American Journal of Engineering Research (AJER)
e-ISSN: 2320-0847 p-ISSN : 2320-0936
Volume-11, Issue-01, pp-01-09
www.ajer.org
Research Paper Open Access

Economic Analysis of Centralized Solar Home System and Decentralized Solar Home System

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ABSTRACT: *The objective of this paper is to use the solar energy in powering solar home system with remote override facilities. The energy supply is undergoing change. Increasing numbers of private individuals, energy cooperatives and municipalities are operating their own solar systems, biogas plants or wind farms and so complementing the major suppliers and power stations. As the other alternative sources reduce gradually, Solar power is now becoming a very popular source of energy in remote areas as well as urban areas. Solar power system can be provided in two ways, centrally and de-centrally. Centralized and decentralized solar home systems has bright prospects for parts of country where natural gas and electric line are not available. The remote location where the electric line is not cost effective or very costly to establish that line makes the solar energy favorable for the people. The growing demand for solar power renders it as one of the most valuable renewable source for electrical energy production. We have used HOMER Pro software for economic analysis for centralized solar home system and decentralized solar home system. After simulation the obtained result is present in this research paper. Eventually cost analysis is done with the help of HOMER Pro Software by combining the capital cost, net present cost, lifetime and other necessary data. This analysis gives a fruitful cost effective result to approach further. This paper briefly describes centralized solar home system and decentralized solar home system and provides a proper suggestion for a better and sustainable solar power system.*

KEYWORDS *– PV module, Solar radiation, Centralized solar home system, Decentralized solar home system, and Net present cost.*

Date of Submission: 26-12-2021 Date of acceptance: 06-01-2022

I. INTRODUCTION

Now-a-days, Solar energy is another topic that becomes increasingly hot over recent years as the fossil and mineral energy sources are approaching inevitable exhaustion in the coming fifty years [1]. In today's world one of the main challenges is the limit the dependency on fossil fuel and the insured clean energy supply for future generation. Therefore, renewable energy is considered to be the key to ensure environmental friendly energy generation with long-term availability. More than One billion people globally lack access to clean electricity, which is addressed under the sustainable and modern energy for all [2]. For the reason of green power, low cost and availability the renewable energy plays an important role in the world energy specially the solar photovoltaic cell has a great contribution in the world electrical energy [3]. Photovoltaic (PV) module and among the main devices used to convert solar energy to electrical energy [4]. Centralized solar power system refers to a large-scale solar plant installation to produce large amount of electricity like the conventional national grid system, centralized solar forms need the same infrastructure which includes electrical substation and transmission lines to be run over long distance to get that clean solar power to the consumer. Centralized plants are usually located at the point where the best resource is available at need a large amount of land to in a cell and highest depended on the geographical location of the country. The main disadvantage of this system is sometimes efficiency and voltage are lost, when electricity has to travel long distance the decentralized solar plant refers to solar energy solution that produce energy on site or near-site. Decentralized electricity generation

by PV systems in built-up areas, in particular on roofs and other building surfaces, is the least Socially controversial.

Nowadays the power generation has become more localized with the deployment of decentralized energy generation systems [5]. For some cases, in the system there are less or no voltage losses as no transmission line is required to are reach electricity to the consumers. Decentralized electricity system emerges as an alternative option for remote areas [6], Which previously were either insufficiently supplied by diesel generators, or not supplied at all [7]. Decentralization solar power system can be more freely operated in any geographic location. To access the cost-effectiveness of both the decentralized and centralized is solution, least cost electricity plans are required. Such plants often combine geospatial analysis with electric electricity system for a certain country or region [8]. The geographical condition of Bangladesh is not very flexible to draw the transmission lines to a very long distance from national grid due to plenty of rivers of island for uneven ground condition as a result the rural areas are remaining without the access of electricity. Centralized and decentralized solar plant installation can be an effective solution in this regard because of its abundant potential. In our paper the cases we are considering for centralized solar home system and desterilized solar home system.

