, 6% use 80W, 2% use 85W, and the rest 16% use other sizes of different categories.

4.2.4 Reasons for buying SHS: This is another step of diffusion process that takes place and reflects on why the owners decide to purchase a SHS. Because they can use it for various purposes such as they can use it for lighting purpose. When load shedding occurs in rural areas, the study of children is hampered but using solar system they can overcome this problem. To charge mobile phones it can also be used. Some people use kerosene in their houses as alternative to electricity that is costly; to save kerosene they also use the solar system, which is environment friendly. And some people use this system to perform all of these tasks.

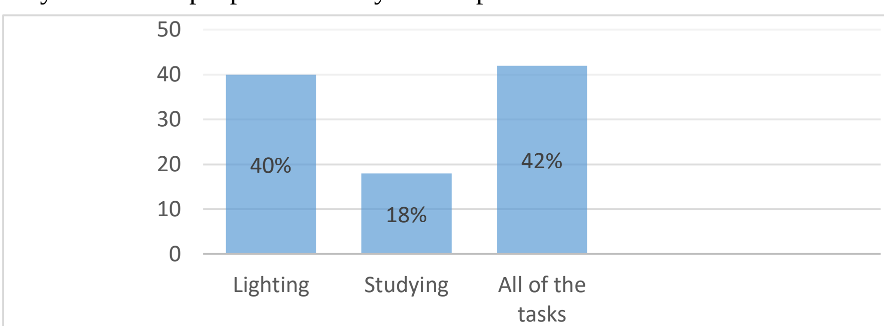

Fig 4.4: Purpose of Buying SHS.

The survey shows that several respondents use solar system for several purposes. Such as 40% of respondent use this alternative energy for lighting purpose, 18% use for children's study and 42% use for lighting, studying, mobile charging, and saving kerosene or all of these tasks.

4.2.5 Influencing others to buy SHS: The last step in the diffusion process happens while a system owner persuades another household to procure a solar home system (SHS).

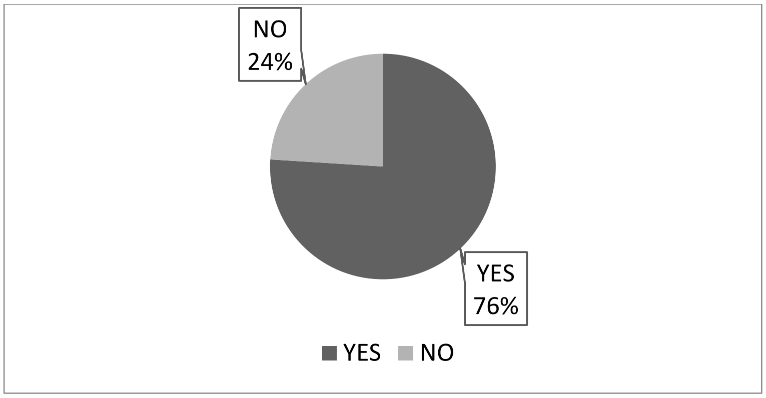

Fig 4.5: Owners influencing others to buy SHS

When the survey was carried out, respondents were asked how much they influenced other households to buy this system. 76% of the owners confirmed that they influenced others to purchase a system but remaining 24 % did not do this. These findings supported that positive oral communication is triggering the diffusion process of solar home system in Cumilla region.

4.3 Monetary gains in using alternative energy system:

4.3.1 Energy used before solar installation: Electricity, the foremost suitable form of energy, is a vital element to promote the socio-economic situation of people and to lessen poverty. Load shedding is a regular phenomenon in the country, for which people seek alternative energy sources to meet their demand. And the study shows that people were used to different kinds of energy such as kerosene, candle, and other types to meet their demand before using the solar system.

