PERSPECTIVE OF BIODIESEL & SOLAR PV AS A COMBINED RENEWABLE ENERGY SYSTEM FOR RURAL ELECTRIFICATION USING HOMER

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Abstract

The power generation method is more over traditional and supply of electricity is decentralized which is considered a single line technology based on limited supply devoid of considering rural consumer's point of view. The main aspect of this paper is to propose the best possible outcome as a combined power system for rural electrification from a combination of renewable resources to complete the electrical demands in a consistent manner of an off grid remote village Bakri, in the district of Jhenaidah, Bangladesh. Renewable energy resources namely solar photovoltaic cell and bio-diesel generators are considered here. The paper estimates the residential demand in the pre HOMER analysis. Using simulation software named HOMER scrutinizes the maximum outcome. It also clarifies that our proposed combine power system is cost effective techno-economically & environmentally sound and last but not the least sustainable. Here HOMER observes a number of simulations and gives us a set of systems for rural electrification requirement of 147 kWh/d and 10kW peak load.

Keywords: *Rural electrification, Combined Power System, HOMER, Bio-fuel generator, Solar PV.*

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1. INTRODUCTION

More than 75% of total population lives in rural area in Bangladesh. No doubt Bangladesh has lack of grid network and electric generation to satisfy the demand of 100% electrification (Uddin and Taplin, 2006). Only 31.2% of the total population is connected to grid capacity (about 80% of urban and 23% of rural households) with vast majority being deprived of a power supply (BBS, 2000, 2008). The particular area that we desire to electrify is a remote area located at $23^0$33' North latitude and $89^0$10' East longitude. Almost 500 inhabitants live there. Traditional power systems are some crucial disadvantages at rural area especially for developing country like Bangladesh, Srilanka, Cameroon, Malaysia and some other countries in Indo Sub-continent & African Nations.[1] Main drawback of this system is scarcity of fossil fuels eg. Oil, coal , Natural Gas. Secondly maintenance & erection cost of such power plant is very expensive. As a result per unit cost (PUC) of power is comparatively higher than the system we proposed in this paper. Our proposed combined system is not only cost effective but also environment friendly too. In this paper we use simulation software named HOMER (Hybrid Optimization Model for Electric Renewable) for finding out the best possible outcome & combination for the system where cost minimization gets priority. At first we pick our desired resources (Solar cell & Bio-fuel) & complete the combination & load Calculation for entire population of a rural area corresponding to summer and winter season. Working module and raw data from embedded HOMER database are set in the application and our module is ready for analysis.

1.1 Physical Scenario of Power Sector in ASIA

Power is a boon to the modern civilization. Production and consumption ratio of power in recent years shows abrupt features in power scenario. Generating power from fossil fuels is well traditional but the problem is its resources are very limited. So changing of load consumption in each year we must have to find an alternative power source. From year 2010 to 2013 power production was 3774 Mtoe (Million tons of Oil Equivalent), 3931 Mtoe, 4032 Mtoe, & 4116 Mtoe respectively as well as primary consumption was 4841 Mtoe, 5060 mtoe, 5258 Mtoe & 5439 Mtoe respectively for Asia Continent[2].It clearly shows that the primary production rate is less than that of power consumption. Combined power system which is combination of solar cell, hydro and Bio-fuel plays a vital role to reduce the dependency of fossil fuels.

2. HOMER TECHNOLOGY

HOMER, the micro power optimization model, simplifies the evaluating tasks designs of both off-grid and grid-connected power systems. After a large number of hourly simulations for a certain arena considering some parameters and component prices HOMER designs the most optimized and cost effective combined generation system. We have to provide the load profile, solar radiation data & prices of the system components to the software. Software calculates thousands of hourly simulations and offers us an optimized system. For observing the impact of changes of the parameters such as, PV investment cost variation, fuel price & component's price variation can also be done. HOMER simulates the operation by balancing the energy calculation for 8760 hours in a year. In this system we include batteries or fuel-powered generators and HOMER decides for each hour how to operate the generators and whether to charge or discharge the batteries. Considering this entire phenomenon HOMER displays a list of feasible outcomes sorted by COE (sometimes called cost of energy) that can be used to compare the design.