II. PROPOSED MODEL STRUCTURE

The following Fig.1 shows the proposed schematic diagram of a centralized solar home system. Here, 32 household system required 40 KWh/d, PV capacity 11 KWp, 92 pcs batteries (each battery rating is 12 V, 83.4 Ah) and 7 kw inverter.

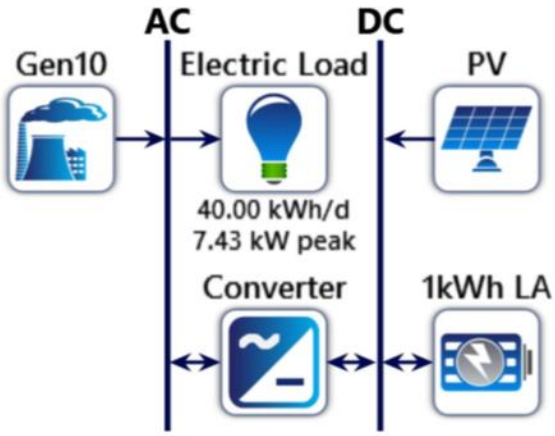

Figure 1 Schematic diagram of centralized solar home system

The following Figure 2 shows the proposed schematics diagram of decentralized solar home system. Here, 1 household required 1.10 KWh/d, PV capacity 0.55KWp and 4 pes battery (each battery reading is 12 V, 83.4 Ah). Solar panel is the main and highest valuable part of the system. Its role is to convert the sun's radiation to electrical energy and then make the electrical energy store in batteries or directly power the loads. Lead-acid batteries are the most popular in solar home system. Its role is to store energy when there is sunlight and release it when necessary. Mainly in night time or when the sun light in not enough, batteries are the supplier of the energy to the loads.

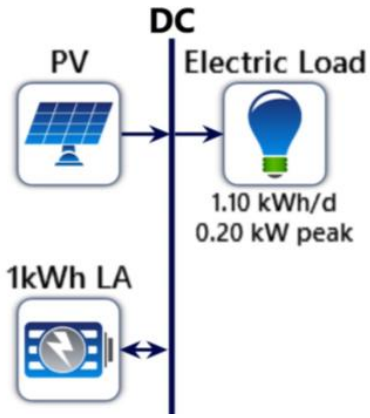

Figure 2 Schematic diagram of decentralized solar home system

III. SIMULATED RESULT AND DISCUSSION

A. *System Simulation Tool*

HOMER (Hybrid Optimization Model for Electric Renewables) is a computer based micro power system optimization model which allows the user to simulate, optimize and also has the ability to do sensitivity analysis on a system consisting of multiple energy sources like wind, PV, diesel generator, battery bank etc. and various loads like AC, DC and thermal loads along with converters and the grid. It is generally used for the design and analysis of hybrid power system [9]. Homers simulation model system ls the best system design and the optimization finds the best possible system configuration which gives the least total NPC that satisfies user defines constraints. It can also provide economic analysis and feasibility of the system. Here in our study we are not considering any sensitivity analysis but HOMER has the ability to do sensitivity analysis. Sensitivity analysis gives the effect of change in the input variables on the optimization results [10]. The HOMER pro software was used to model systems long term implementation. It is a micro power optimization model developed by the National Renewable Energy Laboratory [11] and widely used by many countries for the simulation and optimization of renewable energy systems and hybrid systems. This program is able to simulate the economic performance, environmental performance and hourly implementation of the system, and to supply the optimized system configuration and components sizing.

B. *Centralized Soar Home System*

a. Location, Load measurement and solar irradiation data

For centralized solar home system we have considered our location Z6031, Pabna, Bangladesh (24°0.8'N, 89°15.5'E). For our centralized solar home system simulation, we are considering 32 households and assume all are using same appliances. Here we are considering every household are using LED Light, fan and television.

