Strategy and Organizational Approach to Solar-Biomass Hybrid System for Rural Electrification

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Abstract

Energy is one of the essential requirements to alleviate poverty and socioeconomic advancement. Most of the rural area is not under the national grid; therefore, electrification in rural area is the crying need of Bangladesh. Government of the People's Republic of Bangladesh has issued its vision to bring the entire country under electricity service by the year 2030. The reserve of fossil fuel is diminishing; also the price of fuel is increasing throughout the world. Environmental pollution is another important issue. Green energy is current demand for the existence of future world. For that reason, reducing carbon emission and meeting energy demands are the main topologies to plan energy systems. As Bangladesh is an agricultural based country, biomass resources are available here and there is also good prospect of solar energy. In this paper, a solar-biomass hybrid system is proposed for electrification of rural area in Bangladesh.

Keywords: Biomass, Solar PV, Hybrid System, Gasification, HOMER, Power Generation

1. Introduction

Energy is the basic requisite for the development of a country and electrical energy is superior to All other forms of energy. Bangladesh has a population of 161 million (or 29 million households).Fifteen million of them are concentrated in rural areas. Rural electrification requires a number of conditions. Due to less specific population density, low energy demand and undeveloped rural economics, rural electrification penetration rate is poor. Successful rural electrification and long-term accomplishment is badly needed. Bangladesh has good potential of solar and biomassresources.The earth receives 175 petawatts (PW) of incoming solar radiation (insulation) at the upper atmosphere. Approximately 30% is reflected back to space while the rest is absorbed by clouds, oceans and land masses. The spectrum of solar light at the Earth's surface is mostly spread across the visible and near-infrared ranges with a small part in the near-ultraviolet. The total solar by the Earth's atmosphere, oceans and land masses is approximately 3,850,000 exajoules (EJ) per year. The insolation in Bangladesh varies from 3.8kWh/m2/day to 6.4kWh/m2/day at an average of5kWh/m2/day. These indicate that there are good prospects for solar thermal and photovoltaic application in the country. Bangladesh is an agricultural based country and available biomass is mainly of agricultural residues like rice husk and rice straw from rice plants, sugarcane, jute stick, residues from wheat, potato, oilseeds, spices etc. In addition to the agricultural wastes the other resources are dry materials such as dry wood, dried leaf, charcoal, coconut shells, animal dung etc.Biomass fuel supply usually comes from main three sources viz. Crop residues, animal dung and trees [1]. The percentage of different traditional energy were as follows: cow-dung 20.4%, jute stick 7.5%, rice straw 11.6%, rice husk 23.3%, biogases 3.2%, fire wood 10.4%, twigs and leaves12.5%, and other wastes 11.1% [2]. So, for lightning the rural area, in this paper we tried to develop an optimal system from the practical view point. HOMER, software has been used to exposé combined

cycle with biomass and solar resources. Input information to be endowed with HOMER comprises: primary load, solar and biomass resources, cost, constraints, controls etc. The software focused on an optimal configuration to meet the desired electric loads. To design the most favorable systems HOMER performs the thousands of hourly simulations and it performs sensitive analysis also.

2. Hybrid System

In this analysis, we have designed the hybrid renewable system with biogas generator. Here, solar photovoltaic panel is used as renewable resource and biogas is produced from biomass sources. The hybrid system consists of electric loads, solar resources, biomass resources and system components such as PV, generator, battery, and converter [3]. Figure-1 shows the biogas hybrid solar system

