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LOW COST SOLAR MINI GRID FOR SONADIA ISLAND

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***Abstract*-**Solar Mini Grid of 12 KW in Remote areas is an attempt to visualize possibility of providing reliable power supply to the population of remote locations in Bangladesh. It is extremely difficult to provide grid connection to the places that are separated from mainland and from each other by rivers and hills. Renewable energy like Solar is the best way for providing clean energy to these remote places. The objective of this paper is to design and analyze a solar mini grid system using SAM consisting of PV panels, battery and inverter

Keywords-Renewable Energy;Solar PV; Mini Grid; Financial Analysis;.

1. INTRODUCTION

Electrical power crisis is one of the major problems in developing countries like Bangladesh, the gap between electric power demand and supply is increasing terrifyingly day by day. Due to high population growth in Bangladesh, the demand for electrical power increases and a number of people are living in energy poverty, despite a continued positive efforts experienced for electrification across all over the Bangladesh. The modern energy system access in the developing countries which are integrating with local renewable energy sources is paramount to resolve the energy shortage. Most of the enterprises in Bangladesh along with BPDB limited their electricity supply within the urban areas; while rural access to electricity less than compares to urban areas but 65% of the total population lives in rural areas [1]. Currently, about 55 % of total electrical power has produced by the public sector and rest 45 % produced by private sector including several independent power producers (IPPs)[2]. Most of the power plants in Bangladesh are natural gas based, the future gas reservation cannot meet the demand, and the natural gas based system will be out of phase it is just a matter of time. Now Bangladesh is searching for an alternative solution, as reliable energy sources that can minimize the burden on natural gas and alternative source enhance energy access in Bangladesh. The numerous studies about renewable energy penetration in South Asian country's electricity mix hit up to only 5 %, but next six years the number become double , and the biggest portion will account solar power[3].In this paper, we are going to show that solar mini grid in rural areas of Bangladesh can be an alternative way of supplying electricity and compare the cost with existing method of power generation.

2. SOLAR MINI GRID

A Solar mini-grid is a small scale electricity network fed by solar energy. The generated electricity is supplied – directly or indirectly via batteries – to clients who are connected to this mini-grid electricity network. A group of people, who live close to each other, in for instance a village, can be easily connected to the grid. Solar panels capture sunlight, which is converted to electricity. The electricity then goes to an inverter that converts direct current into alternating current, which is then fed directly or indirectly (via the batteries) into the electricity network. The electricity reaches all customers connected to the network.

The advantages of a mini-grid: provides a higher power level, little maintenance, no emission of pollutants, no dependence on the import of diesel and fluctuating energy prices.

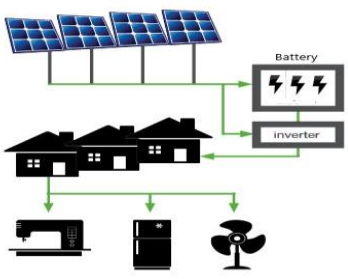

Fig. 01: Solar Mini Grid

The location of our designed project is in Sonadia Island, Sonadia Island known as an 'Island of miracle' is located

16 km, South-west of Cox's Bazar town and by the side of Moheshkhali Island. It is geographically under the administration of Moheshkhali upazila. The area of Sonadia is 9.5 sq. Km seems to be a half moon shaped area consists of sandy soil with widespread Mangrove verities of trees like Sundarbon. The site is mostly government-owned land. In the past, land use was limited due to the effects of natural disasters, but the recent conversion of mangrove and mudflats to shrimp farming and salt pans has had a large impact on the current state of the site. The local community of around 1176 people is highly dependent on the natural resources of the site including agriculture, shrimp fry collection and fishing. Literacy rate is only 12.3%.

Fig. 02: Location Map

3. SYSTEM DESIGN

For system design, we first need to know about the amount of load that will be connected to the solar mini grid. Consider, 50 families are connected to the grid. The amount of their electricity consumption will depend on their income. We roughly estimated the connected load in the Table 1.

Table 1: Estimated Load For 50 Families

Load Type	Device Watts(W)	No of Unit	Total(W)
Light(CFL)	20	200	4000
Fan 56" Sweep	60	50	3000
Television	100	10	1000
Computer/Radio-Cassette	125	5	1125
Water Pump	746	2	1492
		Total	10617

After estimation of load, now we can move towards choosing system equipment's in accordance with the load. The main components are PV module, Inverter and Battery Bank.

