Paper ID E35

Possibilities and potentialities of roof top solar pv system within Chittagong export processing zone (CEPZ), Bangladesh

Sanjib Chakraborty[1], Amit Barua[2], Md. Toufiqur Rahman[1]

[1]Go for Green, Bangladesh
[2] Bangladesh University of Engineering and Technology, Dhaka, Bangladesh
Corresponding *e*-mail: sanjib@goforgreen.se

Abstract

The aim of this research is to find out the possibilities and potentiality of the roof top Solar PV system within the CEPZ area. This research will include the analysis of all the roofs by utilizing NASA SSE solar radiation data, PVsyst simulation software and RETScreen simulation software. Economic assessment of the total project and also the GHG emission reduction by the project will be analyzed. The analysis and the result can be used for any EPZ within Bangladesh and also it can be implemented within any industrial cluster around the world. Also the result will be interesting for the investors and the authority of the CEPZ for the investment on the renewable energy sector within CEPZ.

INTRODUCTION

Bangladesh is one the economically developing country within the Southeast Asia zone, with a GDP growth of 5.5 % and expected to be 6.6% in the year if 2017 reported by Asian Development bank . Over the last 20 years Export processing zones of Bangladesh are playing a vital role for the GDP growth and also they are the hub of rapid rise in the exporting sector. Chittagong Export Processing Zone (CEPZ) is one of the largest export processing zones not only in Bangladesh also it was ranked as third in the best cost-competitiveness category and fourth as the best economic potential EPZ by FDI magazine among the 700 economic zones around the world [1]. Total 502 industrial plots with an area of 2000 m^2 per plot situated in the CEPZ and all the plots are being occupied by the business enterprises. According to the financial express CEPZ has earned 2.09 billion USD during the facial year 2012-2013 [2].

As the industrialization is growing day by day the demand for the power supply is also increasing within the CEPZ area and also in Bangladesh. Also due to rapid industrialization, Greenhouse Gas emission is now much higher than previous years and also it is increasing day by day. During the day time CEPZ consumes almost 40 MW of electricity and in the night time it is less than 5 MW. For the higher production cost of the power, environmental effect due to power production and lack of power supply during peak time is slowing down the growth of countries biggest source of income. To mitigate the problem and also to smoothen the progress of CEPZ in January 2013 Bangladesh Export Processing Zone Authority (BEPZA) has taken initiatives along with International Finance Corporation (IFC) and World Bank to turn CEPZ into a Low carbon zone by identifying different ways to reduce the GHG emission and also find out alternative way for power solutions and energy efficiency. Within the three stage road map one of the major initiatives is to installing Solar PV system within the CEPZ area [3].

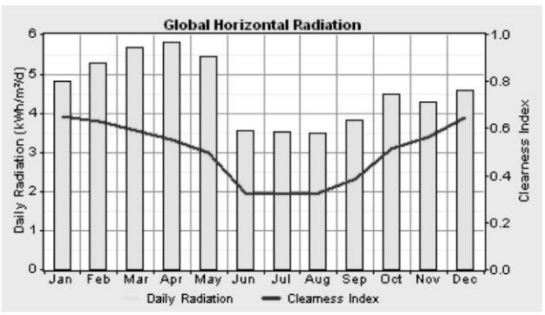

Fig. 1. Solar Radiation throughout the year [4]

Bangladesh is in a suitable position for solar pv system due to suitable global horizontal radiation. There is no actual ground data for the CEPZ location yet but from the NASA satellite data the average solar radiation data in 94% area of Bangladesh is 4-5 KWh/m^2/day which is a higher medium range for technically suitable solar PV system. Fig. 1 illustrates the global horizontal radiation and clearance index of Bangladesh throughout the year. For this research this data will be used considering the same radiation data for CEPZ area.

This study will give a clear idea about the solar pv potential both technically and economically for CEPZ. Also it will open an alternative path for energy crisis and mitigate the low carbon zone initiative of CEPZ.

MATERIALS AND METHODS

This research has been done by using the data from solar radiation data from NASA SSE solar radiation database and main simulation was done by using solar simulation tool PVSyst [5]. Also the economic evaluation of the research was done by using simulation tool RETScreen [6]. The area measurement of the roofs were done by using Google earth line measurement tool and approximated the area last updated Google earth version.

The total CEPZ zone was separated into six zones (Fig. 2) and the area was measured by in accordance to South facing roof, west facing roof and flat roof in each zone.

Fig. 2. Six Zone of CEPZ

The roofs that are covered by obstacles were avoided to get good and feasible simulation result. According to the measurement the data for roof calculation is showing in Table 1.

