IOSR Journal of Electrical and Electronics Engineering (IOSR-JEEE)
e-ISSN: 2278-1676,p-ISSN: 2320-3331, Volume 10, Issue 6 Ver. I (Nov – Dec. 2015), PP 127-135
www.iosrjournals.org

Design of a solar power System for an over populated region (Chandpur, Bangladesh)

Marzana Khatun[1]
[1]*(Department of Electrical Engineering, Hochschule Kempten University of Applied Science)*

Abstract: *By this time, solar technology is convenient, proven and well accepted in Bangladesh. It is environment friendly and price of solar panel is decreasing day by day. Energy generation is one of the key factors in driving the socio-economic growth of any country. In Bangladesh, increasing demands for energy has already exceeded the capacity from existing power plants by conventional sources of energy. Rarikandi is a place of cultivation, for this reason population is also higher in this region. Rarikandi has no direct connection with the town because it is surrounded by a river. But Solar energy can bring a new era for the villagers. Energy status will be discussed in this paper with more explanation and with present and future demand. The performance of solar system in bangladesh has also been good, as the average irradiance remains 4.99 KWh/m2/day throughout the year and the seasonal variation of insulation is small. Chattagram is the nearest place in RETScreen software from where climate data is taken.*

Standalone Solar Power Systems are completely independent from any electric utility grid. They are most often used in remote areas where electricity is not available or where the connection fees of the grid are higher than the cost of an alternative energy system. Standalone solar systems (also known as autonomous, or off grid systems) are used to collect and store solar energy to be used by household appliances. The project at last is only accepted if the cost of overall project is suitable for financing. In this paper the cost was estimated by using Net Present Value (NPV) method. The aim of this paper is to investigate the possibility of supplying electric energy from solar power to the village Rarikandi, Chandpur.

Keywords: *Energy demand, solar potential, Load profile, system design, Cost estimation*

I. Introduction

Less than half of Bangladesh's population of 150.6 million has access to grid electricity; in rural areas, where most people live, the percentage is even lower. Even those with access to grid electricity suffer interruptions in supply because of serious power shortages. Today stands at around 40% of the total population and has a large unsatisfied demand for energy, which is growing by 10% annually. Around 76% of the population lives in the rural area have lower coverage of electricity. [1] Solar home systems are bringing the benefits of electrical power to millions in rural Bangladesh, as a testament to the numerous and varied benefits access to cheap, clean and renewable distributed solar PV can have in developing countries. Microfinance provider Grameen Shakti's efforts to market and sell solar home systems (SHS) in rural areas across the country that lack grid access have proved extremely successful. [2] The main idea of this project is to make an independent solar system which can able to provide sufficient amount of electricity in Rarikandi, Chandpur.

Energy generation is one of the key factors in driving the socio-economic growth of any country. In Bangladesh, increasing demands for energy has already exceeded the capacity from existing plants from conventional sources of energy. Thus access to electricity is very limited where Per capita energy consumption is about 237 KOE [3]. In Bangladesh solar photovoltaic (PV) systems are being widely deployed in rural areas and large scale coverage in rural areas with renewable energy sources is being actively considered with mini-grid structure.]. There are still lots of area where there is no supply of electricity [4].

Rarikandi village is located (23°23'37.5"N 90°40'18.3"E/23.393744, 90.67175) in matlab uttar upojila of chandpur thana of chittagang(23.3°N91.8E) district.[5] Rarikandi is a place of cultivation, for this reason population is also higher in this region. Rarikandi has no direct connection with the town because it is surrounding by a river.

People of this village are mostly farmer and they need electricity only for irrigation purpose and for normal living. So, for better life they need electricity. Figure 1.3 Illustrate the process how PV solar panel batteries and inverter can be connected and supply electricity for daily purposes. Amount of cost estimation also done for overviewing the system expenditure which is very helpful for Investigation.

