Global Journal of Science Frontier Research
Physics and Space Sciences
Volume 12 Issue 5 Version 1.0 Year 2012
Type : Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 2249-4626 & Print ISSN: 0975-5896

Design, Analysis and Performance Study of a Hybrid PV-Diesel - Wind System for a Village Gopal Nagar in Comilla

By M.M Hoque, I.K.A Bhuiyan, Rajib Ahmed, A.A .Farooque & S.K Aditya

University of Dhaka, Bangladesh

Abstract - In this report, a hybrid power system has been designed considering photovoltaic, wind turbine generator and diesel generator. HOMER software has been used for analyzing the performance of the system. Different performance analysis like feasibility, sensitivity, cost, and sustainability has been done. Environmental and economic analysis is used to discuss the sustainability of a hybrid power system. Primary ac loads for 24 hours, solar resource and wind resource inputs for a year are used. Analysis reveals that the hybrid system with photovoltaic, diesel generator, wind turbine give better performance in terms of cost and sensitivity.

Keywords : Hybrid Power System, Renewable energy, Sustainability, HOMER, Photovoltaic.

GJSFR-A Classification : FOR Code: 850599

DESIGN, ANALYSIS AND PERFORMANCE STUDY OF A HYBRID PV-DIESEL-WIND SYSTEM FOR A VILLAGE GOPAL NAGAR IN COMILLA

Strictly as per the compliance and regulations of :

Design, Analysis and Performance Study of a Hybrid PV-Diesel- Wind System for a Village Gopal Nagar in Comilla

M.M Hoque [α], I.K.A Bhuiyan [σ], Rajib Ahmed [ρ], A.A .Farooque [Ѡ] & S.K Aditya [¥]

Abstract - In this report, a hybrid power system has been designed considering photovoltaic, wind turbine generator and diesel generator. HOMER software has been used for analyzing the performance of the system. Different performance analysis like feasibility, sensitivity, cost, and sustainability has been done. Environmental and economic analysis is used to discuss the sustainability of a hybrid power system. Primary ac loads for 24 hours, solar resource and wind resource inputs for a year are used. Analysis reveals that the hybrid system with photovoltaic, diesel generator, wind turbine give better performance in terms of cost and sensitivity.

Keywords : Hybrid Power System, Renewable energy, Sustainability, HOMER, Photovoltaic.

I. Introduction

Energy is the basic requirement of modern life-style. As a developing country, Bangladesh has been encountering difficulties in supplying energy to maintain its large population & economic growth. The current demand for energy exceeds the available resources. Now, it is the time to think alternative energy source. Therefore, Renewable Energy can be alternative to the fossil fuel. Renewable Energy is clean, green, free, pollution less, endless energy source [1].

From current Energy scenario of Bangladesh, total power generation 4500MW, demand 6000 MW and shortage 1500 MW. The resources of total power generation are Gas (81.43%), Furnace Oil (5.43%), Coal (4.77%), Hydro (4.39%), Diesel (4.08%) [2,10].

Majority of rural households in Bangladesh are deprived of steady electricity supply from national grid. Based on national energy policy at least 15% of the energy mix should be based on renewable energy with in 2025. For this the development an isolated systems is needed in the remote areas with the utilization of local energy resources such as Micro, Hydro, Wind, PV etc through stand alone Hybrid system.

Bangladesh is situated between 20°34' and 26°38' north latitudes and 88°01' and 92°41' east longitudes with nearly 162 million people living on 144,000 km^2 land area. Gopal Nagar is a village which is geographically situated in Comilla Zilla, Chittagong Division, Bangladesh, Asia and its geographical co-ordinate is 23°40'0" North, 91°0'0" East, is a suitable place for designing stand-alone hybrid power system because this is not possible to establish grid connected system in this rural area. For ensuring steady and continuous electricity generations, a hybrid power system (HPS) including more than one renewable energy elements is introduced. In this paper, environmental and economic analyses are used to discuss the sustainability of a hybrid power system. An investigation is made on small-scale operations of 100kWh per day HPS as a stand- alone power generation system consisting of solar (photovoltaic) and wind energy [3-8].