3. COMBINED RENEWABLE ENERGY SYSTEM

There are some of energy resources that can be used as renewable resources. Not only these resources are environmentally friendly but also harness natural process. It helps to minimize the negative effects of certain forms of pollution. It described as a cleaner source of energy. If we list some renewable resources it comes out as Tidal, wave power, Solar Power, Wind power, Radient energy, Geo thermal energy, Nuclear power, compressed natural gas, Biomass etc [12]. Among these resources we take Biomass which is converted to Bio-fuel that runs bio-diesel generator and solar photovoltaic cell in this study. A combined generation system mainly consists of electrical load, renewable energy sources, and other components such as PV array, batteries, bio-diesel generators, converter etc. Figure 1 expresses the complete combined renewable system.

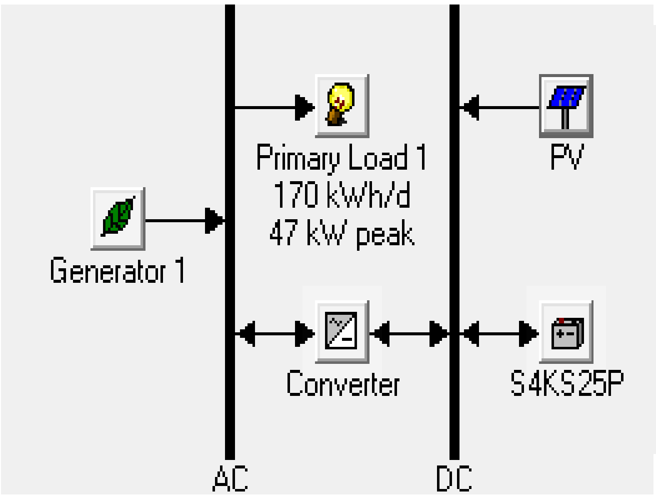

Fig -1: Complete combined renewable energy system

3.1 Electrical Load Distribution

We assume our load calculation for 100 families in a village of a rural area where 500 people live. We divide our load into two segments. One is for summer and another is for winter season. In a summer season each family occupies 5 energy bulb for 4 hours, 2 ceiling fans for 13 hours and a water pump for half an hour. And in winter season all electrical load will be same except there will be no ceiling fan load. And in Additive at winter season we will run a cold storage (11 ft X 8ft X 6ft) because plenty of power is unutilized. Around 170kWh/d load for annually and in weekly 47kWh/d is considered in this system.

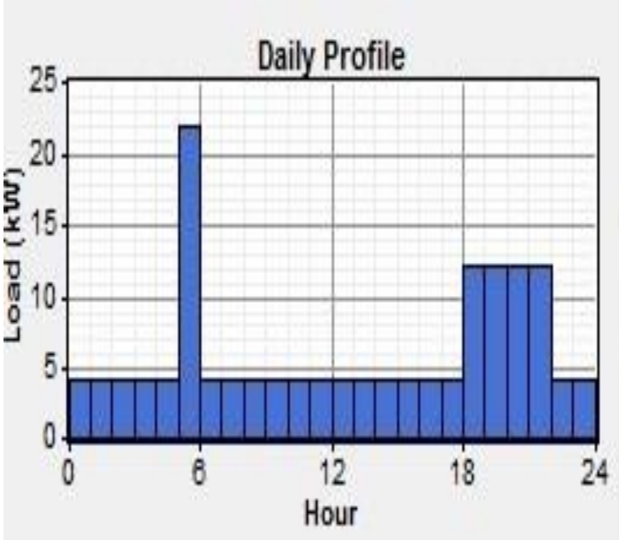

Fig -2: Daily Electric load

3.2 Solar Energy

HOMER combines solar radiation values for each of the 8760 hours of the year. The Graham algorithm exist an authentic collection of data and it is very convenient to use because it requires only longitude and latitude and monthly average values of that particular area that we concern. This practical data are measured with certain statistical properties that reflect global average value. So generated data will not as accurate as solar radiation needed to but tests illustrate that obtained data generate virtually the same simulation results as real data (Demiroren and Yilmaz, 2010). Monthly average global radiation data is collected from NASA (National Aeronautics and Space Administration) [3] for this paper.