II. Energy Status

In 2012, Bangladesh's primary energy consumption was an estimated 56% natural gas, 24% traditional biomass and waste, 16% oil, 3% coal, and 1% hydropower and solar. So far, in Bangladesh, up to 29 April 2012; Infrastructure Development Company Limited (IDCOL) has installed 1,429,440 Solar Home Systems (SHS) throughout the country [11] which clearly has been proved to be a very successful program in Bangladesh to address the lighting demands. Solar photovoltaic (PV) systems are in use throughout the country with over 2.9 million household-level installations having a capacity of 122.2 MW (April 2014). [12]

Population Growth Rate:

The increment of population can be calculated using exponential population growth formula as:

= * e^{r*t} (1)

Where, P: Population after t years (in this case we choose 20 years' time)

Po: current population (currently village has 700 populations) r: rate of increment (we assume 0.26%)

t: time period in years (we assume 10 years)

Rarikandi is a small area (8km2). In 1991 the total population in matlab uttar (Chengar Char)was 262,504 and in 2001 the population was 299,935 and in 2011 the total population was 292,057. The density is 1,122inh./Km2 and the population change rate 0.26%.[13] So in the year of 2022 the total population would be 300,713. But considering only the village rarikandi, every year new people are coming and started living In 2012 the total population was around 600 In 2025 the total population of in rarikandi would be around 10000. And their demand will also increase and the amount of cultivated land will decrease.

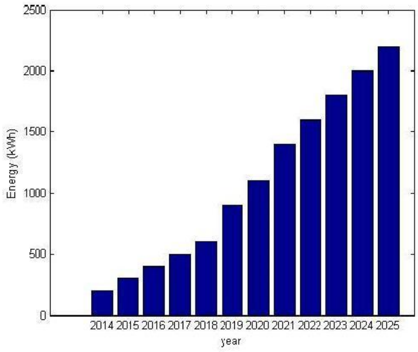

Fig.1: Energy demand curve

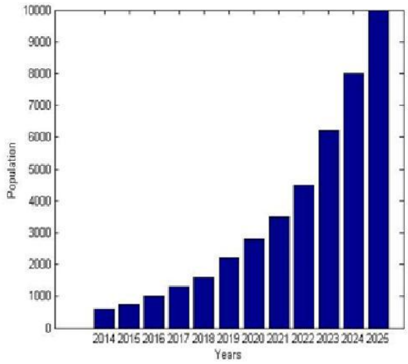

Fig. 2: Population Growth rate of Chandpur Bangladesh

III. Solar Potential

Most of the part of Asia including Bangladesh also lies on subtropical region. Figure 3 and 4 show global horizontal irradiance (GHI) for most of the Asian country which is provided by NREL (National Renewable Energy Laboratory).

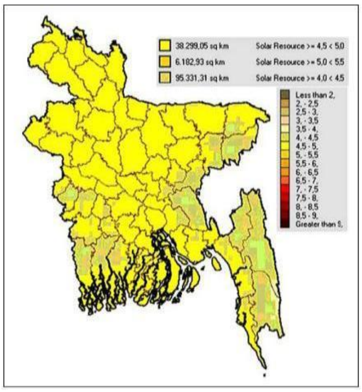

Fig. 3 : Solar isolation potential of different regions of Bangladesh

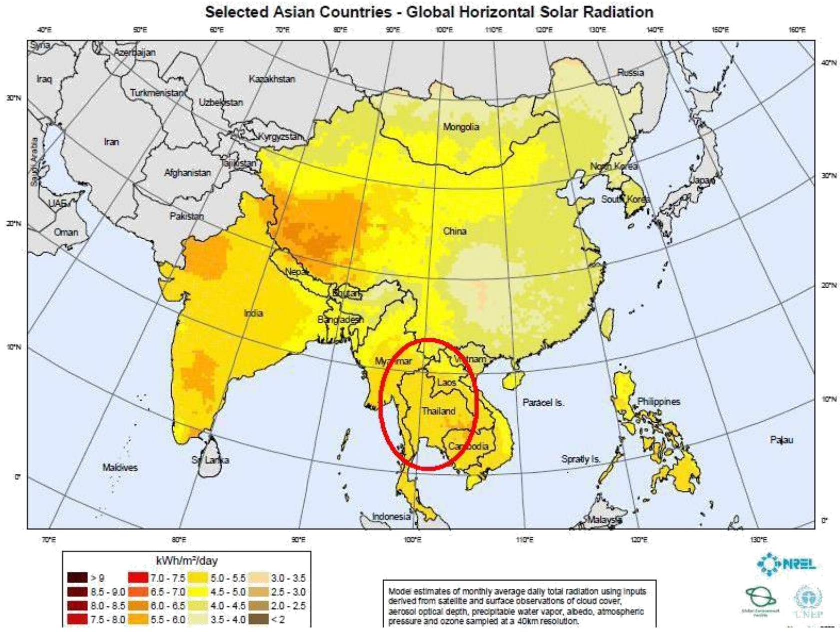

Fig.4 : Global horizontal irradiance (GHI) 40Km resolution for Asia

Average temperature data for chandpur from 1900 to 2009 are taken just for observing the lowest temperature and highest temperature of the area.[14] From figure 3.4 it can be shown that minimum temperature can be found in the month of January.