II. Hybrid Power System

Hybrid power system combine two or more modes of electricity generation together, usually using renewable technologies such as Solar Photovoltaic (PV) & Wind turbines. Hybrid systems provide a high level of energy security through the mix of generation methods and often will incorporate a storage system (battery & fuel cell) or small fossil fueled generator to ensure maximum supply reliability & security. Wind turbines & Solar panels are the most well known of the renewable energy devices used in hybrid power systems. Village hybrid power system can range in size from small household systems (100Wh/day) to ones supplying a whole area (10MWh/day).Village scale hybrid power system can be distinguished into two Micro grids and Mini grids . The components of Micro-Grid (100 kWh/day) power system are wind, PV, Batteries and conventional generator which provide DC power .Mini-Grid power systems (700 kWh/day) uses the same components ,just more of them and larger to provide AC power .The various combinations of hybrid system are PV-Wind, PV-Fuel cell, PV-Wind –Fuel cell, PV-Wind-Battery etc. Hybrid system provide certain advantages over a single resource like lower energy cost ,high reliability, low maintenance, flexibility, longer equipment life and utility grade potential [4-8].

Author α σ ρ Ѡ ¥ : Dept. of Applied Physics, Electronics & Communication Engineering, University of Dhaka, Dhaka-1000, Bangladesh. E-mails : mohammad.hoque64@gmail.com, mithu_apece.du@yahoo.com, rajib.ahmed.apece@gmail.com, dipu6174@gmail.com, aditya@univdhaka.edu

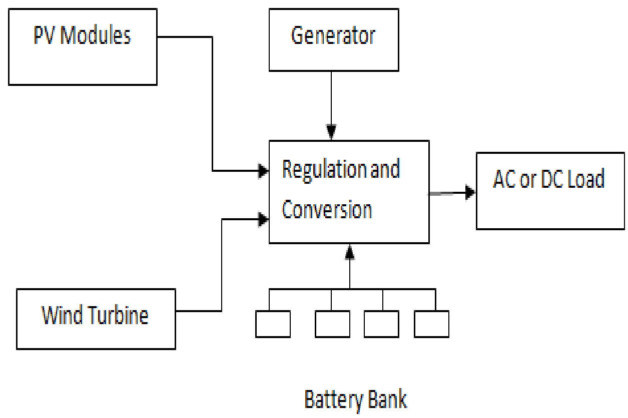


Figure 2.1 : General block diagram of a Hybrid Power System

III. Simulation Setup

We used HOMER (Hybrid Optimization for Electric Renewables) software for modeling Hybrid PV-Diesel-Wind System for a Village Gopal Nagar in Comilla. This program allows for flexible renewable energy hybrid system design using a library of components that can be inserted into the system, including a diverse set of electricity generators, energy storage, and load options. HOMER models off-grid and grid-connected power systems, comprising wind, solar, hydro, biomass and conventional power sources. Renewable as well as conventional power generating technologies can be modeled through HOMER. This model can analyze standalone PV-wind-fuel cell system. The DC power produced from PV arrays and the fuel cell is converted into AC power and then fed to the AC Bus. The AC power generated from the wind turbines is directly fed to the AC Bus. Excess power goes to the Battery bank and is utilized by the fuel cell in case of lack of generated power from Wind or PV sources. The system architecture simulated in HOMER is shown in figure [3.1] [9]

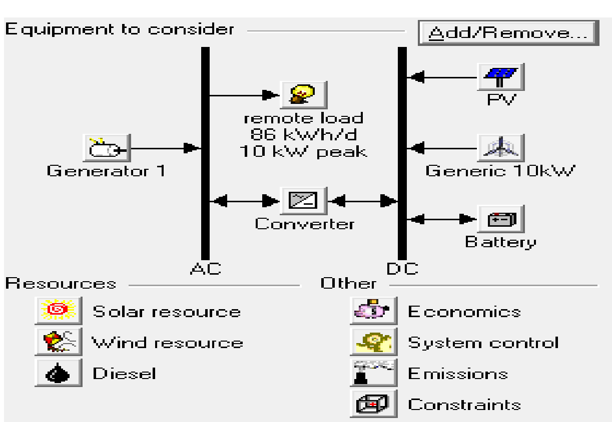


Figure 3.1 : Hybrid System Architecture

The equipments that we used in our simulator are wind turbine (1kW), PV array (1kW),diesel generator (15kW), battery (72 ah) and converter (12kW) .The simulation parameters are used as project lifetime (15 years), Wind resource(Comilla Bangladesh) and Solar resource (Comilla Bangladesh), daily noise to the load (15%), hourly noise to the load (20%), WTG life time (15years), Solar PV life time (20 years), Battery floating life time (4 years) ,Converter life time (15 years) Diesel generator life time (15,000 hours), Diesel price at site (42 taka/liter) and Reduced Carbon/GHG emission.

