Hybrid Renewable Energy System for Sustainable Future of Bangladesh

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Abstract– Bangladesh is the 7th largest population (164.4 Million) and 12th density of population (1034/km2) country in the world. Bangladesh is one of the most electric deprived countries. Electric energy protection is performed of decreasing the quantity of energy used in day by day. Bangladesh is a developing country, so their demand of electricity increases tremendously. Energy preservation is the result of financial capital increase of the country and also increases the environmental values. In Bangladesh maximum electric energy generated by Fossil Fuel, Gas, Coal, which is created air and water pollution and also negative impact on global calamity. That's why the peoples are focus on renewable energy generation system. Non renewable energy source like Fuel, Gas, Coal are limited and it is important to reserve this sources for our future generation. There is large prospective for renewable energy source in Bangladesh, currently their contribution to the electric supply remaining insignificant compare to our total supply (1% only). The main objective of this research paper is to develop an alternative energy generation technique such as "Hybrid Renewable Energy System (HRES)" for sustainable future. When HRES is used in remote area, diesel generator will be coupled with the system for reliability. In this paper, I analyzed 'Wind + Diesel-Generator + Battery', 'Photovoltaic (PV) + Diesel-Generator + Battery' and 'Wind + Photovoltaic (PV) + Diesel-Generator + Battery' HRES is very much essential and useful for rural and isolated Island areas of Bangladesh.

Keywords– Bangladesh, Gridline, HOMER, Hybrid System, Photovoltaic, Solar cell.

1. Introduction

About 80% of the total population of Bangladesh lives in rural areas. Bangladesh governments are facing the tremendous social, economic and political pressure to solve power crisis. In Bangladesh, highest generation of electricity is 4699 MW; however, demand is 6500 MW and population under electricity coverage only 49% [1]. In general, rapid industrialization and urbanization has propelled the increase in demand for energy by more than 8% per year [2]. The government of Bangladesh has declared that it aims to provide electricity for all by the year of 2020. It has become seriously important to look for energy solutions outside the conventional sources like domestic Natural Gas, Coals, Hydroelectricity and Imported Fuels. The natural oil and gas are rapidly decreased due to excessive consumption. Extreme competition and instability of fuel price in the global energy market is continuously hammering the small players like Bangladesh. Discounted petroleum supply from friendly countries, reliance on domestic natural gas, and subsidize fuel supply to the public and private sectors are not longer politically and economically viable options for any country. Global warming and the subsequent increase of the sea level and natural calamities due to excessive carbon emission from fossil fuels are causing severe environmental and ecological havoc for low-lying countries like Bangladesh. The most feasible way out of this multi-dimensional crisis is to increase our reliance on renewable energy. Comparative analysis of the current and projected cost of electricity from conventional and renewable sources it is clear that renewable

power is expensive. Due to other convincing reasons Germany, China and other developed nations are promoting and subsidizing renewable power to supply more than 20% of their total power usage. Because of nuclear power is very sensitive technology and most risky. Coal and gas are not environmentally friendly due to the resulting green house effect. Hydroelectric power is very good, but few countries have sufficient and suitable inland water bodies to install hydroelectric power plants. Bangladesh has only one hydroelectric power plant at Kaptai and capacity is 230MW. Due to high cost of transmission and distribution a large number of rural people have not been connected to the gridline. HRES is the most valuable way to solve these problems.

The intention of this paper to determine the optimum size of system able to requirement of 50 KWh/day primary load HRES plant with 11 KW peak load for 50 house hold for three remote sites located at Cox's Bazar, Sylhet and Dinajpur. The technique applies for simple and useful approach for sizing and analyzing the HRES using Hybrid Optimization Model for Electric Renewable (HOMER) shown in Fig.1.

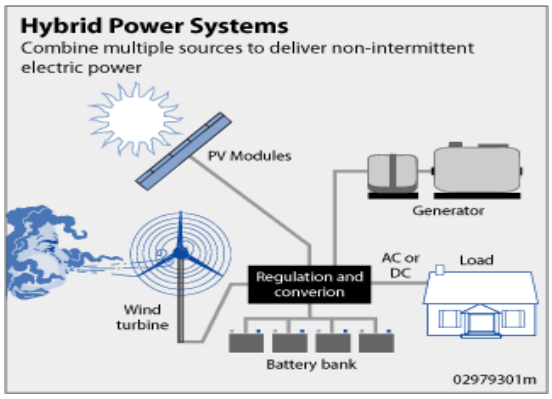

Fig.1. Hybrid Renewable Energy System

The aim is to design of the plant for system reliable and cost effective. Bangladesh is situated between 20.30 and 26.38^0 north latitude and 88.04 and 92.44^0 east longitude, which is an ideal location for solar energy. Monthly solar radiation varies between 3.8-6.5 KWh/m^2 [3] shown in Fig.2. The average sunshine our in a day is shown in Fig.3.