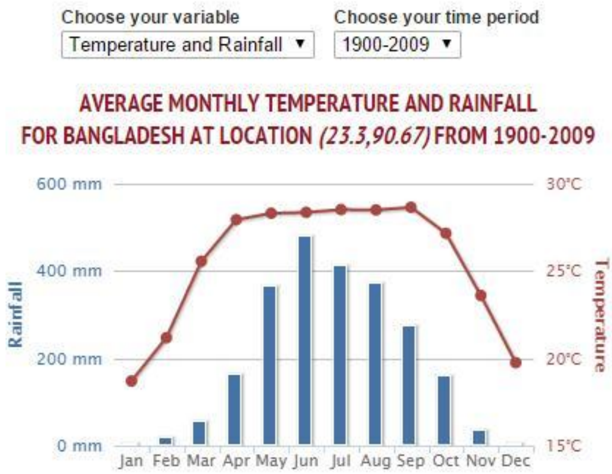

Fig. 5 : Temperature and Rainfall history from 1990 to 2009

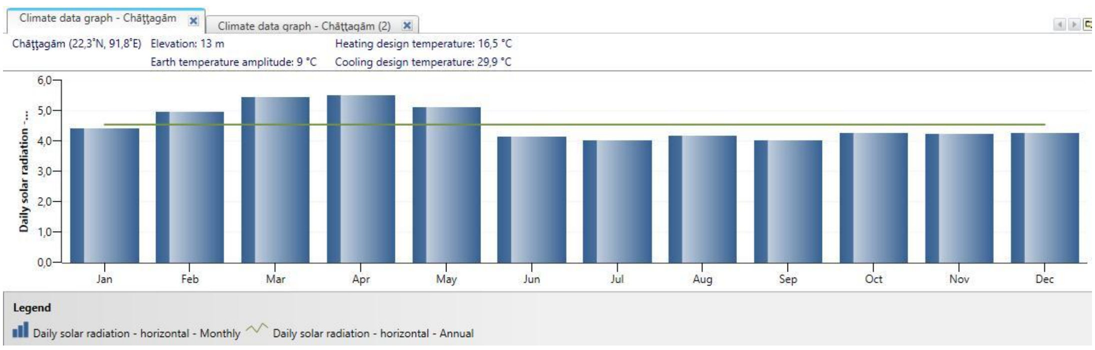

Fig. 6 : Daily solar radiation data from RETScreen

Figure 5 shows the temperature and rainfall history from 1990 to 2009. Minimum temperature can be found in January February and December. So care should be taken for considering the worst condition for designing the system.

Figure 6 represent the daily solar radiation data from RETScreen software and Daily Solar Radiation is the amount of energy emitted by the sun, provides the range of daily radiation throughout the year for chattagram.

Optimum Angles for Solar PV Array Adjust by month [15] so, from the table tilt angle can be adjusted through the year to get the maximum power from solar array. But for fixed tilted system, 67 degree with vertical axis and 23 degree with horizontal axis. For setting up/construct the solar array with a fixed tilt angle is easier than to make the array angle through-out the year. Adjusting of the tilt angle can be achieved by tracking system or by manually-with the help of gear arrangement.

IV. Load Profile

Currrent load profile for the village rarikandi shows in table below. But every year new people are coming and those people who are already living, they also increase their family. Considering the condition it can be seen that the load demand is now around 200Kw and it will be increased day by day.In Load profile calculation different time was taken for power supply For example each house will get 6 hours power supply and school will get 8 hours.

