International Journal of Innovation and Applied Studies
ISSN 2028-9324 Vol. 7 No. 1 July 2014, pp. 273-282

http://www.ijias.issr-journals.org/

Prospects of Solar home system in Bangladesh and a case study for tariff calculation

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ABSTRACT: The increasing demand of electric power and shortage of present energy resources lead today engineers and scientists to think about the alternative sources of energy, the sunlight is a potential sources for generating electric power. In recent years, it is increasingly used to generated power .The use of solar energy is attractive for solar home system application also. Solar home systems are quite needing no fuel and require very little maintenance. Other advantage of a PV system are free energy, reliable power, flexibility and quick installation. Author discussed Solar Photo-voltaic based Renewable energy system in Bangladesh**.** Finally, author try to analyze solar home system per unit cost. The government institute is "Infrastructure development companylimited"(IDCOL) established from 2003 to 2013 solar home system 20lakh and produce100 MW electricity. We know that 70% people lived in rural area. So, this project is not sufficient for development in rural area. Sun is the source of all energy available in the world. The initial cost of the solar energy would be much higher but the experts believe that it would be a cost effective alternative to other source of energy. So, we can take initiative to increase solar energy in our house hold system and able to find an alternate way of renewable energy.

KEYWORDS: Tariff, Solar home system, Rural electrification, IDCOL, Bangladesh.

1 INTRODUCTION

Bangladesh is one of the densely populated countries which have not sufficient supply of energy. In Bangladesh, almost 80% of the people live in the village and only 32% of total population is connected to grid electricity (Rahman, 2006).In light of the present demand for electricity; by 2020 the energy mix will be changed considerably from what it is today. The possibilities of using solar power are already being tested and will mostly increase. But still, most households meet their daily needs with biomass fuel. With only 60% of Bangladeshis having access to electricity, the per capita energy consumption is only 292 kWh per annum. Even people who are connected with the national grid are experiencing frequent load shedding .So electricity source with ownership getting popular day by day without dependency on the national grid supply. As average solar radiation varies here from 4 kWh/m2 day in winter to 6.5 kWh/m2 day in summer, Solar Home System (SHS) has become one of the most popular sources of electricity in rural areas of Bangladesh. And now in some places Solar PV panels have installed commercially. There is no resource constraint for application of SHS as solar energy is abundant throughout the country. Decentralized and standalone systems could effectively become a viable option in rural areas .In the perspective of Bangladesh several NGOs like IDCOL (Infrastructure Development Company Limited), GS (Grameen Shakti), Rahim Afrooz, BRAC (Bangladesh Rural Advancement Committee), CCDR(Center for Community Development & Research)foundations are working to develop our electricity sector with renewable energy sources. The government also has set a target of generating

500 megawatts (MW) of green energy almost ten times the current amount by 2015, in an attempt to narrow the gap between current supplies of grid electricity and the needs of the people .Fossil fuels account for almost all the current capacity of 5,500 MW, with renewable sources mostly solar power contributing just 55 MW.

2 PHYSICAL PERSPECTIVE OF RENEWABLE ENERGY IN BANGLADESH

Today our electricity installed capacity is 10312 MW. Where public sector contribution is 5962 (58%) and private is 4291 (42%) Currently only 62 percent of total population in Bangladesh has access to electricity and per capita generation being 321 kWh which is very low compared to other developing countries. our power generation is dominated by indigenous natural gas which are 90 % during FY2010.share to natural gas for power generation is 80.37% during FY2012 which is declined by 9.63%.it is estimated that share of natural gas for power generation will be reduced by 52% and 20% during 2016 and 2030 respectively. Depletion of gas reserve has forced to shift primary fuel option from natural gas to coal and liquid fuel. Bangladesh trying to reduce its more dependence on natural gas by diversifying sources of primary fuel. At present the average cost of power generation is TK 6.3 /KWh while the cost of diesel based generation is 15.80/kwh. Yet cost of renewable is expensive compare to conventional energy but the difference is decreasing day by day.