Figure 3.2 shows the primary ac load inputs for the month of January in 2011 with annual average load of 85.0 kWh/d, annual peak load 8.18 kW and load factor 0.433.

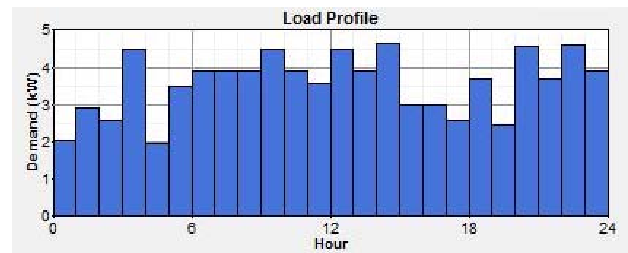


Figure 3.2 : Primary ac load inputs for the month of January in 2011 (Gopal Nagar, Comilla)

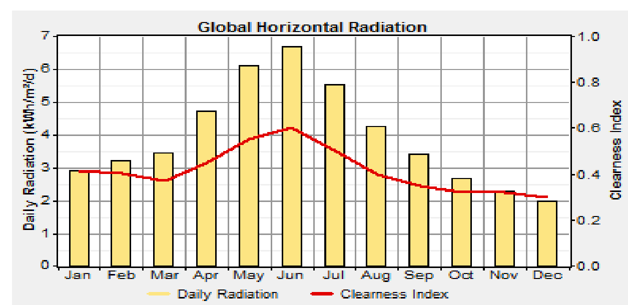


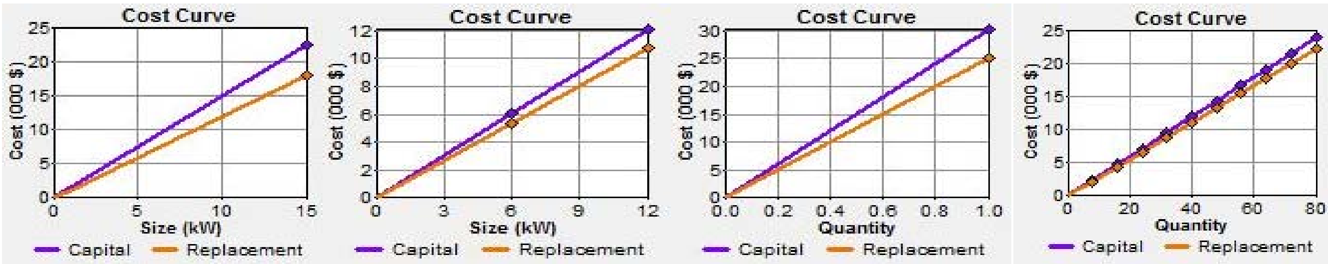
Figure 3.3 : Solar Insolation Data for a Year

Solar insolation data is presented in figure 3.3. Clearness index is low in Sep-Dec at Gopal Nagar due to frequent cloudy and foggy data. Average annual solar insolation is only 3.5 kW/m^2 /day.

The cost curve which the indication of capital cost and replacement cost is shown in figure 3.4 for Generator (A1), Converter (A2), Wind Turbine (A3) and Battery inputs (A4).

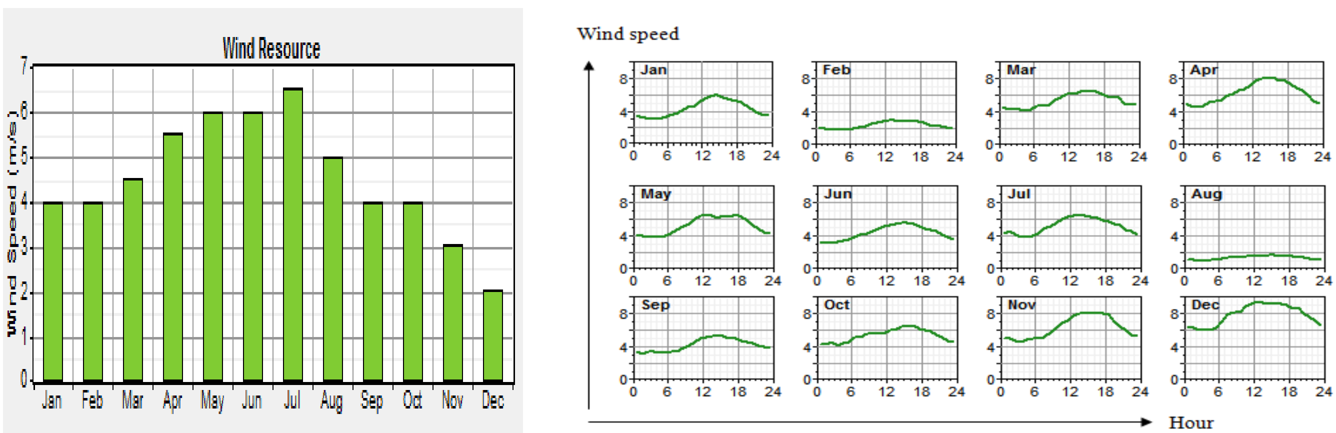
One year wind speed data is presented in figure 3.5(B1). It shows wind speed is low in Cartwright. Annual average wind speed is only 5.02m/s. Wind speed histogram follow the bell shape distribution fit is shown in figure 3.4. Moreover, wind speed profile for each month of year 2011 is shown in figure 3.5(B2).Wind resource is much lower than our initial expectation.