Table 1: Current Load Profile

No.of house	**No.of person/Ho use hold**	**Applicance**	**Number of Applicance**	**AC load (watt)**	**Total AC load(Watt)**	**Consuming electrical load (Watt-hr./day)**	**Total AC Load (Kw)**	**Total Electrcal load (Kw-hr./day)**
120	6	light	2	120	175	600	14,4	72
		fan	1	55		440	6,6	52,8
						TOTAL	**21**	**124,8**
No. Of school		**Applicance**	**Number of Applicance**	**AC load (watt)**	**Total AC load(Watt)**	**Consuming electrical load (Watt-hr./day)**	**Total AC Load (Kw)**	**Total Electrcal load (Kw-hr./day)**
3		fan	15	55	825	4950	2,475	**14,85**
No.of Mosque		**Applicance**	**Number of Applicance**	**AC load (watt)**	**Total AC load(Watt)**	**Consuming electrical load (Watt-hr./day)**	**Total AC Load (Kw)**	**Total Electrcal load (Kw-hr./day)**
2		fan	3	165	405	577,5	0,33	1,155
		light	4	240		840	0,48	1,68
						TOTAL	**0,81**	**2,835**
No.of madrasha		**Applicance**	**Number of Applicance**	**AC load (watt)**	**Total AC load(Watt)**	**Consuming electrical load (Watt-hr./day)**	**Total AC Load (Kw)**	**Total Electrcal load (Kw-hr./day)**
1		fan	4	220	460	1760	0,22	1,76
		light	5	240		1200	0,24	1,2
						TOTAL	**0,46**	**2,96**
No of temple		**Applicance**	**Number of Applicance**	**AC load (watt)**	**Total AC load(Watt)**	**Consuming electrical load (Watt-hr./day)**	**Total AC Load (Kw)**	**Total Electrcal load (Kw-hr./day)**
1		fan	1	55	115	110	0,055	0,11
		light	1	60		120	0,06	0,12
						TOTAL	**0,115**	**0,23**
No of office		**Applicance**	**Number of Applicance**	**AC load (watt)**	**Total AC load(Watt)**	**Consuming electrical load (Watt-hr./day)**	**Total AC Load (Kw)**	**Total Electrcal load (Kw-hr./day)**
1		fan	3	165	345	495	0,165	0,495
		light	3	180		540	0,18	0,54
						TOTAL	**0,345**	**1,035**
No of TV		**Applicance**	**Number of Applicance**	**AC load (watt)**	**Total AC load(Watt)**	**Consuming electrical load (Watt-hr./day)**	**Total AC Load (Kw)**	**Total Electrcal load (Kw-hr./day)**
100		TV	100	150	150	600	**15**	**60**
No.of pump		**Applicance**	**Number of Applicance**	**AC load (watt)**	**Total AC load(Watt)**	**Consuming electrical load**	**Total AC Load**	**Total Electrcal load (Kw-**

						(Watt-hr./day)	(Kw)	hr./day)
6		pump	10	400	400	2400	**2,4**	**14,4**
				TOTAL			**42,605**	**221,11**