2. Methodology

The study areas contain a coastal area like Cox's Bazar (21.4^0 north latitude and 92^0 east longitude) for Wind and Solar potential and other two sites where the average solar radiation is lower but considerable like Sylhet (24.9^0 north latitude and 91.9^0 east longitude) and higher like Dinajpur (25.6^0 north latitude and 88.6^0 east longitude). From the data of National Aeronautics and Space Administration (NASA), the wind speed is too low for power generation at these two sites. HOMER is the renewable energy based system to develop by the US National Renewable Energy Laboratory (NREL). HOMER is HRES design software.

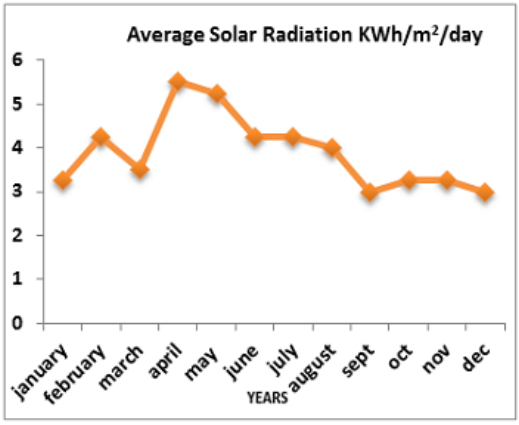

Fig.2. Monthly average solar radiation in Bangladesh

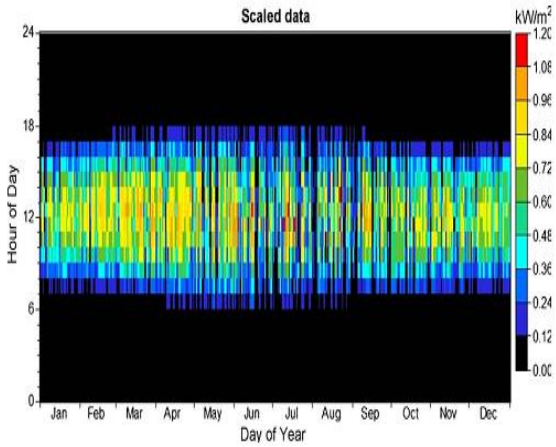

Fig.3. Monthly average sunshine hours in Bangladesh

HOMER input data are electrical load, renewable resources, component technical details/costs, limitations, controls, type of dispatch strategy etc. The software designs an optimal power plant to serve the desired loads and perform thousand of hourly simulations for ensure the best possible matching between supply and demand. HOMER analyses where the value of certain parameters (e.g. diesel price) can be varied to determine their impact on the cost of energy for the system in question [4]. In HOMER the effective value will vary on the bases of wind speed, solar radiation and electric load. HOMER makes the economical analysis and present cost. HOMER produces the solar radiation values for 8760 h of the year by using Graham algorithm. This algorithm creates realistic hourly data and it is easy to use because it requires only the latitude and monthly average values. Synthetic solar data produce virtually the same simulation results as real data [5]. The annual average solar radiation based on NASA at Cox's Bazar, Sylhet and Dinajpur are 4.77 KWh/m^2/day, 4.57 KWh/m^2/day, and 4.99 KWh/m^2/day respectively. The most important factor is temperature but also dust and wiring losses also have a small effect on PV array. The efficiency of

PV array is inversely proportional to temperature and linearly proportional to the incident of solar radiation. The PV energy is expressed by:

$$P_{PV} = f_{PV} * Y_{PV}(\frac{I_T}{I_S})$$

Where f_{PV} is the de-rating factor, Y_{PV} is the total installed capacity of PV array, I_T is the solar radiation and I_S is the incident radiation at standard test condition. Consider of 50 families each of five members for the rural area where grid network isn't connected. A rural household generally uses electrical energy for lighting, cooling and entertaining [6]. The load is 3 energy lamps 15W each, 2 fans 40W each and 1 TV 40W for each family. Fig.5 has shown the different types of load for Solar Home System (SHS). The energy consumption pattern normally varies over 24h and over different months.

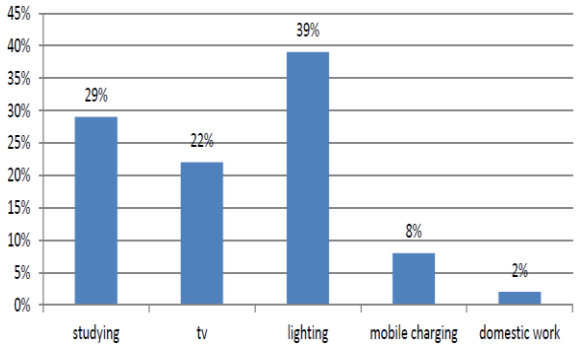

Fig.5. Different types of load in Solar Home System

HOMER's synthetic wind speed data generator is a little more different to use than the solar data because it requires four parameters [5] like weibull (k) value, autocorrelation factor, diurnal pattern strength and hour of peak wind speed. NASA based wind speed data for the location of Sylhet and Dinajpur are low and wind speed average values for Cox's bazaar is considerable for HOMER simulation shown in Fig.6. Establishment cost of wind turbine power plant is very high. The nature of wind speed of Bangladesh is nonlinear and the speed vary up to 150 km/h normally, so the plant should be strong and that will be increase the establishment cost.