The "optimal system" determined by HOMER depends on the input assumptions. Key assumptions for the price of different components of Hybrid system are summarized in the table1 bellow:



(A1) (A2) (A3) (A4)

Figure 3.4 : Cost Curve for Generator (A1), Converter (A2), Wind Turbine (A3) and Battery inputs (A4)



(A1) (A2)

Figure 3.3 : Wind Resource Inputs (A1) and Wind Speed Profile in 2011 (Gopal Nagar, Comilla)

Table 1 : Cost of Different Equipments for the Hybrid System

Parameter	Capital Cost(taka)	Replacement(taka)	O & M(taka)
Generator	25000 BDT/kW	20000 BDT/kW	0.7 BDT/hr
PV module	300,000 BDT/kW	250,000 BDT/kW	500 BDT/year
Wind Turbine	130,000 BDT/kW	100,000 BDT/kW	500 BDT/year
Converter	27,000 BDT/kW	22,000 BDT/kW	50 BDT/year
Battery	7,000 BDT/kWh	6,000 BDT/kWh	50 BDT/year
Diesel	42/lit		
Others	20,000 BDT/kW		

IV. Result Analysis

We have analyzed the Hybrid Power System with HOMER software. Homer optimization results indicate that the hybrid system capable of producing lowest cost electricity should consists of one Generic 10 kW wind turbine, one PV array,15 diesel generator, 32 Batteries and 6 bidirectional converter to link ac and dc bus. Figure 4.1 shows the simulation result of HOMER.

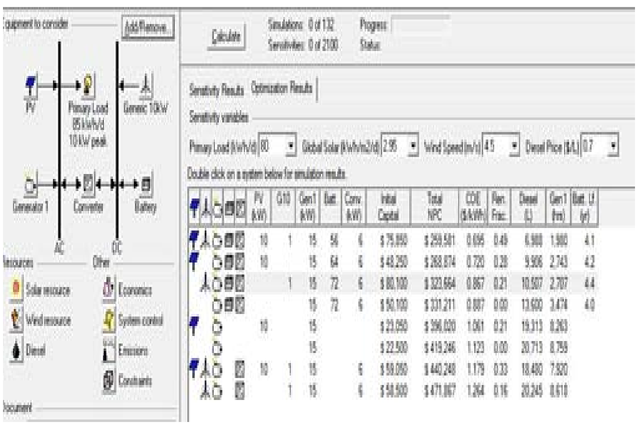


Figure 4.1 : Simulation Result from HOMER

Form the simulation we see the different values of cost of energy (COE) for different combination of PV, Wind, Generator, Converter and Battery. Finally, we can infer that the lowest cost of energy (COE) is found from the first combination (PV–Wind–Generator–Converter-Battery). Initial cost of such a system would be about 35 lac and it will produce electricity (39396 kWh/yr) at a cost of 58 taka per kWh. Therefore the total amount of annual income is 2284968 taka (39396 *58) and payback period is about 15 year. Such a system would result in a renewable energy fraction of 30% using about only 10840L/yr diesel and hence saving a huge amount of it. Excess electricity is only about 3% in this case as shown in Figure 4.2. Moreover the contribution of PV, Wind, and Diesel on our proposed Hybrid system is shown in Table1.