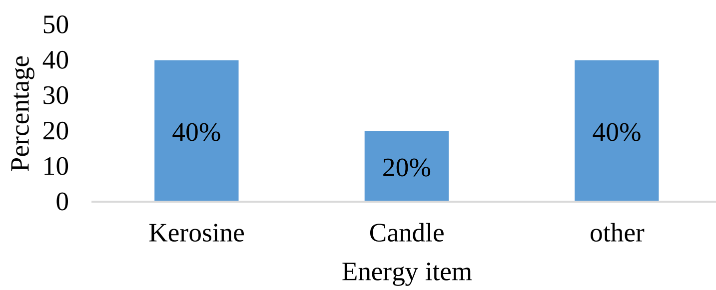

Fig 4.6: Which energy the respondents used before installing SHS

Here, 40%of the respondents used kerosene,20% used candle and the rest 40% used other kinds of energy as alternative to meet the scarcity of electricity and to fulfill their demand that were costlier than the solar system.

From the analysis it is found that the respondents' mean savings is 238 Taka for using the solar system. Their minimum savings is 100 Taka and maximum savings is 500 Taka for using solar as an alternative to their previous energy source. It seems that using solar home system is beneficial to households since they can use it for various purposes and this also gives them monetary savings.

4.4 Benefit-cost Model:

The benefits and costs in this investigation are stated in monetary terms so as to evaluate the overall cost, which incorporates installation cost, operational cost, future maintenance cost and benefits in terms of outcome of solar energy. These cost variations occur at different size and can be stated in terms of the net present value.

4.4.1Cost of a solar system: In this model, we need to vitally scrutinize the cost components for quantification and analysis. The model will allow end-users to formulate an assessment depend on system parameters and its equivalent cost of energy savings. For correctness and exactness of this cost benefit model, we have used latest data for example current energy prices for residential systems, solar system costs from different agencies and costs of power components. The cost of setting up a solar system is initially depending on the system size. The system size determines the number of solar modules based on the available roof space for installation. Table-A1 in the appendix gives the total installation cost of solar system with different size.

The power capacity for solar system also varies with their system size. Lifetime of solar panel was measured 20 years according to panel manufacturers and SHS installers in Bangladesh.

4.4.2 Benefit of a solar system: The larger the system size, the lesser will be the dependency on our conventional electricity. It also gives more output on an annual basis. The consumer receives energy power once solar installation is complete. These benefits also depend on the country's energy utility prices. The average peak hours and utility prices also offer a platform to calculate benefit. The average peak hour per day is a variable factor that increases or decreases the solar system production and affects the capital inflow. The benefit inflows are an outcome of solar energy produced and utility energy prices on an annual basis. The other factor measured in analysis is the annual solar supply which is calculated on the ground of system size and utility energy prices. After recouping the benefits of the system, each consumer benefits from the cash inflows at an expected rate of 6% every year.

4.4.3 Financial analysis: The financial analysis is carried out to mathematically integrate the assumptions made by the system parameters and prediction on the cost-benefit model so as to validate the outcomes of the decision made. This analysis has affected the cost and benefit components that predict the feasibility to pursue solar power system. Therefore, economic parameter such as net present value, payback periods and benefit-cost ratio determine the feasibility of this model.

Net present value (NPV): The conception of net present value suffices the interrelation between the cash inflows and outflows of a system. The core intention of this economic feature is to measure the profit margin and durability of this solar system. The net present value of any scheme is rooted in four vital apparatus such as cost, benefit, discount rate and lifetime. The discount rate is the rate of return which a customer expects out monthly or annually. The expected rate of return can be tailored on the situation of market which changes swiftly due to inflation and changes in utility energy prices.

Payback period: The payback period is the span of time required to recover the cost of an investment. The payback period of a given investment is an imperative factor of whether to take this project, as longer payback periods are usually not attractive for investment options. The payback period overlooks the time value of money.

Benefit cost ratio (BCR): Benefit-cost ratio is used to take a decision to undertake a new investment. If the BCR is greater than one, then the investment is profitable. This will have a higher internal rate of return than discount rate. The following table shows the NPV, payback periods and BCR of this study:

System size (W)	Benefit inflow/year (BDT	Cost outflow/year (BDT)	Discount factor (6%)	NPV	Capital cost	Payback period	BCR
12	429	400	0.94	27.26	1.07	18.64	1.07
20	638	571	0.94	62.98	1.11	17.9	1.11
24	955	950	0.94	4.70	1.005	19.8	1.005
40	1241	1116	0.94	117.50	1.11	17.9	1.11
45	1448	1300	0.94	139.12	1.12	17.9	1.12
50	1483	1329	0.94	144.76	1.11	17.9	1.11
60	1878	1650	0.94	214.32	1.13	17.5	1.13
65	2325	1800	0.94	493.50	1.29	15.4	1.29
80	2671	2116	0.94	521.70	1.26	15.8	1.26
84	2403	2150	0.94	237.82	1.12	17.8	1.12
85	2736	2250	0.94	456.84	1.21	16.4	1.21
100	2861	2300	0.94	527.34	1.24	16.07	1.24