Table 2: Component With Capacity And Efficiency

Components	Model	Capacity	Efficiency
PV Module	SunEdison SE-H360-4	360W	18.396%
Inverter	Auxin Solar:AXU-PV 4000U(208V)	4010W	95.623%
Battery Bank	Lithium Manganese Oxide(LMO)	1.5Ah/cell	93.33%

4. FINANCIAL ANALYSIS

For financial analysis, Equipment cost, Installation equipment cost and indirect capital cost all must be considered. We used the approach of Cost $/W production. Installation equipment includes Balance of System Equipment, Installation Labor, Installer Margin and Overhead. Indirect Capital Costs includes Land Cost, Grid Interconnection, Engineering and Developer Overhead, Permitting and Environmental studies.

Table 3: Cost Analysis

Renewable Energy Equipment	Quantity	Cost ($/W)	Amounts($)
PV Module	40	0.67	9645
Inverter	3	0.17	2447
Battery Bank	1		49521
Installation Equipment			
Balance Of System Equipment		.30	4317
Installation Labor		.20	2878
Installer Margin and Overhead		.30	4317
Contingency	2%		472
Indirect Capital Costs			
Land Cost			2944
Grid Interconnection			1439
Engineering And Developer Overhead			1439
Permitting and Environmental Studies			719
Sales Tax	15%		7396
Total Installed Cost			87537
Total Installed Cost per Capacity			6.08/Wdc

Module degradation of 0.7% per year is considered for this specified module used in the designing of solar mini

grid. Losses of different types are also considered which are listed below in Table 4.

Table 4: Losses

Type of Loss	Percentage (%)
Irradiance Loss	
Average annual soiling loss	5
DC Losses	
Modula Mismatch	2
Diodes and connections	.5
DC wiring	2
DC power optimizer loss	1
AC Loss	
AC wiring	1

4. SIMULATION RESULTS

Figure 3 shows the simulation output using SAM, which gives Levelized COE(real) 23.51cent/KWh(19.3Taka) where the analysis period is for 25 years. Levelized COE(nominal) is also show by considering inflation rate of 6.6%[5] and discount rate of 5%. If incentives like Investment Tax Credit(ITC) provided by our Government like USA of 30%[6] shown in Figure 4, LCOE becomes 15.29cents/KWh (12.5 Taka) which is less than half compared to Diesel based production at 38.40 Taka and less than HFO at19.30Taka/KWh [7]. So, Solar mini grid can be an efficient alternative of current scheme followed by our government.

Metric	Value
Annual energy (year 1)	21,635 kWh
Capacity factor (year 1)	17.2%
Energy yield (year 1)	1,503 kWh/kW
Performance ratio (year 1)	0.76
Battery efficiency	NaN
Levelized COE (nominal)	41.25 ¢/kWh
Levelized COE (real)	23.51 ¢/kWh
Electricity bill without system (year 1)	$477
Electricity bill with system (year 1)	$-148
Net savings with system (year 1)	$625
Net present value	$-60,913
Payback period	NaN
Discounted payback period	NaN
Net capital cost	$87,537
Equity	$0
Debt	$87,537

Fig. 3: LCOE without any incentives

Metric	Value
Annual energy (year 1)	21,635 kWh
Capacity factor (year 1)	17.2%
Energy yield (year 1)	1,503 kWh/kW
Performance ratio (year 1)	0.76
Battery efficiency	NaN
Levelized COE (nominal)	26.82 ¢/kWh
Levelized COE (real)	15.29 ¢/kWh
Electricity bill without system (year 1)	$477
Electricity bill with system (year 1)	$-148
Net savings with system (year 1)	$625
Net present value	$-37,451
Payback period	NaN
Discounted payback period	NaN
Net capital cost	$87,537
Equity	$0
Debt	$87,537

Fig. 4: LCOE with incentives

Table 5 shows the cost of electrical energy production by different conventional sources of Bangladesh and comparison of cost with solar mini grid makes easier to understand that is can be a viable alternative source of production of electricity in Bangladesh especially in remote areas where providing national grid connection through PGCB is almost impossible.