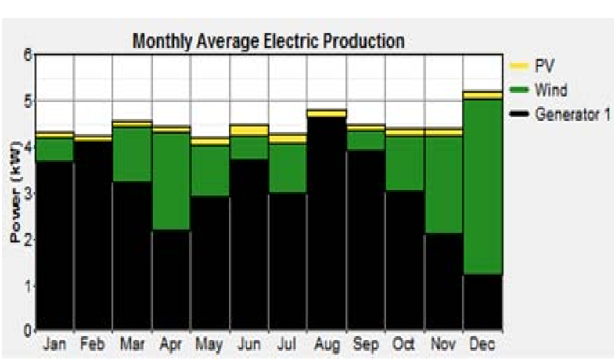


Figure 4.2 : Electricity Production (Yearly)

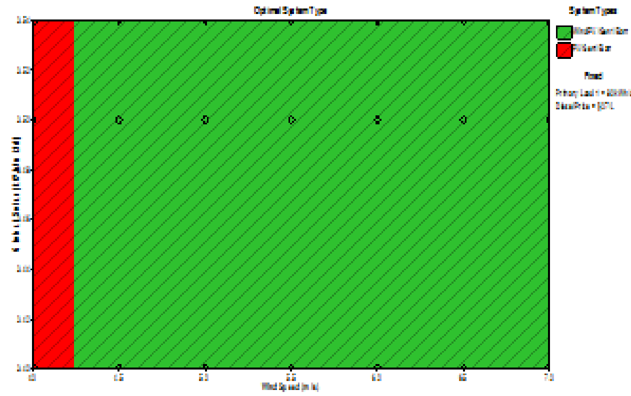


Figure 4.3 : HOMER Optimization

From HOMER Optimization (Figure 4.3) we see that the green part is much wider than red part for primary load 80kWh/day with diesel price $.7/L. The green part means the contribution of PV,Wind,Generator and Battery on sensitivity for the hybrid system. On the other hand, red part for PV, Generator and Battery. Therefore we can infer that the system is more sensible.

V. Further Development

- We have just simulated the Hybrid power system but practical implementation is needed and problems are encountered during implementation should be overcome.
- Practically we don't get sufficient energy from photovoltaic, therefore further investigation should be made for more efficient Hybrid system.
- Detailed economic analysis of the hardware will be carried out with respect to the capital cost and the availability of the wind & solar resources.
- It is also suggested that energy conservation measures should be taken in Gopal Nogor and the possibility of electricity generation using local wood should also be studied.

VI. Conclusion

The result obtained through HOMER simulation is considered as promising. The excess load is only 5% and there is no capacity shortage and unmet load is also fractional which is assumed to be zero. Moreover, the payback period of the system is about 15 years. This are excellent findings. The environmental friendly nature of the hybrid system can also be depicted from the annual emission of the system. However, as the consideration of the equipments was done optimistically for the desired house load , further detailed economic analysis is required for practical implementation .

References Références Referencias

1. Duffe J.A, Beckman W. A.," *Solar Engineering of Thermal Processes*", New York: John Willey and Sons, 1980.

2. Muhtasham Hussain, Md. Shafiuzzaman Khan Khadem, Himangshu Ranjan Ghosh, "Final Report of Solar and Wind Energy Resource Assessment (SWERA) - Bangladesh Project", Renewable Energy Research Center, University of Dhaka, Bangladesh, February 2007.
3. www.maplandia.com/bangladesh/chittagong-div/comilla-zl/gopalnagar-23-36-0-n-91-5-0-e/
4. Saheb-Koussa, D., M. Haddadi, and M. Belhamel, Economic and technical study of a hybrid system (wind-photovoltaic-diesel) for rural electrification in Algeria. Applied Energy, 2009. 86(7-8): 1024-1030.
5. Shaahid, S.M. and I. El-Amin, Techno-economic evaluation of off-grid hybrid photovoltaic-diesel-battery power systems for rural electrification in Saudi Arabia-A way forward for sustainable development. Renewable and Sustainable Energy Reviews, 2009. 13(3): p. 625-633.
6. Shaahid, S.M., et al., Potential of autonomous/off-grid hybrid wind-diesel power system for electrification of a remote settlement in Saudi Arabia. Wind Engineering, 2004. 28(5): p. 621-628.
7. Elhadidy, M.A. and S.M. Shaahid, Feasibility of hybrid (wind+solar) power systems for Dhahran, Saudi Arabia. Renewable Energy, 1999. 16(1 -4 pt 2): p. 970-976.
8. Shaahid, S.M. and M.A. Elhadidy, Wind and solar energy at Dhahran, Saudi Arabia. Renewable Energy, 1994. 4(4): p. 441-445.
9. HOMER - Getting Started Guide for HOMER Version 2.2 2011, National Renewable Energy Laboratory, Operated for the U.S. Department of Energy Office of Energy Efficiency and Renewable Energy.
10. http://www.usaid.gov/bd/programs/energy_response.html#more