MODELING AND ECONOMIC ANALYSIS OF GRID CONNECTED SOLAR PHOTO VOLTAIC SYSTEM IN BANGLADESH

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ABSTRACT

The amount of the conventional energy sources is decreasing day by day. Here in Bangladesh, the main source of energy generation is natural gas. To avoid the upcoming energy crisis, we need to incorporate the renewable energy sources with which Bangladesh is blessed due to its geographical location. Bangladesh has a very good prospect for the solar Photovoltaic integration. The technical potential of grid-connected solar PV in Bangladesh was calculated as about 50,174 MW. Researches are needed to be conducted for modeling optimized grid connected solar photovoltaic system. This paper makes an attempt to model a cost efficient grid connected PV system and performs its economic analysis for Bangladesh.

KEYWORDS: *Solar PV, Distributed generator, Renewable energy, Grid connected solar PV, Sustainable energy*

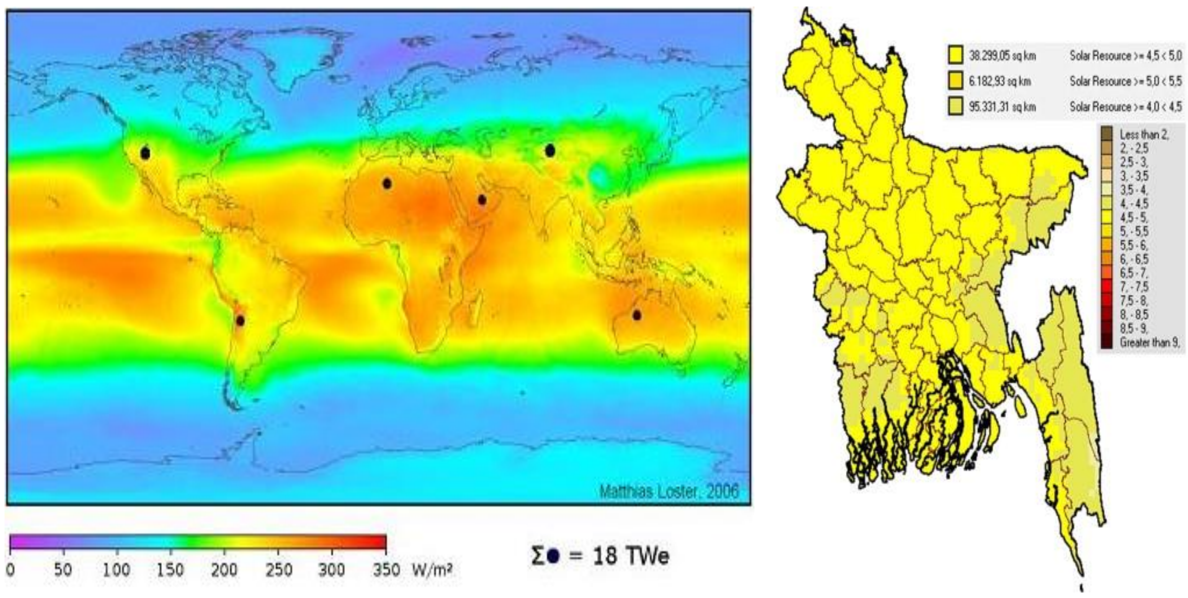
I. INTRODUCTION

Bangladesh is suffering from energy crisis for long many years. The main source of energy generation of Bangladesh is natural gas. 81.4% of the total electricity generation from the installed capacity is accounted by this source of energy [1]. The way the energy consumption is increasing (10% annually), the reserved natural gas of Bangladesh will not last more than 15/ 20 years [2]. In this situation, grid connected solar photovoltaic system can be a fruitful solution. Implementation of renewable energy resources like solar energy will lead to economical, social and environmental benefits [3]. GHG gas emission will be lessened. Researches are going on about the integration of renewable distributed generation (DG) units with medium and low voltage power grids. The potential and viability of grid connected solar PV of 1 MW was studied by Mondal *et al.* [4] using RETscreen simulation software for 14 widespread locations in Bangladesh and it showed the favourable condition for the development of the PV systems in Bangladesh. A study of grid-connected PV systems for residential houses with energy storage was presented by G. Mulder *et al.* [5]. They studied the relation between storage size and energy flow to the grid in Belgium. A technical and economic analysis of grid-connected systems was performed by J. De La Hoz et al. [6] in Spain during the period 1998-2008. They explained the evolution by focusing on the key growth factors and drivers embedded in the legal, economic and technical framework of the PV energy policy. Sopian *et al.* [7] simulated the viability of a hybrid renewable energy generation system for a household in Malaysia using HOMER (Hybrid Optimization Model for Electric Renewables) simulation software, and showed that the most cost optimized system consists of a 2 kW PV and 1 kW wind turbine. Numerous studies were conducted on the subject [8], [9], [10]. Hong *et al.* [11] estimated the loss ratio of solar PV electricity generation through stochastic analysis. PV is becoming more and more attractive in certain countries due to availability of resources and geographical benefits [12]. In Bangladesh, grid connected solar PV system can play an important role for satisfying the unmet energy demand. Bangladesh government has put a target to provide electricity for all by the year 2020, although at present there is a huge unsatisfied demand for electricity, which is growing by more than 8% annually