Government has vision to provide electricity to all citizen by 2021 at reasonable and affordable prices. But it is fact that grid power will not available in some remote and isolated area for the next 20 years. That area, we must depend on solar energy. Renewable Energy Policy of Bangladesh sets targets for developing renewable energy resources to meet 5 percent of the total power demand by 2015 and 10 percent by 2020 [9]. Bangladesh already has achieved some remarkable successes in the implementation of renewable energy technologies (RET).

Bangladesh is situated between20.30-20.38 degrees north latitude and 88.04-92.44 degrees east which is an ideal area for solar energy. Utilization of solar energy potential is very important for the impact analysis of SHS in our country. Daily average solar radiation varies between 4-6.5 KWh per square meter [10]. We can get maximum amount of radiation on March-April and minimum from December – January. The average bright sunshine duration in Bangladesh in the dry season is about 7.6 hours a day, and that in the monsoon season is about 4.7 hours. The highest sunlight hours received is in Khulna with readings ranging from 2.86 to 9.04hours and in Barisal with readings ranging from 2.65 to 8.75 hours. These are very good statistics when compared to the 8 hours of daylight in Spain which produced 4 GW of energy covering 2.7% of national demand by the end of 2010. Moreover Germany produces 18 GW of energy which is 2% of their national demand with only half the solar Bangladesh. According to recent studies, yearly average insolation availability in Dhaka is 1.73MWh per squaremeter on a horizontal surface and 1.86MWh per square meter on a tilted surface. Again the annual amount of radiation is varies from1840-1575 KWh/m2 .which is 50-100% more than the Europe. Taking an average solar radiation of 1900 KWh per square meter, total annual solar radiation in Bangladesh is equivalent to 1010*1018 J. Present total yearly consumption of energy is about 700* 1018 J. It shows that even if 0.07% of the incident radiation can be utilized, total requirement of our energy can be met [11]. At present energy utilization in Bangladesh is about 0.15 Watt/sq. meter land area, whereas the availability is above 208 Watt/sq. This shows the enormity of the potentiality of SHS in Bangladesh by using this huge solar energy. What fraction of it can be used for our use will depend on the availability of the technologies suited to local conditions.