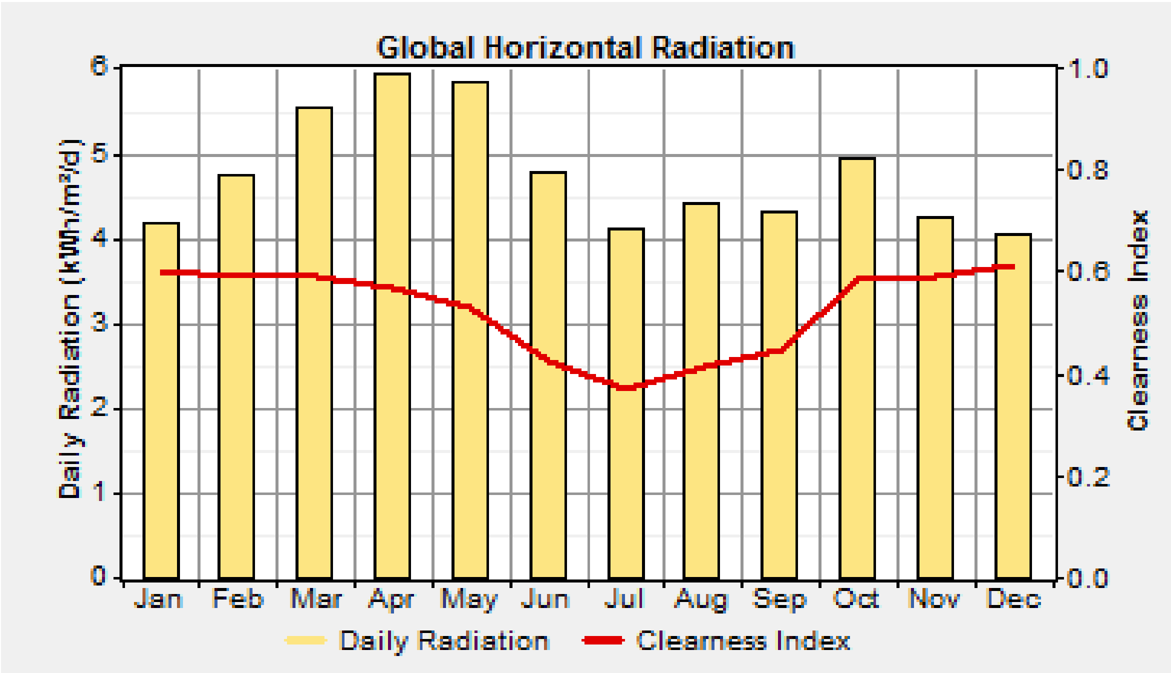

Fig -3: Solar Radiation profile throughout year

3.3 Bio Technology

Biodiesel is a Bio-fuel made from living or recently living organisms such as algae, animal fats, animal waste or vegetable oils and can be used in diesel engines without the need for engine modification. Biodiesel is biodegradable and a cleaning and lubricating agent which helps increase the life of diesel engines.

Biodiesel production & marketing has several segments which is strongly required for better performance. At first we must have to select crop or animal waste or raw product that provide us more & more vegetable oil from where we can produce the finest quality of Biodiesel. After collecting that particular oil we have to charge methanol & catalyst which creates Methoxide and Tritrate oil. By blending that oil and methoxide transesterification is performed to convert vegetable oil to biodiesel. Here we may sell our byproduct which is Glycerin. At last after completing the ASTM D6751 standard specification for biodiesel fuel blend stock we are ready to use our Biodiesel. [6],[11]