Appliances	Watt	No of equipment	Total load (watt)	Hours (used/day)	Total unit (Wh/day)
LED Light	10	4	40	5	200
Fan	25	2	50	15	750
TV	60	1	60	5	300

Table 1 Centralized solar home system for 1 household load information

For 1 household total load=200+750+300=1250 Wh per family/day.
Therefore, for 32 households=1250×32=400000 Wh/day=40KWh/day.
Solar insolation has great effect on performance of the PV system. Monthly average solar insolation data(measured in KWh/m^2 /day) is considered for system design and analysis in this paper.Solar irradiance data for the study area Pabna is obtained from the HOMER pro data base

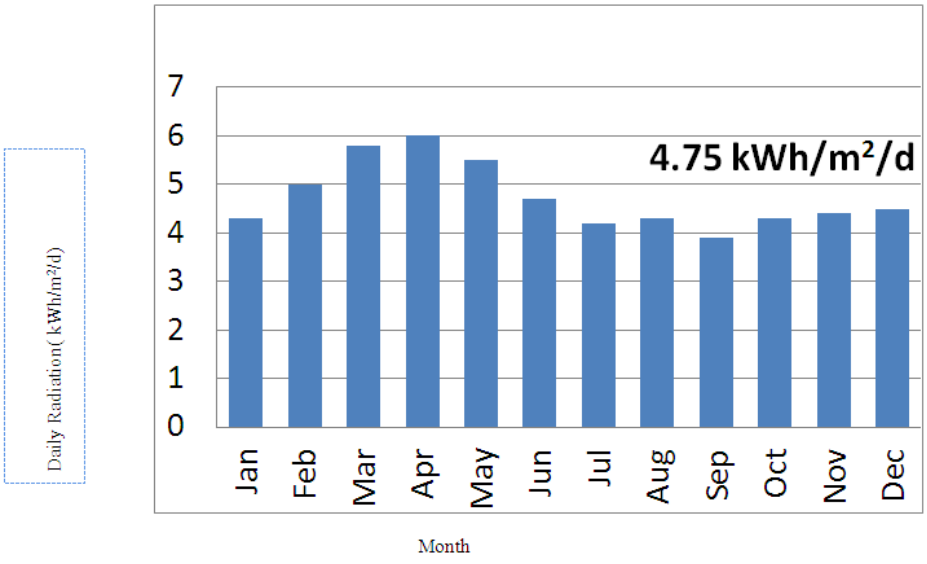

Figure 3. Solar irradiance data for the study area Pabna

Therefore, Daily Average Radiation=4.75 (kWh/m^2/d)

b. ***Centralized PV Module Modeling***

A mono-crystalline high efficiency flat pv solar panel module has been used for this PV model. The output power and efficiency of this solar panel is dependent on the solar cell temperature, solar flux and solar irradiation. Total PV panel needed in this system=40000×1.3=52000 Wh/day. Total Wp of panel capacity needed=52000/4.75= $10947Wp$ ≈11KWp.