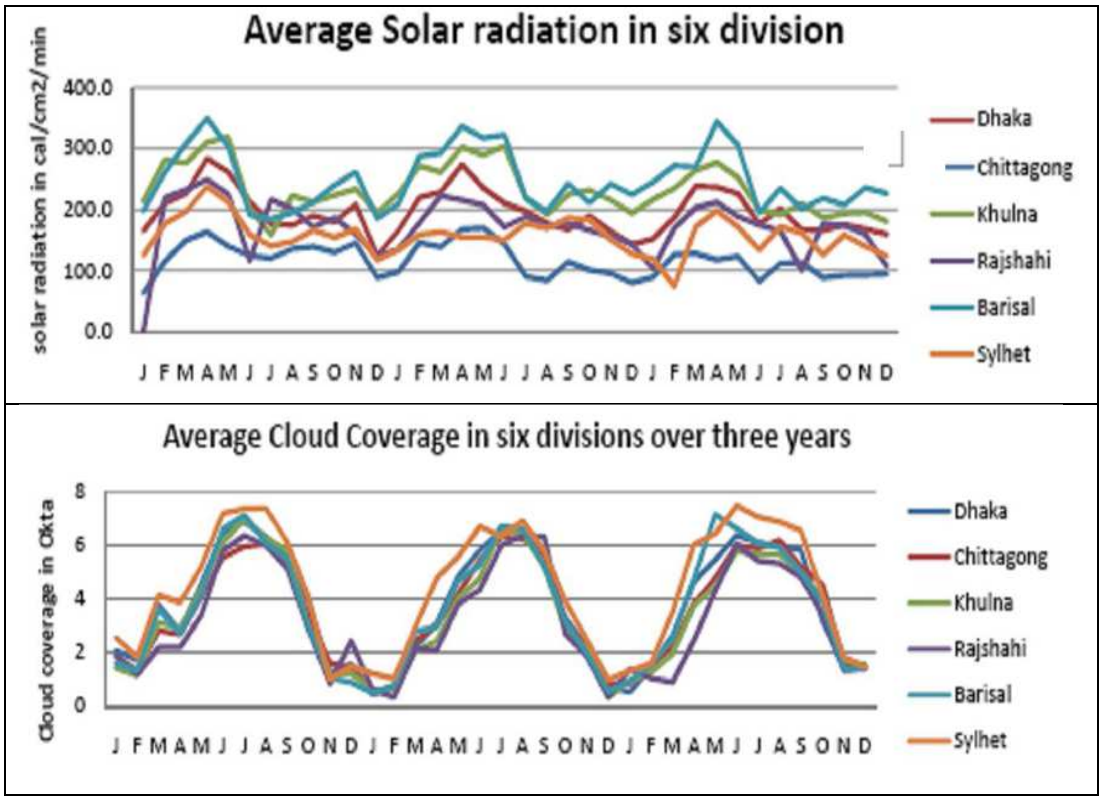


Fig:1.1: Average solar radiation in six divisions and average cloud coverage in six divisions.

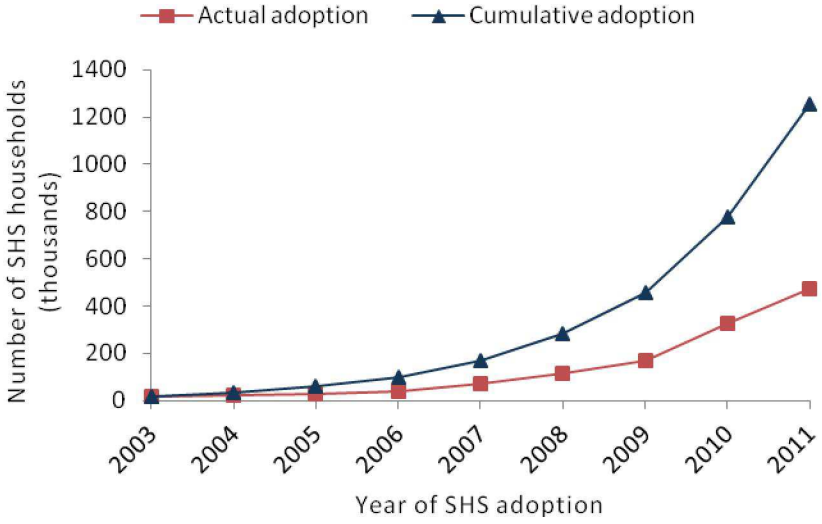
3 PRESENT STATUS OF SOLAR ENERGY IN BANGLADESH

Bangladesh is an agricultural country in South Asia with 163 million people, where sustainable development, energy crisis and food security is of great concern. Nearly 75% of the population lives in rural areas and only about 30% of the rural households have access to grid electricity. Alternative solution is to introduce solar home systems for the rural households in off-grid areas and to introduce solar grid.

Hybrid system for the rural grid areas. Financial initiatives as a result of policy push have major role to play in developing the market in Bangladesh. The basic applied forms of solar PV in rural Bangladesh are solar home system (SHS) and micro utility (electrification of rural markets). Feedback from the users of these system syndicates that solar energy-based electricity has been providing very satisfactory service to consumers. IDCOL, a government-owned agency equipped to develop private sector deploying private public partnership model, was selected as the implementation and monitoring agency of the solar energy program. Worthwhile to mention, IDCOL solar energy program is on of the fastest growing renewable energy programs in the world. It has brought in positive changes in the livelihood of people in remote rural areas of Bangladesh by providing access to electricity. The Chairman of the Senate Foreign Relation Committee of the United States, John Kerry in his speech at the World Bank Head office on 19 November 2009 mentioned IDCOL SHS project as a good example of literally life-altering project of the World Bank. IDCOL promotes dissemination of solar home system (SHS) in the remote rural areas of Bangladesh through its Solar Energy Program with the financial support from the World Bank, Global Environment Facility (GEF), KFW (German Development Bank), GIZ (German Technical Corporation),