Table 2: Load profile after 15 years

No.of house	**No.of person/House hold**	**Applicance**	**Number of Applicance**	**AC load (watt)**	**Total AC load(Watt)**	**Consuming electrical load (Watt-hr./day)**	**Total AC Load (Kw)**	**Total Electrcal load (Kw-hr./day)**
1500	6	light fan	2 1	120 55	175	600 440	180 82,5	900 660
						TOTAL	**262,5**	**1560**
No. Of school		**Applicance**	**Number of Applicance**	**AC load (watt)**	**Total AC load(Watt)**	**Consuming electrical load (Watt-hr./day)**	**Total AC Load (Kw)**	**Total Electrcal load (Kw-hr./day)**
12		fan	15	55	825	4950	9,9	**59,4**
No.of Mosque		**Applicance**	**Number of Applicance**	**AC load (watt)**	**Total AC load(Watt)**	**Consuming electrical load (Watt-hr./day)**	**Total AC Load (Kw)**	**Total Electrcal load (Kw-hr./day)**
8		fan light	3 4	165 240	405	577,5 840	1,32 1,92	4,62 6,72
						TOTAL	**3,24**	**11,34**
No.of madrasha		**Applicance**	**Number of Applicance**	**AC load (watt)**	**Total AC load(Watt)**	**Consuming electrical load (Watt-hr./day)**	**Total AC Load (Kw)**	**Total Electrcal load (Kw-hr./day)**
3		fan light	4 5	220 240	460	1760 1200	0,66 0,72	5,28 3,6
						TOTAL	**1,38**	**8,88**
No of temple		**Applicance**	**Number of Applicance**	**AC load (watt)**	**Total AC load(Watt)**	**Consuming electrical load (Watt-hr./day)**	**Total AC Load (Kw)**	**Total Electrcal load (Kw-hr./day)**
2		fan light	1 1	55 60	115	110 120	0,11 0,12	0,22 0,24
						TOTAL	**0,23**	**0,46**
No of office		**Applicance**	**Number of Applicance**	**AC load (watt)**	**Total AC load(Watt)**	**Consuming electrical load (Watt-hr./day)**	**Total AC Load (Kw)**	**Total Electrcal load (Kw-hr./day)**
10		fan light	3 3	165 180	345	495 540	1,65 1,8	4,95 5,4
						TOTAL	**3,45**	**10,35**
No of TV		**Applicance**	**Number of Applicance**	**AC load (watt)**	**Total AC load(Watt)**	**Consuming electrical load (Watt-hr./day)**	**Total AC Load (Kw)**	**Total Electrcal load (Kw-hr./day)**
900		TV	900	150	150	600	**135**	**540**
No.of pump		**Applicance**	**Number of Applicance**	**AC load (watt)**	**Total AC load(Watt)**	**Consuming electrical load (Watt-hr./day)**	**Total AC Load (Kw)**	**Total Electrcal load (Kw-hr./day)**
20		pump	10	400	400	2400	**8**	**48**
				TOTAL			**423,7**	**2238,43**

V. System Design

Standalone Solar Power Systems are completely independent from any electric utility grid. They are most often used in remote areas where electricity is not available or where the connection fees of the grid are higher than the cost of an alternative energy system. Standalone solar systems (also known as autonomous, or off grid systems) are used to collect and store solar energy to be used by household appliances. These systems typically generate from 100 Watts (very small systems) to 5 kilowatts (larger systems, multi family homes). During the day, the electricity generated is used to power the home and charge the batteries. At night, and during rainy days, all necessary power is provided by the batteries.

If the off grid home has no other power source, both the PV array and the battery bank have to be significantly oversized by design to account for possibly 4-5 days of inclement weather.

Currently, PV is most competitive in isolated sites, away from the electric grid and requiring relatively small amounts of power. In these off-grid applications, PV is frequently used in the charging of batteries, thus storing the electrical energy produced by the modules and providing the user with electrical energy on demand.[17]