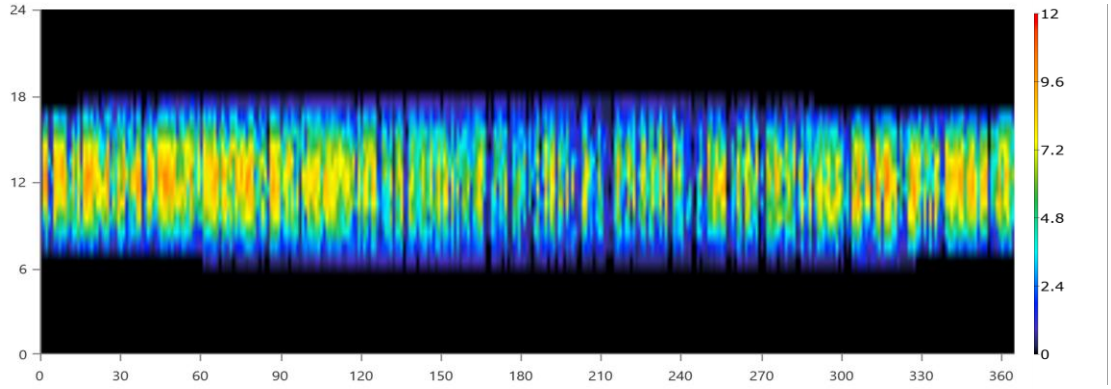

Fig. 4 System simulation PV output

C. *Centralized Battery Storage, Inverter and Generator Modeling*

In this model lead-acid batteries were used for the purpose of storing unused solar power. The charging and discharging characteristic of the battery were modeled to accurately validate the system. Here an important thing we should keep in mind that the battery should be large enough to store sufficient energy to operate the appliances at night cloudy days.

Battery capacity $(Ah) = \frac{40000X1}{0.85X0.5X12} = 7843$, Here Battery Days of autonomy =1,Battery loss=0.85,

Depth of discharge=0.5 and Nominal Battery voltage=12

Therefore number of Batteries required for our system $= \frac{7843\ Ah}{83.4\ \text{Ah}} \approx 92$

Here, each battery rating is 12V, 83.4 Ah

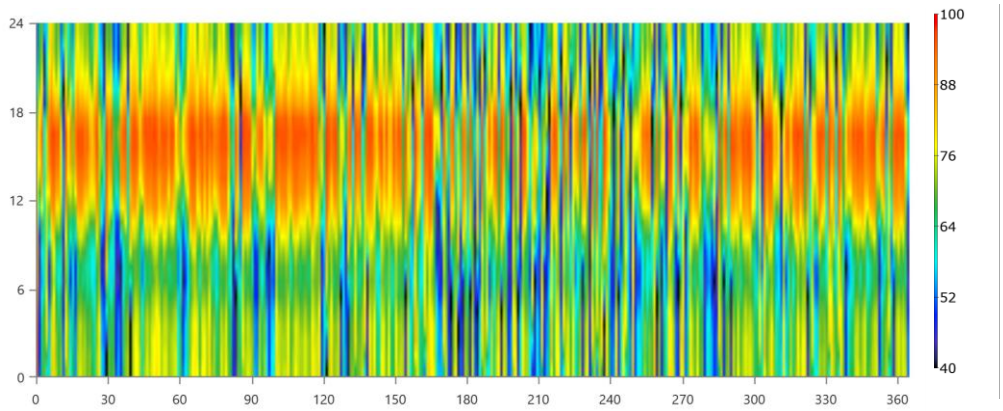

Figure 5 Generic 1 kwh lead acid state of charge (%)

Inverter is required for any system that contains converts DC to AC. It's a matter of concern that the inverter size should be 25-30% bigger than total Watts of appliances.

Total watt of equipment's=32×150=4800 watt.

Inverter capacity=4800+(4800×30%)≈7 kw. So our system need total 7 kw inverter.

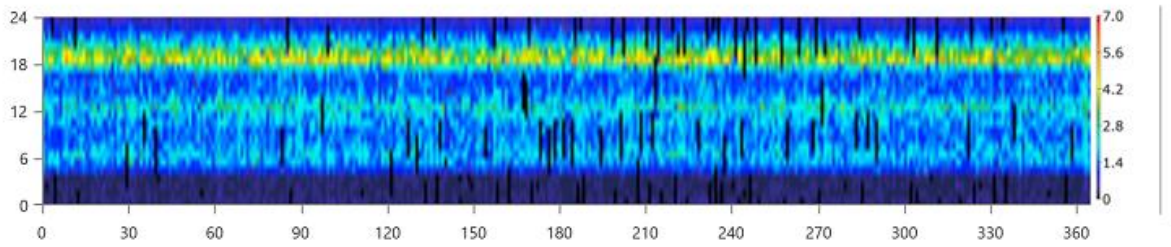

Figure 6 system inverter output

A generator is a device that produces electric energy and consumes fuel. A backup generator is a backup electrical system that operates when there is not sufficient energy to supply. In our system we consider auto size generator. we consider fixed capital cost (include land cost) =6,00,000 BDT=$7017. We also consider O&M cost $140 which is 2% of our fixed capital cost.