Asian Development Bank, USAID and Islamic Development Bank. IDCOL started the program in January 2003 and its initial target was to finance 50,000 SHSs by the end of June 2008. The target was achieved in September 2005, 3 years ahead of schedule and US$ 2.0 million below estimated project cost. IDCOL then revised its target to install 1 million systems by 2012. This was also achieved ahead of schedule by june 2011. IDCOL celebrated installation of 2 million Solar Home Systems under its Renewable Energy Programs on 12 May 2013. Now IDCOL target to finance 4 millions SHSs by the and of year 2015.Up to November 2013, a total of 2,677,896 SHSs have already been installed under the program. IDCOL is implementing this programme with financial assistance from the World Bank, ADB, IDB, GEF, GIZ, CIDA,JICA and KFW. IDCOL implements through 47 partner organizations (POs) and solar PV growth market improves quality of life through access to electricity, which provides access to electricity to 200,000 people per month while adding 2.0 MW to national power generation by

installing 50,000 systems, creates additional income, generates activities in the rural areas, promotes local entrepreneurs, creates jobs in rural areas for both skilled and unskilled people, promotes domestic industries, and reduces carbon.



4 SOLAR ENERGY SOURCE OF BANGLADESH

First solar PV was disseminated by Rural Electrification Board (REB) in 1993 then Local Government Engineering Department (LGED), and then Infrastructure Development Company Limited (IDCOL) started their solar energy program (Islam & Marufa 2012). Currently, a numerous Government Organizations (GOs) and Non-Government Organizations (NGOs) are disseminating SHSs throughout the country under various renewable energy program financed by IDA, GTZ, KFW, GEF, ADB and IDB. IDCOL is the pioneer organization supporting its 47 Partner Organization (PO) to disseminate SHSs So far, up to November 2013, a total of 2,677,896 SHSs have already been installed under the program. A snapshot of SHSs dissemination by various GOs and NGOs in Bangladesh is shown in Table 1.

Table 1: Dissemination of SHSs by different organizations in Bangladesh

Organization	Number of SHSs Installed	Capacity
IDCOL's PO		
GS	1020,014 SHSs all over the country	10-130Wp each
RSF	389,583 SHSs all over the country	
BRAC	77,019 SHSs all over the country	40Wp (20%), 50Wp (60%) and 75Wp (20%)
Srizony Bangladesh	58,927 SHSs	
HFSKS	37,078 SHSs	
UBOMUS	25,234 SHSs	
BRIDGE	20,449 SHSs	
IDF	14,238 SHSs	
TMSS	13,059 SHSs	30–75Wp each
PDBF	10,672 SHSs	
SEF	21,720 SHSs	
AVA	12,817 SHSs	
DESHA	10,931 SHSs	
BGEF	50,000 SHSs	
RDF	20,027 SHSs	
COAST Trust	6,181 SHSs especially in coastal areas	
INGENI Ltd.	9,871 SHSs	
NUSRA	9,372 SHSs	
RIMSO Foundation	8,196 SHSs	
GHEL	6,138 SHSs	
SFDW	9,485 SHSs	
Other	29661 SHSs	
LGED	SHSs, centralized units, and water pump in different remote and coastal off-grid areas all over the country	53.84 kW
BPDB	1212 SHSs at off-grid Hill areas, 6 solar vaccination refrigerators, 3 solar water pump, 30 solar street light, 4 centralized solar PV power plant at Juraichari upazilla	374.26 kW
REB	23,412 SHSs Plants and Solar Power	1,937.855 kW
BCSIR	82 SHSs, 1 pump, 2 solar data logging units	1.5 kW
Total	About 2 million SHSs/SHLSs with solar water pump, solar central unit of total capacity 94 MW	