[13], [14]. The Rural Electrification Board (REB) noted that they had supplied electricity services to about 31% of the total rural population (Master plan, 2000). It aims to reach 97 million rural populations by 2020, which is about 84% of the total rural population [15]. In recent years, rapid development in grid-connected building integrated PV systems is due to the government-initiated renewable energy programs aiming at the development of renewable energy applications and reduction of greenhouse gas emissions. Germany introduced a "1, 00,000 roofs program" [16]. These kinds of projects are being initiated worldwide to overcome the energy crisis in a sustainable way. Several countries are taking numbers of initiatives in this regard. In USA, a PV system dissemination program has been very successful, and its 1 million solar-roof initiative is going well [17], [18]. With the advancement of technology, the installing cost is also being reduced gradually. The efficiency and performance of PV systems have risen dramatically over the last decade while installation and maintenance costs of systems have declined [19], [20], [21]. Over the last two decades, the cost of manufacturing and installing solar PV has decreased by about 20% for every doubling of installed capacity [22]. From 2008 to 2012 prices of solar panel have decreased by 25% in the United States from approximately $4/Watt, with many currently installed systems below $3/Watt [23].

However, in the course of exploitation, constraints such as land use, geographical area and climate are encountered. In addition, several of solar energy technologies are limited by different factors. For detailed information, it is therefore necessary to examine the potential of solar energy from the viewpoint of a specific application [24]. The average annual power density of solar radiation is typically in the range of 100-300 W/m^2. Thus, with a solar PV efficiency of 10%, an area of 3-10 km^2 is required to establish an average electricity output of 100 MW, which is about 10% of a large coal or nuclear power plant [25]. Several factors are considered when procuring a PV system, such as the known solar insolation of a given area [26], cloud cover, energy payback associated with regional energy provider(s), individual building factors such as energy demands [27], and environmental effects including air pollution and dust [28], [29]. Compared to conventional energy options and considering multiple geographic and buy-back regions, PV generated electricity remains expensive, although prices are falling due to government incentives and the rapid expansion of the industry [30], [31].

Bangladesh is situated between 20.30° and 26.38° north latitude and 88.04° and 92.44° east longitude. The amount of solar radiation varies from area to area in this country.



(a) (b)

Figure 1. Solar radiation (kWh/m^2/day) (a) worldwide and (b) Bangladesh

The amount of solar radiation in various districts is listed below.

Table 1. Average daily solar radiation in various sites in Bangladesh [32], [33].

Site names	Latitude (Degrees)	Longitude (Degrees)	Radiation (KWh/m^2/day) (RERC)	Radiation (KWh/m^2/day) (NASA)
Dhaka	23.7	90.4	4.73	4.65
Rajshahi	24.4	88.6	5.00	4.87
Sylhet	24.9	91.9	4.54	4.57
Khulna	22.8	89.6	-	4.55
Rangpur	25.7	89.3	-	4.86
Cox's Bazar	21.4	92	-	4.77
Dinajpur	25.6	88.6	-	4.99
Chittagong	22.3	91.8	-	4.55
Bogra	24.8	89.4	4.85	4.74
Barisal	22.7	90.4	4.71	4.51
Jessore	23.2	89.2	4.85	4.67
Mymensingh	24.8	90.4	-	4.64

So, it can be seen that, Bangladesh has a good prospect for solar photovoltaic integration as a good amount of solar radiation is available throughout this country.
The remainder of this paper is organized as follows. Section II sets forth the methodology of the simulation software HOMER. The characteristics of the site that has been chosen for the case study is reported in section III. Section IV describes the overall system configuration and the specifications of the system components. Section V provides the results and discussions of the simulation. The comparison of emissions among different system models is shown in section VI. Section VII depicts some future works. Concluding remarks are provided in section VIII.