Table 2 Simulated Fuel summary

Quantity	Value	Units
Total fuel consumed	1,213	L
Average fuel per day	3.32	L/day
Average fuel per hour	0.138	L /hour
Carbon Dioxide Emissions	3,169	Kg/yr.

d. ***Cost summary centralized solar home system***

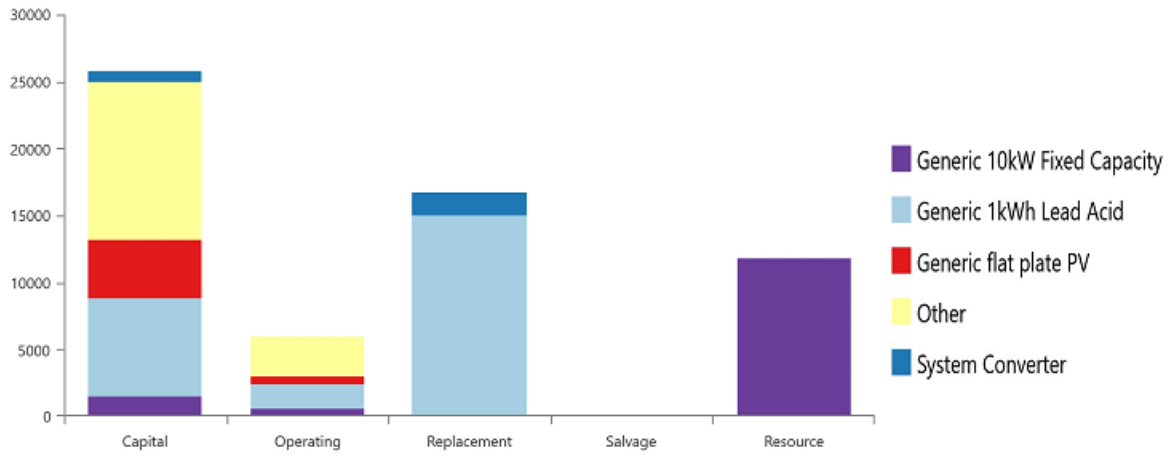

Figure 7 Cost summary centralized solar home system

Table 3 Net Present Cost

Name	Capital	Operating	Replacement	Salvage	Resource	Total
Auto size Genset	$1456.00	$515.42	$0.00	$0.00	$11,785	$13,756
Generic 1kWh Lead Acid	$7,360	$1,882	$14,976	$0.00	$0.00	$24,217
Generic flat plate PV	$4,400	$562.47	$0.00	$0.00	$0.00	$4,962
Other	$11,695	$2,991	$0.00	$0.00	$0.00	$14,686

System Converter	$840.00	$0.00	$1,709	$0.00	$0.00	$2,549
System	$25,751	$5,951	$16,685	$0.00	$11,785	$60,172

From Table3, it is seen that the capital cost $25,751. The total net present cost (NPC), replacement cost, operating cost, resources cost over the 25 years' life time period is given as $60,172, $16,685, $5,951 and $11,785 respectively. In this system 32 households, total cost=$60,172, Therefore 1 household system=$1,880.37.

Per unit cost $= \frac{(\$60,172 \times 85.5 \times 1000)}{(40,000 \times 25 \times 365)} = 14.09$ BDT.

Table 4 Simulated Electrical Load Summary

Component	Consumption (kWh/yr.)	Percent
AC Primary Load	14,600	100
DC Primary Load	0	0
Deferrable Load	0	0
Total	14,600	100

For 32 household system annual AC primary load=14,600KWh/y. Therefore 1 household system annual AC primary load=456.25 KWh/y.