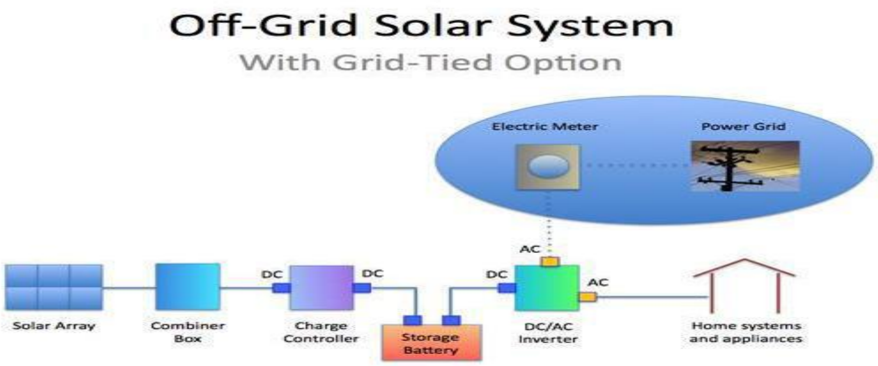

Fig.7: Off-grid System line diagram

The DC electricity produced by the solar panel or module (s) is used to charge batteries via a Solar charge controller. AC appliances are powered via an inverter connected directly to the batteries. Most standalone solar system need to be managed properly. Users need to know the limitations of a system and tailor energy consumption according to how sunny it is and the state of charge (SOC) of the battery. The solar panel need to be configured to match the system DC voltage, Which determined by the battery. The operating voltage of a solar panel in a off grid system must be higher enough to charge the batteries. A charge controller is design to control and to protect the battery so long wording life time should be ensured without impairing the system efficiency. Main purpose of the controller is to protect the battery from over-charging by limiting the charging voltage and prevent the current flowing back (reverse current) into the solar panel during night. The charge controller passes the generated electricity on to the batteries. The battery or stand-alone power inverter is the heart of the AC coupled system. It ensures that generated and load power are balanced at all times. If too much energy is generated, the inverter stores this surplus energy in the batteries. If energy demand exceeds supply, the inverter discharges energy from the batteries. The battery storage system is generally configured to run at 24 or 48 volts. It is contained in a separate room or enclose, if in the same room as the inverter and other componentry. A management system that includes battery, generator, and load management is absolutely essential for the optimum operation of a off grid power supply system. Cables need to be UV resistant and suitable for outdoor applications. It is very important to keep power losses and voltage drop in the cable to a minimum. It is recommended that this be less than 3% between the array and the batteries and less than 5% between the battery and DC loads.

Table 3: Peak Current and corrected Amp-hr load calculation

Total Load power (KW)	Load power (W)	Daily duity cycle	Weekly duity cycle (hr/wk)	Power conversio	Nominal system voltage	Amp-Hr Load (Ah./day)
200	200000	4,5	1	0,85	48	22058,82353

Total Load power (KW)	Load power (W)	Nominal system	Peakcurrent Draw(A)
200	200000	48	4166,67

Total Amp-Hr Load (Ah./day)	wire Effincy factor	Battery Effincy factor	Corrected Amp-hr.Load (Ah./day)
22059	0,98	0,90	25010,20

Table 4: Total number of PV module (series and parallel)

Design Current (A)	Module Derate Factor	Derected Design Current(A)	Rated Module Current (A)	Module in Parallel
3847,69	0,9	4275,21	8,08	529,11
				530,00

Nominal Battery voltage (V)	Batteries in series	Factor	Voltage Required to charge the batteries (V)	Highest Temp. Module Voltage (V)	Module in series	Module in Parallel	Total Module
6	8	1,2	57,6	30,93	1,86	530	**1060**
					2,00		

Table 5: Short circuit voltage and current calculation

	Num.of Module	Rated Module Voltage (V)	30,93		Num. Of Array	Rated Module current (A)	8,08
Module Series	2	Rated Array Voltage (V)	61,86	Module Parallel	530	Rated Array Current (A)	4282,4
	2	Moduled open Ckt Voltage (V)	37,68			Moduled Short Ckt Current(A)	8,63
		Array open Ckt Voltage (V)	75,36		530	Array short Ckt Current(A)	4573,9

Table 6: Calculation of controller

Array short ckt Current (A)	Factor	Minimum controller current (A)	Controller Capacity(Array side) (A)	Controller in parallel
4573,9	1,25	5717,375	60	95,28958333
				96

Table 7: Total number of battery calculation (series and parallel)

Corrected Amp-Hr. Load (AH/Day)	Storage Days	Max. Depth of Discharge	Derate for Temperature	Required battery capacity (AH)	Capacity of selected battery (AH)	Batteries in parallel
25010	2	0,7	1	71457,14	303	235,8322
						236

Nominal System Voltage (V)	Nominal Battery Voltage (V)	Batteries in Series	Batteries in parallel	Total Batteries
48	6	8	236	**1888**

Here, table below mention the manufactures list, country list and the quantity of all the products.

Table 8: Total quantity list for products

Product	**Manufacture**	**Country**	**Quantity**
PV Module	Motech Industries	Taiwan	1060
Controller	OutBack power	USA	96
Inverter	OutBack power	USA	96
Battery	Everexeed	China	1888

VI. Cost Estimation

He project at last is only accepted if the cost of overall project is suitable for financing. In this scientific project the cost was estimated by using Net Present Value (NPV) method which is discussed in this sub chapter. The formula for NPV calculation is given in equation 3 as:

$= - \; + \Sigma(\; - \;)/(\;)^{i} =$ ……. (3)

Where, Ao = initial investment, Ai = Annual investment, Zi = Annual payback, n = number of years, and q=1+p, p = interest rate in %

At NPV = 0, **0** = -Ao + (Zi. /a), (we can write this from equation 3, where a=q−1/1−q−n)

From NPV method we can find the following three cases related to project financing:
1) If NPV = 0 ,Investment will be paid back with p interest rate within n years
2) If NPV > 0 ,Investment paid + profit from project
3) If NPV <.0 , Loss from project

For estimating the cost recent market price has been taken and using Net Present Value (NPV) method NPV is chosen as zero. Cable cost and other costs like labor and maintenance cost are included for total project cost estimation. But if government will provide some financial support then lower tariff can be obtained. So in this case NPV is taken as zero.