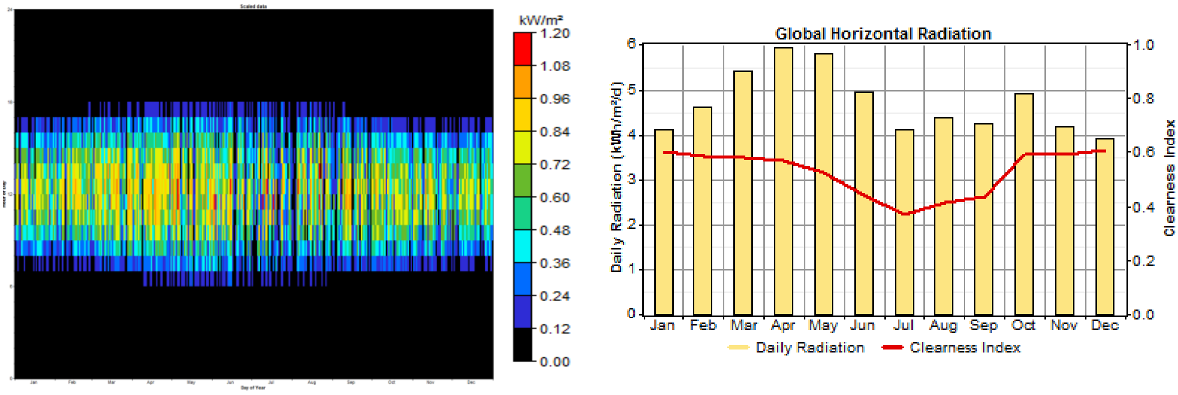
II. HOMER METHODOLOGY

HOMER, the micro power optimization model, simplifies the task of evaluating designs of both off-grid and grid-connected power systems for a variety of applications. The HOMER energy modelling software is a powerful tool for designing and analyzing hybrid power systems, which contain a mix of conventional generators, power grid, cogeneration, wind turbines, solar PV, batteries, fuel cells, hydro power, biomass and other inputs. It is currently used all over the world by tens of thousands of people [34]. HOMER is a software that designs the most optimized and cost effective hybrid generation system after a huge number of hourly simulations for a certain arena considering some parameters and component prices. The load profile, solar radiation data, wind speed data, tariff rate of the utility, feed-in-tariff, prices of the system components have to be provided to the software. HOMER performs hundreds or thousands of hourly simulations to ensure the best possible matching between supply and design in order to design the optimum system. To observe the impact of changes of the parameters such as, solar radiation variation, PV investment cost variation, wind speed and diesel fuel price variation on the optimum result, sensitivity analysis can also be done. HOMER simulates the operation of a system by making energy balance calculations for each of the 8,760 hours in a year. For each hour, HOMER compares the electric and thermal demand in the hour to the energy that the system can supply in that hour, and calculates the flows of energy to and from each component of the system. For systems that include batteries or fuel-powered generators, HOMER also decides for each hour how to operate the generators and whether to charge or discharge the batteries. This software has been applied for research in many simulations. A techno-economic feasibility analysis was done for 500 kW grid-connected solar PV system using HOMER software and RET Screen computer tools [35].

III. SITE CHARACTERISTICS

In this paper, a case study has been conducted for a remote residential area in Rajshahi. The co-ordinates for this district are 24°22′00″ N latitude and 88°36′00″ E longitude. According to the data of

RERC, Dhaka University, the daily solar radiation for this district is 5.00 KWh/m^2 (4.87 KWh/m^2/day, NASA), which is very much preferable for solar PV energy.



(a) (b)

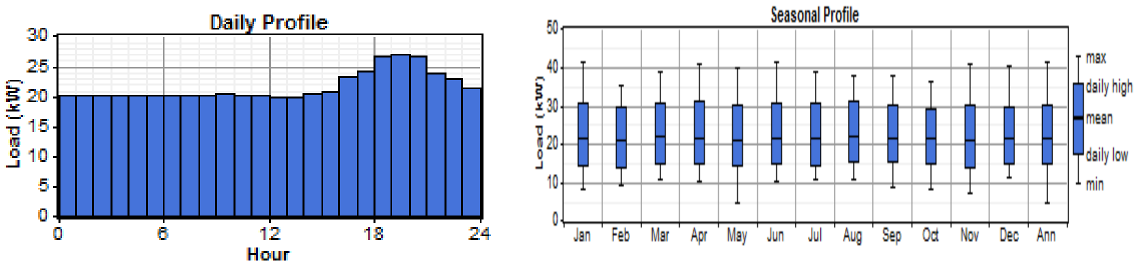
Figure 2. (a) Sunshine hours in Rajshahi throughout the year. (b) Monthly average solar radiation in Rajshahi.