2.1. Electric Load

In this study a community of 100 households and 10 shops has been considered of a village near the Barisal city, Bangladesh. The load is based on 3 energy efficient lamps (15 W each), on an average 1 ceiling fan (100 W), and 1 television (70 W) for each family and 2 energy efficient Lamps (15 W each), 1 fan (100 W) and overall 2 refrigerators (1.2 kWh/day each) for shops. Also, 5 refrigerators (1.2 kWh/day each) and 5 pumps (150 W each) are considered among the residential. Load data are synthesized by specifying typical daily load profiles and adding some randomness of 10 % daily. These scaled up the annual peak load to 45 kW and primarily load245kWh/day and deferrable load 18kWh/day. Figure-2 represents the daily load from November to February and Figure-3 contains the daily load profile from March to October.
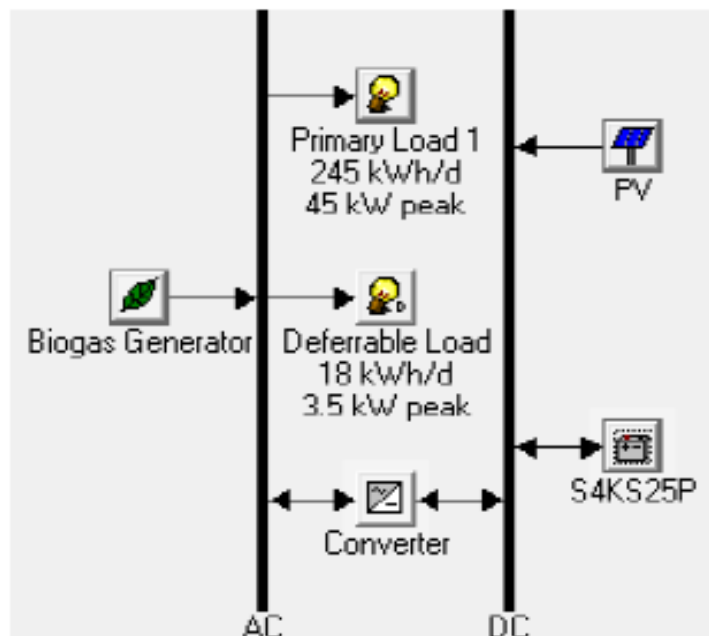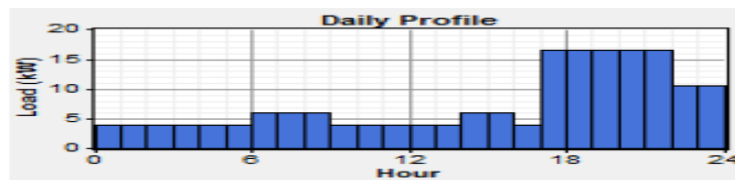

Figure 1: Hybrid energy renewable system
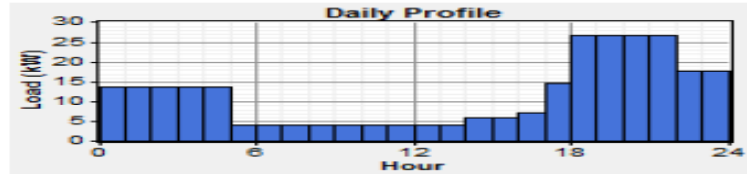
Figure 2. Load profile of a day (November-February)

Figure 2: Load profile of a day (March-October)

3. Renewable Energy Resources

3.1. Solar Resource

Bangladesh has good prospects of solar photovoltaic generation. The average insulation in Bangladesh is 5kWh/m2/day. In this analysis, monthly average global radiation data has been taken from NASA (National Aeronautics and Space Administration) to estimate the generation of solar system. Solar data at Barisal (Latitude: 22.75, Longitude: 90.36) in Bangladesh is presented graphically by using HOMER software in Figure 4. Homer use the solar resources input to calculate the PV array power. And, the synthesized data is obtained by putting the longitudinal and latitudinal value in HOMER software.
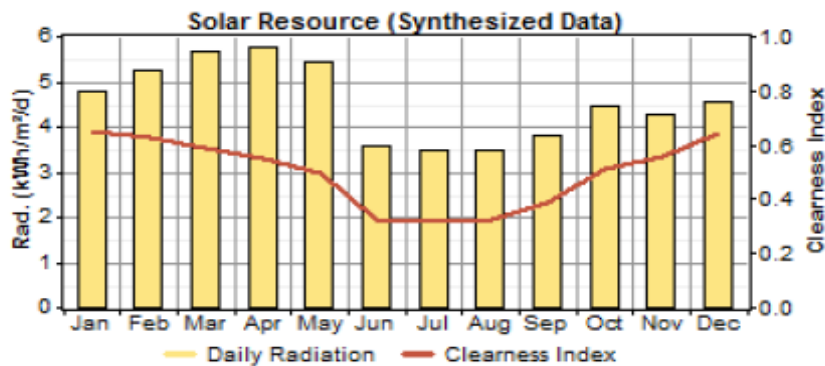

Figure 3: Solar Radiation data throughout the year

3.2. Biomass Resources

Biomass is the oldest source of energy known to humans. The term biomass encompasses a large

Variety of materials, including wood from various resources, agricultural residues, and animal and human waste. Bangladesh is an agree-based country and main sources of biomass are agricultural residues. And in villages, mainly in Barisal, cow is still utilized for plowing land and farming. So, animal dung is available in resourceful amount. Biomass contains stored energy. That's because plants absorb energy from the sun through the process of photosynthesis. When biomass is burned, this stored energy is released as heat. Many different kinds of biomass, such as wood chips, corn, and some types of garbage, are used to produce electricity. Some types of biomass can be converted into liquid fuels called

biofuels that can power cars, trucks, and tractors. Leftover food products like vegetable oils and animal fats can create biodiesel, while corn, sugarcane, and other plants can be fermented to produceethanol.More than 25000 bio gas plants are already set up in Bangladesh and they are mainly family sized and used only for cooking purposes. But, we need to focus to use this biomass energy for rural electrification. And that will be helpful for our economic advancement.