4.1 COST ANALYSIS OF SHS

Normally 40~85 Wp systems are mostly used in the rural areas. The cost of a 40 Wp system was 23,600 BDT, whereas for a 85 Wp system, the cost was 44,800 BDT. Table 4 represents the cost of SHSs with detail equipments provided by the POs. Battery, PV panel and charge controller are the three main components of the PV system. POs also provide structure for panel and battery, lamps and ballast, switch, switch board and necessary wires during the installation period. But, the owner or user had to buy other equipments if they need, such as, adapter, DC-DC converter for radio, cassette and mobile charger, etc. The breakdown of total cost of a 50 Wp system is shown in table 5. The Battery and solar panel were found to be the main reasons of the high cost of the PV system. Solar panel contributed to 28%, whereas battery cost was around 30% of the total cost though most of the batteries were produced in Bangladesh. Three years after sale service and installation cost 13.50%, overhead cost 10%, cable, switches and others 7.50% and lamp shade 5% were the significant others costs.Except these, tube lights and steel structure for panel contributed 2% and 1% of total cost respectively. This break down of cost was

also similar for 40 and 60 Wp system as price variation was not much. On the other hand, percentage of battery and panel cost was little bit higher for 80 and 85 Wp system. It was found that for 80 and 85 Wp battery and panel cost were 33% and 30% of the total cost respectively

Table 2: Current Cost of SHSs system

System Wp	Total cost (BDT)	Equipments
40	23600	One 40 Wp Solar Module , one 55/60 Ah Industrial Battery, 1No. 10 Amps Charge Controller, 1 No. Structure, 3 Nos. 7 Watt Lamp, Switch, Switch Board, Installation & Other Accessories.
50	28500	1 No. 50 Wp Solar Module, 1 No. 80 Ah Industrial Battery (Tabular Plate), 5 or 10 Amps Charge Controller, 1 No. Structure, 4 Nos. 7 Watt Lamp, Switch, Switch Board, Installation & Other Accessories
60	34400	1 No. 60 Wp Solar Module, 1 No. 80 Ah Industrial Battery (Tabular Plate), 1No. 10 Amps Charge Controller, 1 No. Structure, 5 Nos. 7 Watt Lamp, Switch, Switch Board, Installation & Other Accessories
65	36000	1 No. 65 Wp Solar Module, 1 No. 100 Ah Industrial Battery (Tabular Plate), 1 No. 10 Amps Charge Controller, 1 No. Structure, 5 Nos. 7 Watt Lamp, Switch, Switch Board, Installation & Other Accessories.
80	42200	1 No. 80 Wp Solar Module, 1 No. 100 Ah Industrial Battery (Tabular Plate), 1 No. 10 Amps Charge Controller, 1 No. Structure, 7 Nos. 7 Watt Lamp, Switch, Switch Board, Installation & Other Accessories
85	44800	1 No. 85 Wp Solar Module, 1 No. 130 Ah Industrial Battery (Tabular Plate), 1 No. 10 Amps Charge Controller, 1 No. Structure, 8 Nos. 7 Watt Lamp, Switch, Switch Board, Installation & Other Accessories.

CASE STUDY

Consumer name : Abdur Sattar .

Address :Raniganjo,kapasia, Gazipur.

Installed by : grameen Shakti.

Installment date : 21.08.10

Price : 24702 tk (actual price is 21400tk. But they gave 15% (3210tk) down payment first then rest 85% paid in 6% flat rate include service charge(597tk) through 36 installment. so total price is 24702 tk.

SOLAR HOME SYSTEM(40W)

Solar panel : 40Wp (warranty 20 years)

Battery : 55 Ah (warranty 5 years)

Charge controller: 10A (warranty 3 years)

Tube light : 3piece ,10W

Fan :12V DC, 10W

TV : 12” black and white, 20W

Mobile charge :1 piece ,15W.