3.1. Solar radiation property

After giving input of the coordinates (latitude and longitude) of the site area Rajshahi, HOMER automatically generates the radiation data via internet [36]. The highest solar radiation is achieved in the month of April (around 5.85 KWh/m^2/day) and lowest solar radiation is achieved in the month of December (around 3.90 KWh/m^2/day).

3.2. Load profile

A group of locality has been chosen for the case study. This group contains around 800 households with primary demand 514 kWh/d and annual peak load 41 kW. This load is based on 3 energy efficient lamps (15 W each), 1 fan (40 W) and 1 television (40 W) for each family.



(a) (b)

Figure 3. Load profile (a) Daily (b) Monthly

3.3. Energy purchase price and sell back rate (feed-in-tariff)

HOMER models the grid as a component from which the micro power system can purchase ac electricity and to which the system can sell ac electricity. The cost of purchasing power from the grid can comprise an energy charge based on the amount of energy purchased in a billing period and a demand charge based on the peak demand within the billing period. HOMER uses the term grid power price for the price that the electric utility charges for energy purchased from the grid, and the demand rate for the price the utility charges for the peak grid demand. A third term, the sellback rate (feed-in-tariff), refers to the price that the utility pays for power sold to the grid.
The load that is discussed in this paper is domestic type. The tariff that is fixed for domestic customers is 3.330 BDT/ kWh (Bangladeshi Taka, currency of Bangladesh, 1 USD = 83 BDT) for off-peak hours, 4.930 BDT/ kWh is the flat rate (shoulder) and 7.980 BDT/ kWh is for peak hours. The feed-in-tariff or sell back rate for the renewable components in Bangladesh has multiple rates which are 2.150 BDT/ kWh for off-peak (00:00-06:00 hrs), 3.090 BDT/ kWh for flat rate (06:00-18:00 hrs) and 4.50 BDT/ kWh for peak (18:00-24:00 hrs). Figure 4 will illustrate that thing clearly.

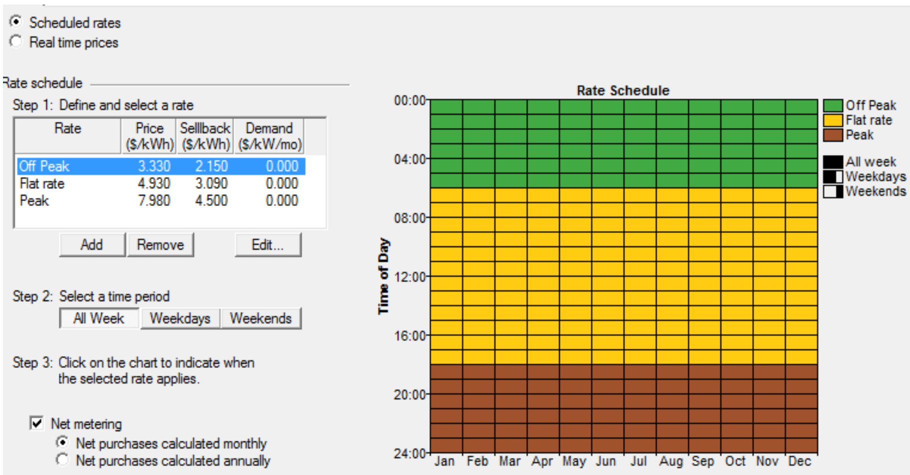


Figure 4. Energy purchase price and sellback rate (feed-in-tariff)

IV. DESCRIPTION OF THE SYSTEM

Among the renewable energy sources, solar energy has been utilized with grid connection in this study. A typical grid-connected PV system comprises the following components [37]:

- Solar PV Modules: these convert sunlight directly to electricity.
- Inverter: converts the DC current generated by the solar PV modules to AC current for the utility grid.
- Main disconnect/isolator Switch
- Utility Grid

The hybrid generation system, discussed in this study, consists of electrical load, power grid, renewable energy source and other system components such as solar PV, battery and converter. Figure 5 shows the complete hybrid energy system.