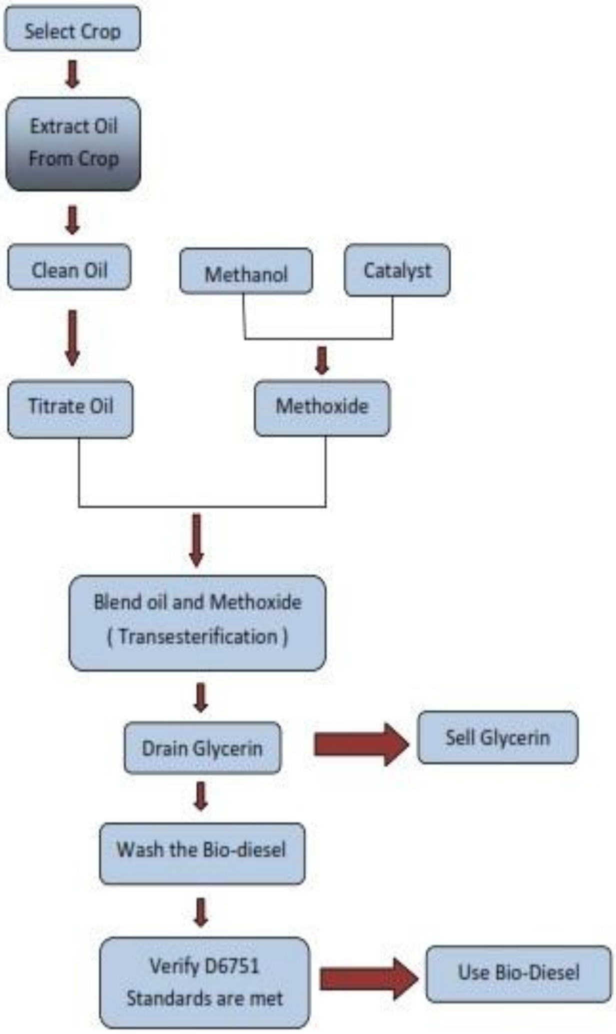

Fig -4: Biodiesel production process

The net energy ratio (NER) is the units of energy obtained from biodiesel divided by the units of energy that go into biodiesel production. If the net energy ratio of an energy source is less than 1, then the amount of energy required to produce that source is greater than the amount of energy gained from using it and is therefore not beneficial. Thus, a requirement of the biodiesel production system is that biodiesel be produced with a net energy ratio greater than 1. Here in this paper we consider that our net energy ratio is greater than 1. We have plenty of raw materials around our project area and thus utilize those resources properly. And also we use our bio diesel generator slope (kg/hr/kW output) 1. [11]

We consider in our renewable combined system a 15kW generator run by bio-diesel. Here in Homer Analysis we calculate only the price of generator. Raw materials cost is not included because we will collect it from our project nearby areas at free of cost. A minor transportation cost is needed which we evaluate as a maintenance and operating cost in generator.

4. COMBINED SYSTEM COMPONENTS

This combined system comprises of PV panels, generators based on bio fuel, batteries and converters.

4.1 Solar Photovoltaic

In this paper for specific calculation we have to enter capital cost, replacement cost, operation & maintenance cost, Life time, derating factor's value at Homer analysis. 20 KW PV modules are considered. The parameters considered for solar PV (1 USD= 80 BDT) are stated in Table-1. Nominal Operating cell temperature of this photovoltaic cell is 47 ^{0}C.

Table -1: Solar PV array Specification

Parameter	Unit	Value
Capital cost	BDT/W	90
Replacement Cost	BDT/W	75
O/M Cost	BDT/W	2.5
Life Time	Years	20
Derating factor	Percent	80
Tracking System	No Tracking System	0.05

4.2 Bio-Diesel Generators

The cost of a diesel generator depends on its size. The diesel generators utilized are of 15 kW. For a capacity range of 5 Kw to 45 Kw, the slope and the intercept coefficient are 0.05 l/h/Kw and 1 (l/h/KW output) for biodiesel respectively [8]. Minimum load ratio is 30 and efficiency curve is analyzed by Homer simulation. A Bio-diesel generator of 15 KW rated power with technical and economic parameters (1 USD= 80 BDT) furnished in Table-2 and also efficiency curve.