Table 5: Cost Comparison

Electrical Energy By Source	**Cost(Taka)/KWh**
Hydro energy	1.11
Gas	2.24
Coal	8.93
HFO	19.30
Diesel	38.40
Wind	41.43
Solar Mini Grid(Proposed)	12.5

Monthly energy production throughout the year is also showed in Figure 5. Here it is evident that maximum energy is produced during December-January and minimum energy is produced during June-July due to nature of solar radiation.

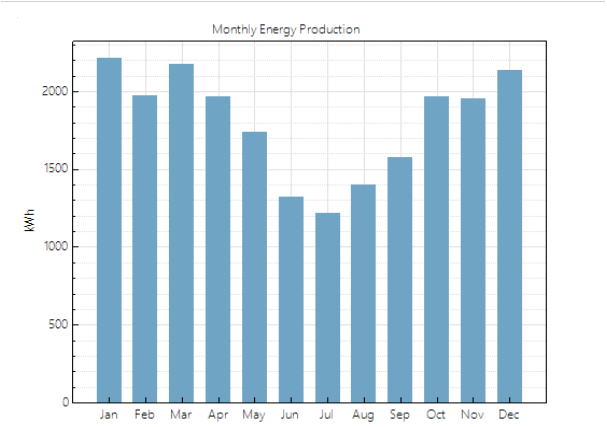

Fig. 5: Monthly energy production throughout the year

Yearly energy production also decreases due to module degradation which is evident from simulation output and shown in Figure 6.

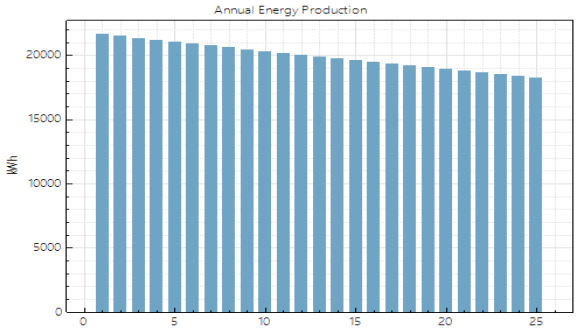

Fig. 6: Annual Energy Production throughout the lifetime of the Solar Mini Grid

Cash flow from the system excluding tax is shown in Figure 7 which describes that 1st bar is for the investment at the beginning of the project. Then from 2nd bar which are at the opposite direction because those are cash out from the system.

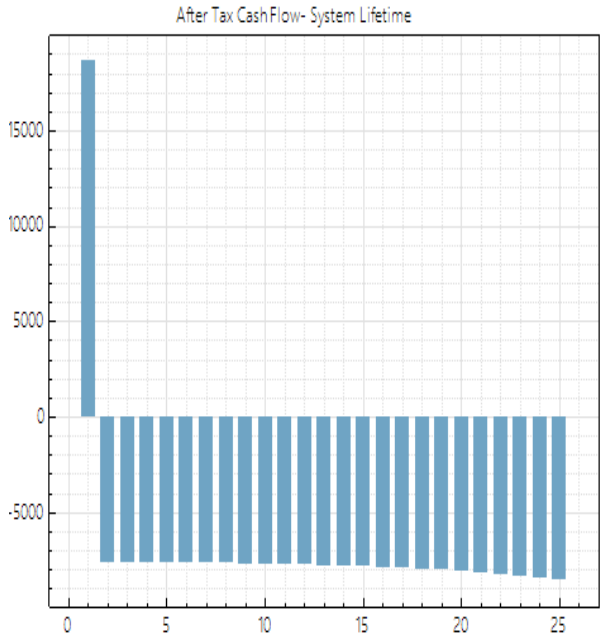

Fig.7: Cash Flow From the system

5. CONCLUSION

Financial analysis was done using SAM [8] and it was shown that Mini grid solar PV system might be able to substitute imported fuel and decrease the exploitation of the country's natural gas resources. The goal is to achieve energy access in non-electrified areas by renewable energy sources. GHG emission savings for this system is 7.77 ton of Carbon Dioxide per year. It is also clear that solar mini grid is the efficient option for power hungry rural areas of Bangladesh. Hybrid system can also be designed by adding a Diesel Generator with Solar Mini Grid for ensuring continuous supply of electricity in case of unfavorable weather conditions.

6. ACKNOWLEDGEMENT

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8. NOMENCLATURE

Symbol	Meaning	Unit
LCOE	Levelized Cost of Energy	Taka