Table 4.1: Value of NPV, Payback period and BCR at different system size

The benefit cash inflows are consequence of solar power produced and its subsequent system size. The larger the system size, the higher the benefit cash inflows in BDT yearly. In our study, it is seen that computed net present value increases as the system size increases. It is also shown that all system gives as positive NPVs. This is indicative of carrying benefits to the solar user.

The payback period is the time span (years) taken by the solar system to recover its cost generated by the system, together with related risk for using solar system. In this study, our solar lifetime was 20 years. And given result show that each system size has less than 20 years of payback period. For example, if we consider a system size of 12W the payback period is 18.64 years. Inverse relation between capital cost and capital inflow per years is found. Table 4.1 shows that different solar sizes have different payback periods and that all users can recover their costs in less than 20 years. The higher the system size, the lower the payback period, which means higher capacity of solar system gives higher return and the consumer can recover it very early than the small-sized solar home system.

The benefit cost analysis shows the relationship between the cost and benefit cash inflow over a period of time. If the benefit-cost ratio is greater than one, then the investment is profitable. Table 4.1 shows that all BCRs are greater than one with any solar size. For a higher solar size BCR is also higher and its investment for buying the solar home system brings benefit to their customers.

From the findings of Benefit-Cost Analysis, it is concluded that solar home system is effective for rural households of Cumilla region. The statistical analysis used in the model to quantify the costs and benefits were dependent on the system size. The benefit of solar home system depends on the location and the average peak hour of getting power. In this study, as is evident from the results, all solar sizes give positive NPV, the payback period is lower from 20 Years and the BCR is also higher than 1, the cost of the solar system can be recovered. It obviously brings benefits to all households.

5. Conclusion

The off-grid solar home system has grown significantly since the first system was installed in 1996. The growth of solar system in Cumilla region is high especially in Muradnagar and Debidwarupazila. This growth was driven by the positive oral communication, existence of microfinance institutions, and the belief held by the people that solar energy is superior to alternative energy types, especially kerosene. This paper concludes that these factors are necessary for the diffusion process of solar home system for society as a whole. The data demonstrates that oral communication was the key driver in knowledge dissemination about solar home system. The surveyed owners learned at first about SHS from neighbors, relatives, field workers or from other sources. And 76% of the owners affirmed that they had influenced others to procure a SHS.

In the study area, all of the respondents use kerosene, candle or other kinds of energy as an alternative during load shedding or as an alternative energy source before installing the solar home system. They had to pay on an average 238 Taka per month for that purpose. At present they can save this money.

From the cost and benefit analysis we have seen that different sizes of solar system are being used in different households and their costs also vary. In the study area, the solar system size is found to vary from 12W to 100W. Payback periods vary from 15.4 to 19.8 years, their NPV also vary from 5 to 527 taka. The BCRs are also higher than one and vary from 1.005 to 1.29. The values of these parameters vary due to the variation in financial benefits and costs of different size of SHS. High positive NPV and higher BCR indicate the economic attractiveness of using solar PV. Directly and indirectly, solar PV offers enormous positive effects on daily life of rural people. It increases the study hour of children, increase the standard of living, increase the security at night, reduce the carbon emission and is environmentally friendly. It is found that using solar home system is cost effective for the rural area of Cumilla region. The solar home system is, therefore, the more reliable technology for rural areas of Cumilla region. In order to make it more affordable and attractive, adequate training and excellent installment scheme would need to be provided to the rural communities.

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Appendix – A:

Table - A1: Total cost of solar system for different size

System size (W)	Total installation cost (in BDT)
12	8000
20	11417
24	19000
40	22333
45	26000
50	26578
60	33012
65	36000
80	42333
84	43000
85	45000
100	46000