Table below mentioned all the price list and total price for battery, inverter, and controller and PV module are calculated and total project cost was estimated. NPV was taken as zero for calculating fid in tariff.

Table 9 : Price list for all products

PV module	0.473€/Wp
Inverter	1394€/piece
Controller	441.8€/piece
Battery	200€/piece

Table10: Cost calculation for the project

Total PV panel cost	9,46,00€
Total inverter cost	1,33,824€
Total Controller cost	42,413€
Total Battery cost	2,83,200€
Extra (Labor, maintenance, others)	150,000€
Total project cost	**7,04,036€**

On the basis of rough design, an initial estimate of system costs can also take place. The costs in the calculation shown here include power inverter, PV module storage battery, installation cost and other cost.

Table 11: Fid in tariff calculation

NPV = 0		
Initial Investment	A_0	0,704M€
interest rate in %	P	5%
Number of years	n	15
Annuity factor	a	0,096

Annual Payback Z_i	0,06782M€
Annual energy yield	0,365GWh
Fid in tariff	**0,18€/KWh**

VII. Conclusion

The major benefits would be a large amount of people can able to use electricity which can help them to develop themselves and they can able to know what's happening daily. This project is an example for Proper utilization of solar energy and also a population free process.

Initial Cost is high for the owner of the station but government can also provide some financial help which can be profitable but processing takes long time. Design must be perfect. Lack of knowledge about proper maintenance of solar technologies can be an issue. Major limitation would be happened when rainy season comes and solar panels are not able to provide enough electricity. In this circumstances power supply may be cut off.

References

[1]. http://cleantechnica.com/2014/10/25/solar-energy-revolution-everyones-ignoring-bangladesh/

[2]. http://cleantechnica.com/2011/12/30/cheap-solar-home-systems-bringing-light-new-opportunities-to-millions-in-rural-Bangladesh/

[3]. Shahidul I. Khan, Md. Abul Kashem, Md. Ariful hoque, ―Design and Analysis of A Mini Solar Grid in Remote Area of Bangladesh,‖ IEEE Transl.. North American Power Symposium, DOI:10.1109/NAPS.2009.5484056, October 2009. [Digests on International Conf. North American Power Symposium, 2009].

[4]. Mir Nahidul Ambia, Md. Kafiul Islam, Md. Asaduzzaman Shoeb, Md. Nasimul Islam Maruf, A.S.M.

[5]. Mohsin, ―An Analysis & Design on Micro Generation of A Domestic Solar-Wind Hybrid Energy System for Rural & Remote Areas-Perspective Bangladesh,‖ IEEE Transl. Mechanical and Electronics Engineering, vol. 2, pp. 107-110, August 2010. [Digests 2 and International Conf. Mechanical and Electronics Engineering , 2010].www.google map.com

[6]. http://www.reuk.co.uk/Solar-Declination.htm

[7]. http://www.itacanet.org/the-sun-as-a-source-of-energy/part-3-calculating-solar-angles/#3.2.- The-Hour-Angle

[8]. http://support.homerenergy.com/index.php?/Knowledgebase/Article/View/203/0/10045---clearness-index-in-homer

[9]. http://www.greenrhinoenergy.com/solar/radiation/tiltedsurface.php

[10]. http://www.journal-ijeee.com/content/pdf/2251-6832-5-5.pdf

[11]. The Infrastructure Development Company Limited (IDCOL) website. [Online] Available: http://www.idcol.org/

[12]. https://energypedia.info/wiki/Bangladesh_Energy_Situation#Solar_Energy

[13]. Bangladesh bureau of statistic web

[14]. http://sdwebx.worldbank.org/climateportal/index.cfm?page=country_historical_climate&ThisRegion=Asia &ThisCCode=BGD

[15]. http://solarelectricityhandbook.com/solar-irradiance.html

[16]. http://www.gosolargreenny.com/standalone-solar-power-systems.html

[17]. http://solar.smps.us/off-grid.html

[18]. http://greencomplianceplus.markenglisharchitects.com/discussions/grid/designing-solar-every-architect-should-know/