ENERGY CONSUMPTION IN A DAY

Date : 31.03. 14

Weather situation: fully sunny day

Consumption	Morning	Afternoon	Evening	Night	Total Wh
Fan, 10W	11-12			10-012	30Wh
Tube light reading room,10W			6.30-7.00	7.00-8.30	20 Wh
Tube light bed room,10W				8.30-9.00 10-10.30	10Wh
Tube light bath room,10W	At least 30 minutes				5Wh
TV,20W				9.00-10.0	20 Wh
Mobile charger,15W	At least 30 minutes				7.5Wh

Total Wh=92.5Wh

Date : 01.04. 14

Weather situation: fully sunny day

Consumption	Morning	Afternoon	Evening	Night	Total Wh
Fan, 10W	11-12			10-01	40Wh
Tube light reading room,10W				7.00-9.00	20Wh
Tube light bed room,10W				8.30-9.00 10-11.00	15Wh
Tube light bath room,10W	At least 30 minutes				5Wh
TV				9.00-10.00	20Wh
Mobile charger.15W	At least 30 minutes				7.5Wh

Total Wh=107.5Wh

So average is =92.2+107.5=200/2=100Wh.

Here we use this generation constant for all over year. So yearly generation is =100Wh ×365= 36500Wh =36.5 KWh.

And life time generation = 36.5×20 = 730 KWh

4.2 CALCULATION FOR SOLAR HOME SYSTEM: PRESENT FORMULA

This consumer take 40W solar home system with this condition that he pay 15% of the total price as down payment. The remaining 85% of the total cost is to be repaid within 36 months with 6% (flat rate) service charges.

Total price of the 40Wp SHS is = 21400. tk

Down payment 15% = 3210 tk

Due = 18190 tk

So principal installment per month = 18190/36 = 505.27 tk

Interest installment per month = (18190 × 6%)/12 = 90.95 tk

Total installment per month = 505.27+90.95 =596.27 tk .

TARIFF CALCULATION

Total price of SHS is 24702 tk.

Solar module is warranty for 20 years. So we do not need to change it.

Battery warranty is 5 years. In the first installation battery cost is included. So they need change battery for 3 times. The cost of changing the battery in 20 years is =3*6000= 18000 taka (6000 for each battery)

Now, charge regulator is warranty for 3 years. In first installation Charge regulator cost is included. Approximately 6 charge regulator need for 20 years. So the cost of changing the charge regulator in 20 years is:6*600=3600tk. (600 for each battery)

Battery need at least two time distilled water and charge in a year .this operation and maintenance cost approximately 100 tk per year. So for live time O&M cost is =100 × 20=2000tk

So total cost need to use SHS(40Wp) for 20 years is=24702+18000+3600 + 2000 =48302tk.

So per Unit cost for SHS(40Wp) is= 48302/730KWh= 66.17 tk per KWh

PVIFA FORMULA

PVIFA means Present Value Interest Factor Of Annuity. Its a most popular formula to calculate monthly payment needed to repay a loan. PVIFA is used in finance theory to refer to the output of a calculation, used to determine the monthly payment needed to repay a loan. The calculation has a number of variable factors, which include the quantity borrowed **P**, the given interest rate **r**, the number of regular intervals **n** at which the loan is to be repaid and the term of the loan.

85W SOLAR HOME SYSTEM

Principal = 40800 tk Down payment = 6120 tk Due = 34680 tk Interest = 6% Nominal interest **r** = .5% Installment = 36 We know

$$\text{Principal} = A \times \text{PVIFA}$$

$$\Rightarrow 34680 = A \times \left[= \frac{\{1-\frac{1}{(1+r)^n}\}}{r}\right]$$

$$\Rightarrow 1{,}455{,}348{,}300 = A \times \left[\frac{\{1-\frac{1}{(1+0.005)^{36}}\}}{0.005}\right]$$

A = 1055.03 tk

TARIFF CALCULATION

Unit Generation	1 st year	2 nd year	3 th year	4th year	5th year	6th year	7th year	8th year	9th year	10th year
Inslaiied capacity(KW)	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Total generation(KWh)	36.5	36.5	36.5	36.5	36.5	36.5	36.5	36.5	36.5	36.5