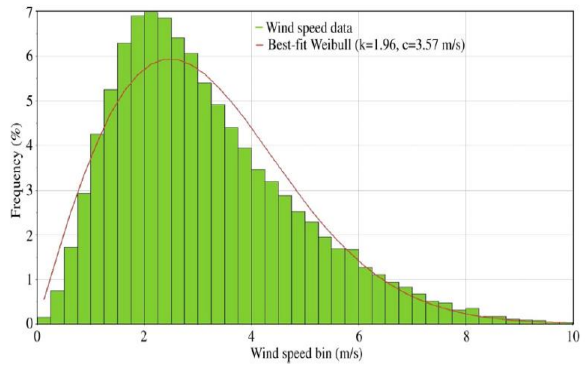

Fig.6. Wind speed data system by HOMER

HOMER calculated daily load profiles and adding daily 10% noise. These have annual peak load to 11 KW and primary load to 50KWh/day. In summer season the incident of solar radiations are maximum and it is helpful to satisfy the peak demand in summer season for cooling fans.

The proposed hybrid system for Cox's Bazar is PV + Wind + Diesel-Generator + Battery and for Dinajpur and Sylhet PV + Diesel-Generator + Battery. Consist of two generators 5 KW and 10 KW, battery and converter. The operation strategy is follows:

►Normally Solar PV feeds the load for Sylhet and Dinajpur sites.

►Solar PV and Wind turbine feeds the load for Cox's Bazar site.

The excess energy stored in the battery. Two diesel generators are in online when PV or PV + Wind fail to satisfy the load and Battery storage is depleted the Generators will be run one by one.

3. Result and Discussion

HOMER provides the result in terms of optimal system and sensitivity analysis for long time. Here optimized results are presented depend on solar radiation, wind speed, diesel price, annual capacity shortage and renewable energy fraction. HOMER gives the opportunity to design a cost-minimizing power system that provides a tailor-made power supply for the specific load demand [7]. A key objective is to compare the cost of energy (COE) and the Green House Gas (GHG). A HRES of 6 KW PV array, a 10 KW diesel generator and 10 storage battery in addition to 5 KW converter is found to be most feasible system with a minimum total net cost 6.56 million Taka, COE of 25.41 Tk/kWh [8], (1 USD= 80 Taka). The PV + Diesel-Generator + Battery HRES is most economically at all investigation. Due to the low intensity of wind speed wind hybrid isn't selected for Bangladesh except Cox's Bazar. One environmental externality, electricity generation by fossil fuel the carbon dioxide (CO_2) is most harmful for GHG. The diesel generator system being used at the selected sites are considered and HOMER calculate that a total of 24681 kg/year of CO_2 adds into the local atmosphere of a village consist of 50 families based on the diesel's lower heating value 43.2 MJ/kg, density 820 kg/m^3 and carbon content 88%. The PV + Diesel Generator + Battery system can bring down the quantity of CO_2 to 15421 kg/year with 40% renewable energy fraction. So a reduction of CO_2 is around 38% in every year.

4. Conclusion

This paper mention that the selected places blessed with a considerable annual average global solar radiation (3.81 to 6.47 KWh/m^2/day) are prospective candidate for establish PV + Diesel Generator + Battery HRES. The HOMER's result mention that for all selected location are most economically feasible system for 50 rural off-grid households. The system contains 6 KW PV array, 10 KW diesel generator and 10 numbers of battery which each has 2 voltage and capacity of 800Ah. The renewable energy fraction is 43%. The diesel price is gradually increasing in Bangladesh like, 2010 diesel price was 45 Taka/L and 2012 diesel price is 61 Taka/L. On the other hand the solar PV panel, circuit, converter, lamp etc price are decreasing gradually and unit price of gridline electricity is increasing day by day. So HRES cost of energy become more and more cost effective in day by day compare with gridline power unit price. This study also indicate that isolated Island remote locations in Bangladesh are prospective candidates for the establishment of PV + Diesel Generator + Battery HRES for power generation because of available of solar radiation and quite impossible to connect with gridline. Using this HRES for electricity generation the Diesel Generator runs very short time compare with only Diesel Generator system. It is not only reduces the cost of COE but also reduces the environmental pollution by dropping down the CO_2 emissions which will be stable our global calamity.

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