Table1. Area measurement of suitable roofs

Facing/ Zone	1	2	3	4	5	6	Total
South	16	22	28	17	18	8	109
Total Area (m2)	8400	11600	18000	15500	8500	6700	**68700**
West	16	10	9	14	15	9	73
Total Area (m2)	9800	4400	7800	9000	12000	15500	**58500**
Flat roof	9	8	10	7	5	4	43
Total Area (m2)	16000	21000	18500	15000	5700	5800	82500
****	12000	16000	14000	11500	4300	4500	**62300**

For the ease of simulation total area of the tilted south facing roof was simulated considering it one roof, same for tilted west facing roof. Primary tilt of the roof was considered as 20 degree. For the flat roofs the tilt was considered 14 degree, as it was optimized by the simulation for maximum radiation on the collector plane, also the total area of the flat roof was reduced by 30% (****) to give the mounting arrangement allowance on the roof.

Using the roof area in the entire south faced roof it is possible to install 10.8 MW, in west faced roofs 9.2 MW, in flat roofs with a 14 degree tilt 10.3 MW of solar system can be installed. For the simulation in PVsyst PPAM 300 W [7] solar module has been used with a module efficiency of 15.6%, SMA SMC 11000 TL [8] has been used with an efficiency of 98.5%. To cover up the total area 101,249 unit of solar module and 2232 unit of inverter has been used.

To evaluate the project from economic point of view the system has been simulated in RETScreen by using a similar capacity solar module. Different costing parameter has been added to the simulation to evaluate the viability of the project. The major costing parameters are shown in Table 2.

Table 2 . Parameter for Economic Analysis

Constraints	Unit	Value
Price of the system	Per wp	$1.76
O&M cost	Per wp/ year	$20
Fuel cost escalation rate [9]	%	5
Discount rate [9]	%	5
Inflation rate [10]	%	7.5
Depreciation rate	%	-1
Life time of the system	year	25
Export rate to grid [11]	Per MWh	$130

RESULTS AND DISCUSSIONS

The useable electricity that will be produced by the solar system installed in the three different category roofs; south faced, west faced and flat roof are shown in the [Fig. 3, 4, 5]

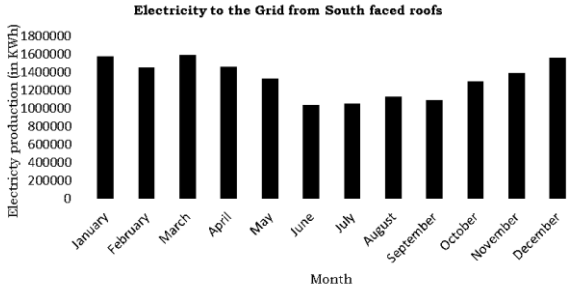

Fig. 3. Electricity to the Grid from South Faced roof

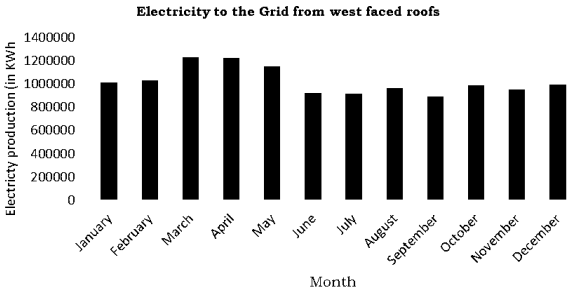

Fig. 4. Electricity to the Grid from west Faced roof

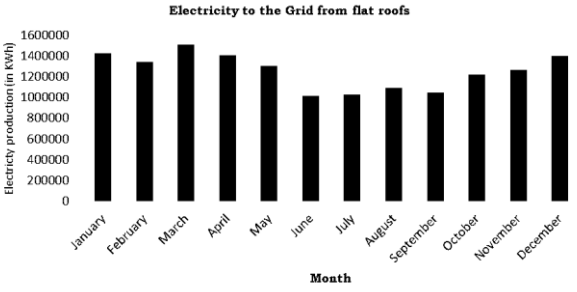

Fig. 5. Electricity to the Grid from flat roofs

From the figures it can be illustrated that the entire roofs can generates satisfactory amount of electricity with a good performance ratio. From the total system it can be possible to generate and use 43,344 MWh of electricity in total after considering the loss of grid ejection. The system has the highest generation on March and lowest generation on June for each case. The performance ratio of the system is on an average 83%.

To evaluate the system economically different results from the RETScreen simulation will be discussed in this segment.

Break even analysis is a tool by which it can be very easy to evaluate the viability of the project. From [Fig. 6] it is clear that the break even period for the project is 11 years if it is compared to the current electricity tariff for commercial use. By analysis the break even period it is very easy for the investors to make decision for the investment.