Per year energy cost=456.25×14.09=6,428.56 BDT, So per month energy cost=535.71 BDT.

Payback period=$\frac{\$25,751 \times 85.5}{14.09 \times 14,600}$=10.7 years. Here, $25,751 is capital cost.

C. Decentralized Solar Home System

We have considered our location and solar radiation is taken same that has been used in centralized. We considered 1 household systems are connected with our proposed system. Here we are considering one household are using LED light, dc fan and television. For 1 household total load=200+600+300=1100Wh per family/day. Therefore, for 1 households=1.1 KWh/day

Table: 5 Decentralized Solar home system load information

Appliances	Watt	No of equipment	Total load (watt)	Hours (used/day)	Total unit (Wh/day)
LED Light	10	4	40	5	200
DC Fan	20	2	40	15	600
TV	60	1	60	5	300

From table 5, for 1 household system 1.1 KWh is required. This system contains pv module and battery storage only. The model of the pv panel and battery storage is taken same that has been used in centralized system. The pv panel and battery storage lifetime, capital cost, O&M cost is considered same. From the simulation HOMER finds a total of 0.55KWp pv panel and 1 no of battery which is the best fit for the system.

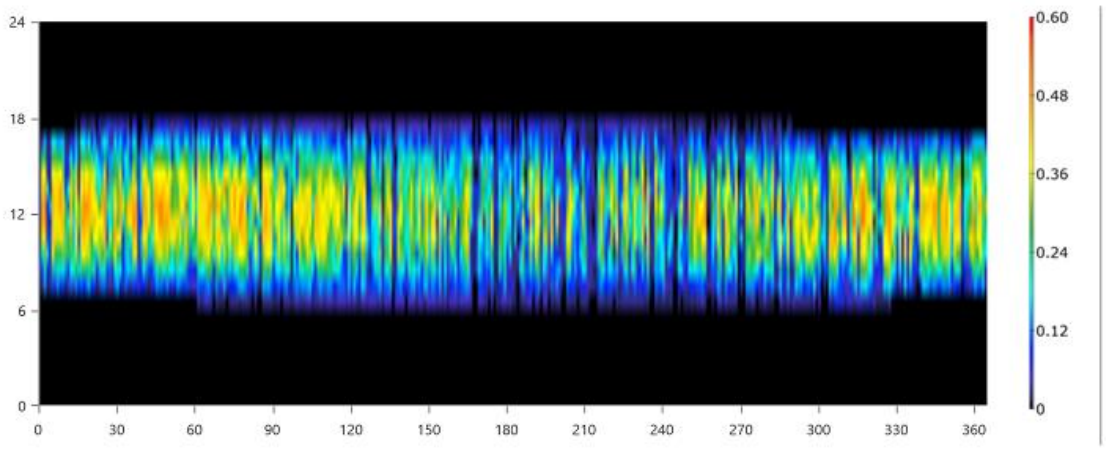

Fig. 8 System simulation PV output

Cost summary decentralized solar home system:

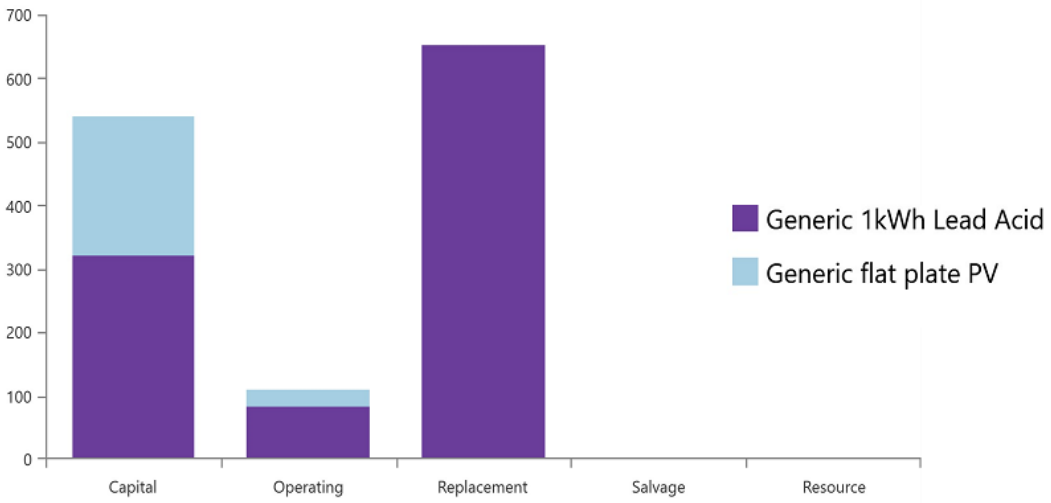

Figure 9 Cost summary decentralized solar home system

Table 6 Net present costs

Name	Capital	Operating	Replacement	Salvage	Resource	Total
Generic 1kWh Lead Acid	$320.00	$81.81	$651.11	$0.00	$0.00	$1,053
Generic flat plate PV	$220.00	$28.12	$0.00	$0.00	$0.00	$248.12
System	$540.00	$109.94	$651.11	$0.00	$0.00	$1,301

From table 6, it is seen that the total capital cost for the system is $540. The total net present cost (NPC), replacement cost ,operating cost over the 25 years life time period is given as $1,301 , $651.11,$109.94 respectively .For 1 household system, Total cost=$1,301

Per unit cost=$\frac{(\$1301\times85.5\times1000)}{(1100\times25\times365)}$=11.08BDT

Component	Consumption (kWh/yr.)	Percent
AC Primary Load	0	0
DC Primary Load	400	100
Deferrable Load	0	0
Total	400	100

Table 7 Simulated Electrical Load Summary

For 1 household system annual DC primary load =400 KWh/y. Therefore per month energy cost=11.08× 32.85 =363.98 BDT. Payback period $=\frac{(\$540\times85.5)}{(11.08\times32.85)}=10.5$ years, Here $540 is capital cost.

D. Result summary Centralized and Decentralize solar home system.

Table 8 Result summary centralized and decentralized solar home system

	Centralized Solar Home System (32 households)	Decentralized Solar Home System (1 household)
Net Present Cost	$60,172	$1,301
LCOE ($/kWh)	$0.322	$0.254
CAPEX	$25,751	$540
OPEX	$2,693	$109.94
CO2 Emitted (kg/yr.)	3,169	0.00
Fuel Consumption (L/yr.)	1,286	0.00
Per unit cost (BDT)	14.09	11.08
Payback period (years)	10.7	10.5
Per month energy cost (BDT) (1 household)	535.71	363.98

In table 8, it is seen that the decentralized solar home system net present cost, levelized cost of energy, capital expense, operating expense, per unit cost, payback period is more cost effective than centralized solar home system. So our research paper decentralized solar home system is more economically benefits.

IV. CONCLUSION

The model of solar photovoltaic power centralized and decentralized home systems has been successfully developed for the sustainability assessment. The model is capable of performing a long- term simulation of the system's economic, technical and environmental feasibility. From our simulation, the total system cost of one household in centralized system is $,1880.37 in 25 years where in decentralized system it is $1,301. Here, decentralized system is more cost-effective. It is important to have a back-up power. Like in centralized system batteries are the main back-up power source to lighten up at night but it also has a back-up generator for powering the lights when there is not sufficient sunlight for many days. Hence, in decentralize system there is no such thing. So it is better to choose centralized system in order to get continuous power supply. Considering all these aspects, we can say that centralized solar home system can be better if the place is non- developing area. Therefore, for city areas as well as for any places decentralized solar home system is better option. Just proper monitoring and maintenance is required to make this system is the best.

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