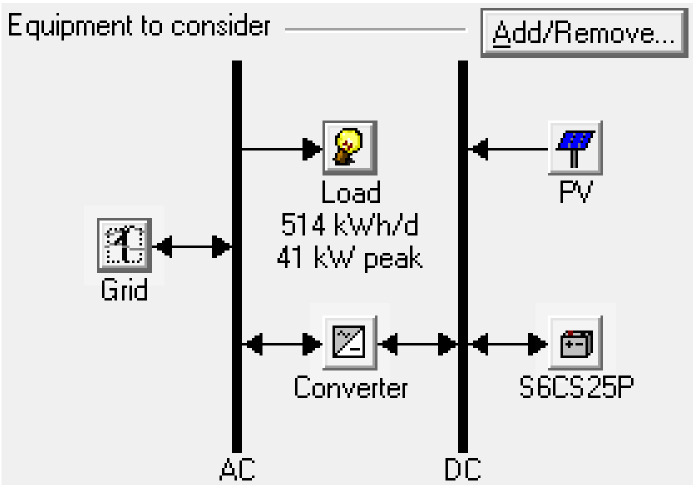


Figure 5. Complete hybrid system

4.1. Solar photo voltaic

Capital cost, replacement cost, O&M cost etc have to be provided to the software for the simulation and modeling purpose. 20 KW PV modules are considered. The parameters considered for solar PV (1 USD= 83 BDT) are stated in Table 2.

Table 2. Solar PV Array Specifications

Parameter	Unit	Value
Capital cost	BDT / W	498000
Replacement cost	BDT / W	415000

Operation and maintenance cost	BDT / W/ yr	99600
Lifetime	Years	25
Derating factor	Percent	90
Tracking system	No tracking system	

4.2. Converters

Most of the house appliances are compatible for AC current nowadays. As the electricity generated from the PV is DC, converter is needed to change it into AC. The converter selected for the power system should have features that make the system more robust. Proper control systems must be provided to the designated system such as the use of multilevel converter control schemes applicable to a general multilevel converter and to any types of the renewable energy resources [38]. Table 3 shows the technical and economical parameters of the converters.

Table 3. Specifications of Converters.

Parameters	**Unit**	**Value**
Capital cost	BDT/ KWrated	35,600
Replacement cost	BDT/ KWrated	30,500
Lifetime	Years	10
Efficiency	Percent	90
Rectifier capacity	Percent	95
Rectifier efficiency	Percent	85

4.3. Battery

The Surrette 6CS 25P storage batteries have been utilized in the hybrid system. This battery bank stores the excess energy provided by the solar PV and supplies to the grid when necessary. The technical and economic parameters (1 USD= 83 BDT) are stated in Table 4.

Table 4. Specifications of Battery

Parameter	**Unit**	**Value**
Nominal voltage	Volt	6
Nominal capacity	Ah	1156
Maximum charge current	A	41
Round trip efficiency	Percent	80
Minimum state of charge	Percent	40
Capital cost	BDT/ KWh	99600
Replacement cost	BDT/ KWh	83000
Operation and maintenance cost	BDT/ KWh/ year	830

V. RESULTS AND DISCUSSION

The amount of the storage of the conventional energy sources is decreasing day by day. To support these conventional sources, renewable energy sources are being incorporated to ensure continuous power supply and a green sustainable world. In this study, an attempt has been taken to model a renewable energy generation system hybridized with the power grid connection which will be cost effective and optimized.

It is the main target to get the hybrid energy generation model which costs the least per kWh or costs least NPC. After thousands of simulations, HOMER shows the hybrid configurations with respect to net present cost and cost/kWh.

5.1. Analysis of the model where energy is supplied by only Grid

From the simulation result, it can be seen that, the most cost optimized energy generation model is configured with grid only which is basically not environment friendly.

In figure 6, we can see that, this configuration is the cheapest configuration with COE (cost of energy) of 5.430 BDT/ kWh and Net Present Cost (NPC) with 14, 358, 153 BDT. The amount of the initial capital cost is 0.00 BDT as there is no solar PV integrated with the grid supply in this model. There is no need of inverter and battery storage either. The renewable fraction is 0.00% and no capacity shortage. Though this configuration is the cheapest one, it is not feasible as there is no solar PV integrated. Our main objective is to integrate solar PV with power grid to reduce the adverse effects of using the conventional energy sources. In figure 7, the cash flow summary of this model, it can be seen that, all the cash flows due to the cost of the operation and maintenance of the grid only system.

Double click on a system below for simulation results.

PV (kW)	S6CS25P	Conv. (kW)	Grid (kW)	Initial Capital	Operating Cost ($/yr)	Total NPC	COE ($/kWh)	Ren. Frac.	Capacity Shortage
			500	$ 0	1,018,746	$ 14,358,153	5.430	0.00	0.00
	2	20	500	$ 911,200	1,063,921	$ 15,906,041	6.016	0.00	0.00
	3	20	500	$ 1,010,800	1,068,262	$ 16,066,825	6.076	0.00	0.00
	4	20	500	$ 1,110,400	1,072,603	$ 16,227,609	6.137	0.00	0.00
	6	20	500	$ 1,309,600	1,081,285	$ 16,549,176	6.259	0.00	0.00
	8	20	500	$ 1,508,800	1,089,968	$ 16,870,744	6.380	0.00	0.00
	12	20	500	$ 1,907,200	1,107,332	$ 17,513,876	6.624	0.00	0.00
	14	20	500	$ 2,106,400	1,116,014	$ 17,835,444	6.745	0.00	0.00
	16	20	500	$ 2,305,600	1,124,697	$ 18,157,012	6.867	0.00	0.00

Figure 6. Optimization result from HOMER (model where energy is supplied by only Grid is highlighted), All the currency values were considered in terms of BDT (Bangladeshi currency) instead of $ (USD).