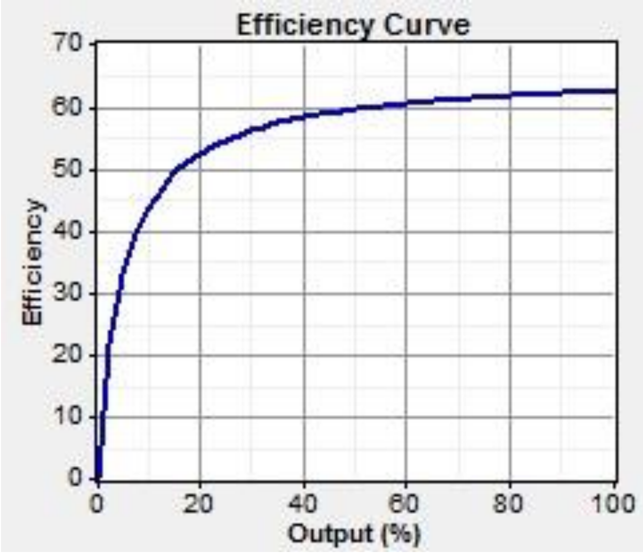

Fig -5: Biogas Efficiency curve

Table -2: Biodiesel generator Specification

Parameter	Unit	Value
Capital cost	BDT/kW	100000
Replacement Cost	BDT/kW	90000
Operation & Maintenance Cost	BDT/hr	2.857
Operation Life Time	Years	15000
Minimum Load ratio	Percent	30
Fuel curve intercept coefficient	1/hr/kW rated	0.05
Fuel curve slope	1/hr/kW output	1
Bio-Fuel Price	BDT/kg	3 (transportation cost only)

4.3 Battery

For a solar photo voltaic cell system battery is an important criterion to complete the procedure. For working a solar system properly it is very much important to set the current level in higher range ie approximately 60 A. In this combined renewable energy system we use Surrette 4KS25P battery whose nominal specification is 4V, 1900 Ah, 7.6 kWh & efficiency is 80%. Operating & maintenance cost is very negligible around 5000 taka/yr. Counting all these criteria we have to consider 30 identical batteries for the system [4]. The technical and economic parameters (1 USD= 80 BDT) are stated in Table-3. Discharging characteristics are also shown in figure 6.

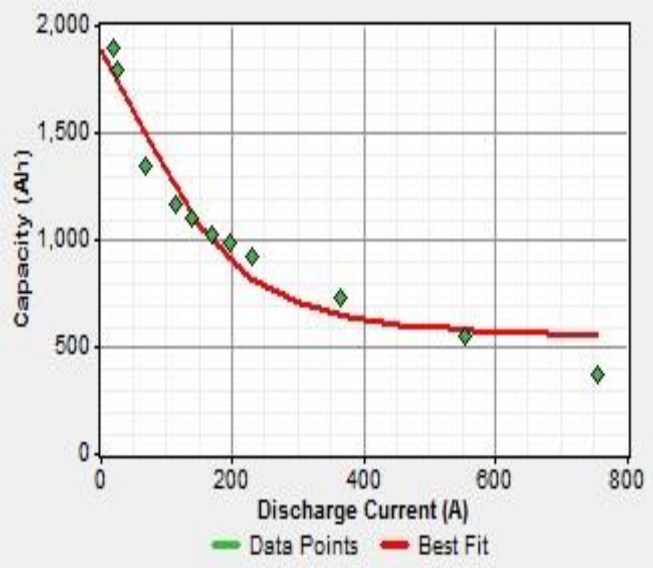

Fig -6: Discharge Current curve

Table -3: Battery Specification

Parameter	Unit	Value
Capital cost	BDT/kW	4000
Replacement Cost	BDT/kW	3000
Nominal Capacity	Ah (kwh)	1900
Nominal voltage	Volt	4
Round Trip efficiency	Percent	80%
Min. State of charge	Percent	40%
Life Time	Year	6
Maximum Charge Current	Amp	67.5

4.4 Converter

A converter is required for the systems in which DC components serve an AC load or Vice Verse. A converter can be an inverter (DC to AC) rectifier (AC to DC) or both. Now a day's most of the home appliances are run by AC current. As the electricity generated from the PV is DC, converter is needed to change it into AC. Table-4 shows the technical and economical parameters of the converters. Here the converter Efficiency level is 80%. So we need a bigger inverter which can easily maintain the output. Here we use Delta SOLIVIA 20 TL , 20KVA and another 5 KVA Inverter simultaneously [9,10]. The technical, economical properties and cost curve are mentioned below.