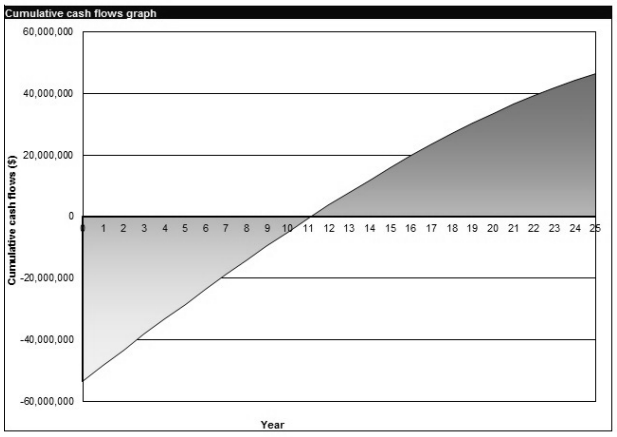

Fig. 6. Break-even analysis for proposed project

The internal rate of return (IRR) could be defined as the interest rate which equates the present worth of a series of cash flow to zero; IRR also has been considered a popular measure of worth for purposes of project evaluation [12]. For the proposed Solar PV system an IRR of 6.4% can be obtained from the particular location.

Net present value is used to understand the difference between the cash in and cash out flow, considering all kinds of discount rate [13]. It can be illustrated form [Fig. 7] that on an average the net present value of the proposed Solar PV system is 6.8 Million USD, which is positive and shows huge potentiality for such investment in Bangladesh.

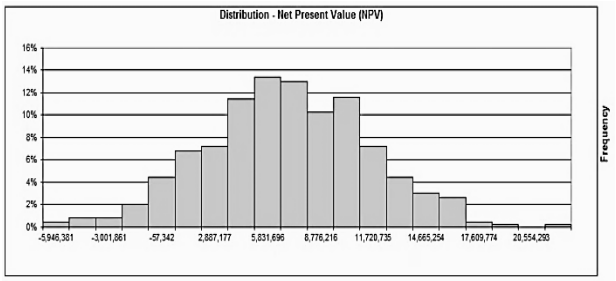

Fig. 7. Net Present Value of the Project

From the analysis it is found that for the proposed system the benefit –cost ratio is 1.13, which is a better range for the investment perspective. Also the cost of energy per MWh is estimated 118 USD.

Environmentally this proposed project will not only help the CEPZ to solve the power crisis also it will facilitate the low carbon zone agenda of CEPZ. From the analysis the total solar system will offset 8706 ton of CO2, which is equivalent to 3,740,726 liter of gasoline not consumed or 3002 ton of waste recycled properly each year.

CONCLUSION

This research reveals the technical and economical potentiality of roof top solar electricity generation within CEPZ to match the road march of low carbon zone agenda. It is estimated that 43,344 MW of electricity per year can be generated from solar PV. Also economically this research has

shown great opportunity as the payback period of 11 year and positive net present value. Also the per unit price of electricity production cost from the research found 0.12 USD which is cost-competitive compared with traditional fuel based electricity production system. The per unit cost would be lower more if carbon credit, clean development mechanism strategies can be inter corporate with the project , so that the higher initial investment can be paid off early.

REFERENCES

[1] Daily Star archive. Available at : http://archive.thedailystar.net/newDesign/news-details.php?nid=156868 [Accessed April 1st , 2014]

[2] Financial express archive. Available at: http://www.thefinancialexpress-bd.com/old/index.php?ref=MjBfMDdfMTJfMTNfMV8yXzE3NjE5Mg== [Accessed April 1st , 2014]

[3] S Das, A Bandyopadhyay and A Ganguly. 2013. Empowering the low carbon future of export processing zones in Bangladesh. Performance Vol. 5, Issue 3, August 2013

[4] MH Ullah. An Efficient Solar-Wind-Diesel-Battery Hybrid Power System for St. Martin Island of Bangladesh , International Journal of Renewable Energy Research, Vol.3, No.3

[5] PVSyst Website. Available at . http://www.pvsyst.com/en/[Accessed June 2nd 2014]

[6] RETScreen. RETScreen International, natural resources Canada 1997-2008. Available at http://www.retscreen.net/ang/home.php [Accessed June 5th 2014].

[7] PPAM Sweden AB webshop. Avilable at http://webshop.ppam.se/ cited [Accessed June 5th 2014].

[8] SMA http://www.sma-america.com/ cited [Accessed June 5th 2014].

[9] MAH Mondal and AKMS Islam. 2011. Potential and viability of grid-connected solar PV system in Bangladesh, Elsevier, Renewable Energy, 36: 1869-1874.

[10] U Onneshan. 2013. Bangladesh Economic Update Monetary Policy: Evidence Based? Bangladesh Economic Update, vol 4, no. 1, 2013.

[11] Dhaka Electrical Supply Company Limited. Available at : https://www.desco.org.bd/ ?page=tariff-rate-2 , [Accessed June 5th 2014].

[12] J Hartman and IC Schafric. 2004. The Relevant Internal Rate Of Return, Taylor & Francis, The Engineering Economist, 49: 139-158.

[13] S Chakraborty, R Hossian, T Rahman, AF. Rabbi. 2014. Economic and Environmental assessment of a 1 MW grid connected rooftop solar PV system for an enery efficient building in Bangladesh. International Congress on Energy Efficiernccy and Energy Related Materials, Springer Processiding in physics. 155: 345-352.