In figure 8, it can be seen that, the AC primary demand is 187, 611 kWh/ year which is being supplied by the grid only. The renewable fraction is zero with no capacity shortage. Monthly average electrical production is shown in graphical manner.

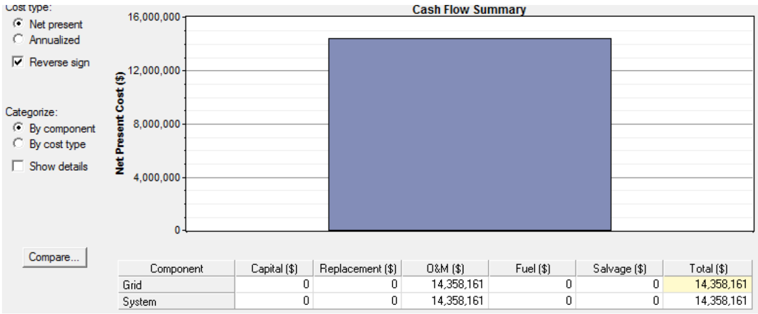


Figure 7. Cash flow summary of the only grid connected model, All the currency values were considered in terms of BDT (Bangladeshi currency) instead of $ (USD).

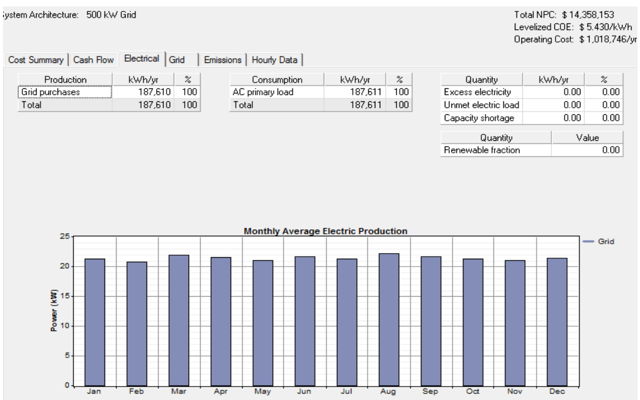


Figure 8. Monthly average electricity production

5.2. Analysis of the model where energy is supplied by Grid connected PV without storage

A PV array is connected and synchronized to the grid using an appropriate power conditioning sub-system that converts the DC energy to alternating current (AC) energy synchronized to the grid energy [39]. In this section, the economy of grid connected PV system without battery storage has been analyzed. In figure 9, it has been illustrated that, the COE of this system is 19.428 BDT/ kWh and the total NPC is 51, 514, 676 BDT. Comparing with the system illustrated in previous section, the cost of this system is higher as the operation and maintenance costs and the initial capital of the solar

PV (kW)	S6CS25P	Conv. (kW)	Grid (kW)	Initial Capital	Operating Cost ($/yr)	Total NPC	COE ($/kWh)	Ren. Frac.	Capacity Shortage
			500	$ 0	1,018,746	$ 14,358,153	5.430	0.00	0.00
	2	20	500	$ 911,200	1,063,921	$ 15,906,041	6.016	0.00	0.00
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	6	20	500	$ 1,309,600	1,081,285	$ 16,549,176	6.259	0.00	0.00
	8	20	500	$ 1,508,800	1,089,968	$ 16,870,744	6.380	0.00	0.00
	12	20	500	$ 1,907,200	1,107,332	$ 17,513,876	6.624	0.00	0.00
	14	20	500	$ 2,106,400	1,116,014	$ 17,835,444	6.745	0.00	0.00
	16	20	500	$ 2,305,600	1,124,697	$ 18,157,012	6.867	0.00	0.00
20		20	500	$ 10,672,000	2,897,889	$ 51,514,676	19.482	0.18	0.00
20	2	20	500	$ 10,871,200	2,906,571	$ 51,836,240	19.604	0.18	0.00
20	3	20	500	$ 10,970,800	2,910,912	$ 51,997,024	19.665	0.18	0.00
20	4	20	500	$ 11,070,400	2,915,253	$ 52,157,808	19.726	0.18	0.00
20	6	20	500	$ 11,269,600	2,923,935	$ 52,479,376	19.847	0.18	0.00
20	8	20	500	$ 11,468,800	2,932,617	$ 52,800,944	19.969	0.18	0.00