Table -4: Converter Specification

Parameter	Unit	Value
Capital cost	BDT/kW rated	3200
Replacement Cost	BDT/kW rated	2800
Life Time	Year	15
Efficiency	Percent	90%

5. COMBINED SYSTEM PARAMETERS & CONSTRAINTS

The project life is considered about 20 years. In Homer analysis we have to maintain a particular set of constraints. Such as maximum Annual capacity shortage, minimum renewable fraction, minimum primary energy savings, temperature and those are stated at table-5.

Table -5: Constraints used in HOMER

Maximum Annual capacity Shortage	10 %
Minimum Renewable fraction	0%
Minimum Primary energy Savings	5%
Temperature	24.5^0C

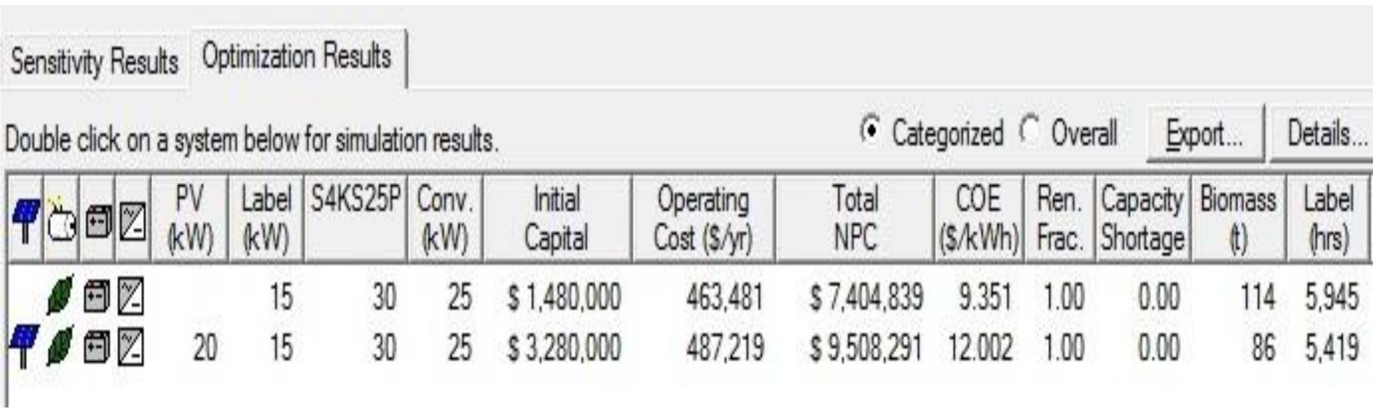

Fig -7 Optimized Result for Solar PV – Biodiesel Combined system

6. RESULTS & DISCUSSION

The main purpose is to find out the most feasible combined energy generation system which provide the most optimized result in terms of least NPC(Net present cost) and COE (cost of energy per kWh). After a significant number of simulations HOMER reveals that particular system where NPC in BDT (Bangladeshi currency) 9,508,291 (USD $ 118853.64) & COE is 12.002 BDT / kWh (USD $ 0.15 / kWh) with a renewable fraction 100%. The system is configured with a 20 kW PV array, 15 kW Bio-diesel generator, 25 kW converter and 30 identical batteries.

7. CONCLUSION

It's high time for us to reduce extra burden from fossil fuels. Stock of fossil fuels is limited. Today or tomorrow it will come to an end but necessity of power generation is increasing not decreasing. So at this regard more & more renewable energy resources should practiced in our power generation. Here in this study we find solar PV, Bio-diesel combined system has the best feasibility. The main purpose is to find out the most feasible combined.

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BIOGRAPHIES

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