Unit Generation	11 th year	12 th year	13 th year	14th year	15th year	16th year	17th year	18th year	19th year	20th year
Inslaiied capacity(KW)	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Total generation(KWh)	36.5	36.5	36.5	36.5	36.5	36.5	36.5	36.5	36.5	36.5

Fixed cost	1 st year	2 nd year	3 th year	4th year	5th year	6th year	7th year	8th year	9th year	10th year

O & M (TK)	100	100	100	100	100	100	100	100	100	100
Replacement	1080	1080	1080	1080	1080	1080	1080	1080	1080	1080
Installment	9274	6064	6064	0	0	0	0	0	0	0
interest on term lone	963.227	584.4	210.87	0	0	0	0	0	0	0
Total fixed cost	11417.2	7828.4	7454.87	1180	1180	1180	1180	1180	1180	1180
Tariff per year	312.801	214.477	204.243	32.329	32.329	32.3288	32.329	32.329	32.329	32.32877

Fixed cost	1 st year	2 nd year	3 th year	4th year	5th year	6th year	7th year	8th year	9th year	10th year
O & M (TK)	100	100	100	100	100	100	100	100	100	100
Replacement	1080	1080	1080	1080	1080	1080	1080	1080	1080	1080
Installment	0	0	0	0	0	0	0	0	0	0
interest on term lone	0	0	0	0	0	0	0	0	0	0
Total fixed cost	1180	1180	1180	1180	1180	1180	1180	1180	1180	1180
Tariff per year	32.329	32.329	32.329	32.329	32.329	32.3288	32.329	32.329	32.329	32.32877
Tariff	64.0555									

COMPARISON OF TWO METHOD

Monthly installment in Present formula is 1137 tk.

But PMT formula monthly installment is 1055.03 tk .

So different is (1137 – 1055.03) = 81.97 tk per installment. and finally different is =81.97 × 36 =2950.92 tk.

Tariff in present formula = 85.98 tk per KWh

Tariff in PVIFA formula = 81.92 tk per KWh So different is (85.98- 81.92) = 4.06 tk per KWh

5 CONCLUSION

The summary of this paper exhibits that, there is a considerable opportunity of Bangladesh to meet its future power demand and thus economic growth through renewable resources. Solar energy sources discussed above can help Bangladesh to produce more power in order to reduce Load-shedding problem. Time has come to look forward and work with these renewable energy fields to produce electricity rather than depending wholly on conventional method. Already SHS (Solar home system) established in our country. This paper showed the tariff difference between present formula and PVIFA formula. Which is 2.12 tk/KWh for 40Wp and 4.06tk/KWh for 85Wp. Here author also try to prove solar PV most cheaply then diesel generator. Authors also include this paper Sandwip solar power plant which is established by a private organization. They sell their electricity to the rural consumer where grid connection will not extend within 30 years. And they give electricity to the consumer cheaply compeer then diesel generator electricity distributor. Solar PV based power plant can be a big solution to fill our lacking on power sector. So government and privet sector should focus this point. It also reduces the solar PV electricity unit cost compare then SHS. Here also consumer can be use conventional ac load. This paper will help solving current power crisis and at the same time will have a positive impact over social and economic status of rural society using green energy technology. If we go ahead as planned, it will be possible for all citizens to have access to power within 2021. In addition, a six year plan up to 2016 has been adopted to improve power scarcity and provide excess power for future. Vision of increasing economic growth to 8 percent by 2014 and 10 percent by 2017 through industrialization will be a reality with the implementation of this plan. Other countries with similar socio-economic status can utilize the same policy to develop their electricity sector. With the help of these resources Bangladesh can generate electricity & May able to meet the required demand in the future. Therefore, the Government and the Private sector should work hand to hand to emphasize more on renewable energy sources to produce electricity to solve our power crisis problem.

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