Figure 9. Optimization result from HOMER (model where energy is supplied by Grid connected solar PV without storage is highlighted), All the currency values were considered in terms of BDT (Bangladeshi currency) instead of $ (USD)

Production	kWh/yr	%
PV array	33,644	18
Grid purchases	157,491	82
Total	191,134	100

Consumption	kWh/yr	%
AC primary load	187,611	100
Grid sales	159	0
Total	187,770	100

Quantity	kWh/yr	%
Excess electricity	0.180	0.00
Unmet electric load	0.00	0.00
Capacity shortage	0.00	0.00

Quantity	Value
Renewable fraction	0.176

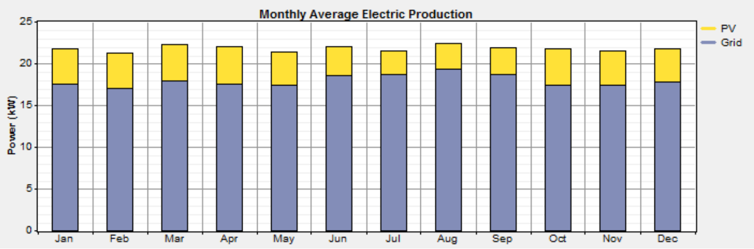

Figure 10. Monthly average electricity production of the grid connected PV system

Month	Energy Purchased (kWh)	Energy Sold (kWh)	Net Purchases (kWh)	Peak Demand (kW)	Energy Charge ($)	Demand Charge ($)
Jan	13,112	47	13,065	41	72,264	0
Feb	11,479	16	11,463	35	63,615	0
Mar	13,319	18	13,301	39	73,622	0
Apr	12,655	14	12,641	41	70,228	0
May	12,933	12	12,921	40	71,758	0
Jun	13,411	1	13,410	41	73,789	0
Jul	13,919	0	13,919	39	76,512	0
Aug	14,388	5	14,383	37	79,058	0
Sep	13,439	2	13,437	38	73,985	0
Oct	13,016	16	13,000	36	71,630	0
Nov	12,559	17	12,542	41	69,752	0
Dec	13,261	11	13,249	41	73,183	0
Annual	157,491	159	157,331	41	869,396	0

Figure 11. Monthly energy purchase and sold to the grid

PV and the inverters are included in the NPC. During day time, the excess energy of the load demand is sold back to the power grid and feed-in-tariff is obtained according to the tariff rate. Though, the consumers need to pay an increased COE/ kWh for this system comparing to the system model configured with grid only, figure 10 illustrates that this model supplied a total 33,644 kWh/ year from PV which is equivalent to 18% out of total energy supply to the consumers.

Comparing with the model where the total energy demand is satisfied by the grid only, the clean energy penetration is higher in this system. This effort will give support to the gradually reducing conventional energy sources. On the other hand, the amount of carbon emission will be reduced which will help to create a green and sustainable world. In this system, 20 kW solar photovoltaic and 20 kW converter have been used with 500 kW power grid connections. The amount of unmet load is zero and no excess electricity.

In figure 11, the energy purchased from the grid and sold back to the grid has been discussed month wise. The maximum amount of energy supplied by the solar PV to the power grid is done during the month of July (13,919 kWh) and minimum amount is supplied in the month of February (11,463 kWh). The total yearly supply of energy to the national grid by the solar PV is 157,331 kWh. This penetration will increase more and more with the development of the manufacture and efficiency of the solar PV.

5.3. Analysis of the model where energy is supplied by Grid connected PV with storage

The amount of solar radiation is not constant all throughout the day. Battery storage can be used to store the excess energy supplied by the solar PV for the later use when the solar radiation is low. Here in this study, the battery, that has been used is Surrette 6CS 25P with nominal voltage 6 volt and Maximum charge current 41 ampere.

PV (kW)	S6CS25P	Conv. (kW)	Grid (kW)	Initial Capital	Operating Cost ($/yr)	Total NPC	COE ($/kWh)	Ren. Frac.	Capacity Shortage
			500	$ 0	1,018,746	$ 14,358,153	5.430	0.00	0.00
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20	3	20	500	$ 10,970,800	2,910,912	$ 51,997,024	19.665	0.18	0.00

Figure 12. Optimization result from HOMER (model where energy is supplied by Grid connected solar PV with storage is highlighted), All the currency values were considered in terms of BDT (Bangladeshi currency) instead of $ (USD)

The most cost effective model, configured with the grid connected PV with storage battery, consists of 20 kW solar PV, 20 kW converter, 500 kW power grid connection and 2 storage batteries. Here, the COE/ kWh and NPC get increased when storage is added with the grid connected PV system. The more the battery is, the more is the cost. From the simulation in figure 12, it can be seen that the COE of this system is 19.604 BDT/ kWh and total NPC is 51,836,240 BDT. The amount of renewable fraction is 18% with no capacity shortage. Comparing the system with the grid connected PV without storage, this system is costlier. The total operation and maintenance cost and the total initial capital cost get also increased as the O&M and initial capital of the storage battery get included in NPC.

The amount of the energy, supplied by the solar PV per year stays constant for both of the models (grid connected solar PV with and without battery storage). However, this model ensures reliability and uninterrupted energy supply to the consumers end.

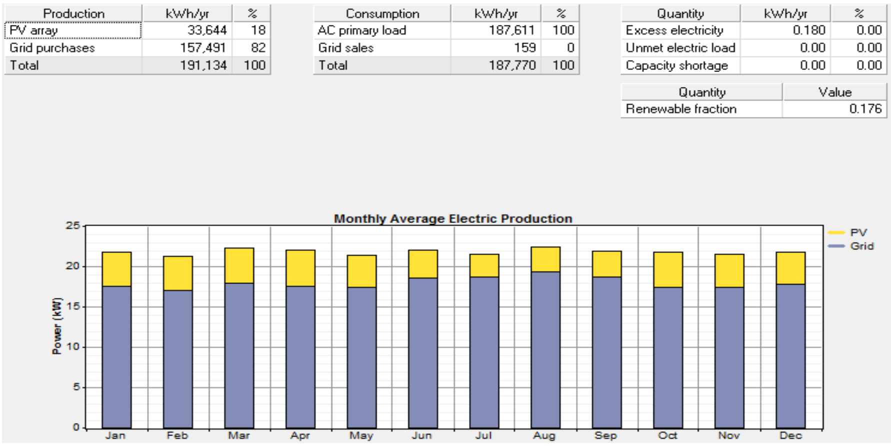

Figure 13. Monthly average electricity production of the grid connected PV system

VI. EMISSION ANALYSIS

Grid connected solar PV system provides much cleaner energy. As, a significant amount of energy is being supplied from the solar PV, the amount of burning of fossil fuel gets decreased. As a result, the amount of carbon emission in the atmosphere decreases accordingly. As there is no burning of fuels in the energy generation process of solar PV, this system is clean and environment friendly.

Table 5. Comparison of emissions among different models

Pollutant	Emissions (kg/yr)		
	Only Grid	Grid connected PV without storage	Grid connected PV with storage
Carbon dioxide	118,570	99,433	99,433
Carbon monoxide	0	0	0
Unburned hydrocarbons	0	0	0
Particulate matter	0	0	0
Sulfur dioxide	514	431	431
Nitrogen oxides	251	211	211

In table 5, we can see that, the amount of carbon emission, Sulfur dioxide and Nitrogen oxides emission for the system configured with grid only is respectively 118,570 kg/ yr, 514 kg/ yr and 251 kg/ yr. On the other hand, when the Solar PV is integrated with the power grid connection, the amount of carbon emission, Sulfur dioxide and Nitrogen oxides emission becomes respectively 99,433 kg/yr, 431 kg/yr and 211 kg/yr. So, integration of renewable energy system with the power grid reduces the yearly amount of GHG emissions.

VII. FUTURE WORKS

The amount of PV penetration into distribution grids is increasing rapidly. As a result, the effects of high penetration of solar PV on operating characteristics of the overall power system and fault analysis has become significant. Future work will deal with assessing the impact of PV penetration on system protection and developing mitigating strategies on a large interconnected system.

VIII. CONCLUSION

Recent IEA and other scenarios [40] have demonstrated that a large basket of sustainable energy technologies will be needed to address the challenges of moving towards clean, reliable, secure and competitive energy supply.

This paper proposes an optimized model for grid connected solar PV which will be cost efficient and environment friendly for Bangladesh. This paper also shows the economic analysis and environmental impact of different grid connected solar photo voltaic system models. The simulation based test result also indicates that the carbon emission and other pollutants due to energy generation process are much higher when the energy is supplied by grid only. The integration of renewable energy systems lessens the amount of emissions. Large integration of renewable energy systems into power grid may solve the problem of unmet energy demand in a sustainable way in Bangladesh.

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