3.2.1. Gasification

Gasification of biomass has been known as one of the effective technology options for the utilization of this renewable energy resource. Gasification is the process of converting solid fuels into a combustible gas mixture with a controlled amount of oxygen and/or steam; this is accomplished by reaction of the material at high temperature (more than 7000c). The resulting gas mixture is called syngas or producer gas. The power delivered from gasification of biomass and combustion of the resultant gas is considered to be a source of renewable energy. The calorific value of this gas varies between 4.0 and 6.0 MJ/Nm3 or about 10 to 15 percent of the heating value of natural gas [2][4]. The process of generation of electricity from biomass is Illustrates in Figure 4.

The three different stages of total gasification produces are:

1) Gasification process starts as auto thermal heating of the reaction mixture.

2) In the second stage, combustion gases are pyrolysis by being passed through a bed of fuel at high temperature.

3) Initial products of combustion, carbon dioxide (CO_2) and (H_2O) are reconverted by reduction reaction to carbon monoxide (CO), hydrogen (H_2) and methane (CH_4).Biomass gasification is an alternative option of thermal biomass utilization for the production of heat and power based on biomass. Within the last 20 years several different gasification technologies were developed and demonstration plants were realized. Based on the experience from these demonstration plants the gasification technologies were further developed. Gasification plants consist of several process steps, which are shown in figure 6. The solid biomass fuel delivered needs to be adjusted (fuel conditioning and handling) to the fuel characteristics (particle size, water content) required for the gasification process. The conditioned fuel enters the gasification process, which produces raw product gas. The raw product gas needs to be cleaned in order to achieve the product gas quality needed for further utilization. The cleaned product gas is used for the production of electric power, heat and fuel based on different technologies. During the thermo-chemical biomass gasification process solid biomass is cracked by thermal energy and a fumigator and converted into a product gas. The product gas is cleaned and used for the production of heat and power
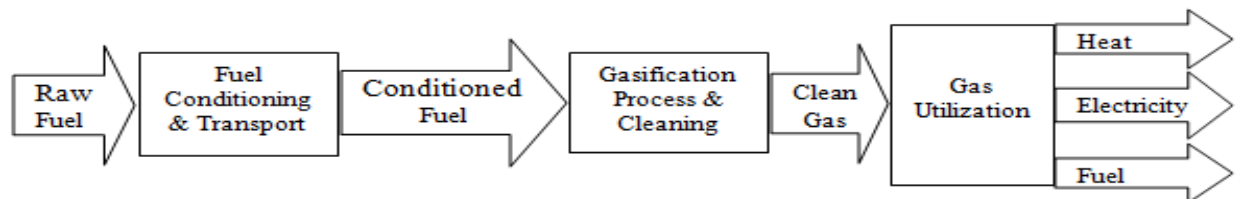

Figure 4: Basic process steps of a biomass gasification plant

3.2.2. Conversion to Electricity

Theoretically, biogas can be converted directly into electricity using a fuel cell. In most cases, biogas is used as fuel for combustion engines, which convert it to mechanical energy, powering an electric generator to produce electricity.

Appropriate electric generators are available in virtually all countries and in all sizes. The technology is well known and maintenance is simple. In most cases, even universally available 3-phase electric motors can be converted into generators. Gas turbines are occasionally used as biogas engines, especially in the US. They are very small and can meet strict exhaust emissions requirements. Small biogas turbines with power outputs are available on the market, but are rarely used for small-scale applications in developing countries as they are expensive. Furthermore, due to their spinning at very high speeds and the high operating temperatures, the design and manufacturing of gas turbines is challenging and maintenance requires specific skills. External combustion engines such as Sterling motors have the advantage of being tolerant of fuel composition and quality. They are, however, relatively expensive and characterized by low efficiency. Their use is therefore limited to a number of very specific applications. In most commercially run biogas power plants today, internal combustion motors have become the standard technology either as gas or diesel motors.

3.2.3. Energy Generation by Using Cow Dung

Several types of gasifier e.g. fixed bed updraft and downdraft gasifier, fluidized bed gasifier and bubbling bed gasifier are available in the existing market with different sets of pros and cons. However, the downdraft gasifier is a comparatively cheap and gasification in this type of gasifiercan produce a product gas with very low tar current [4].All the collected cow dung is fed into an anaerobic digester. The digester is built to hold 21 days of farm waste. Bacteria convert the waste into various products, one of which is methane gas. Gas produced by the bacteria builds up the pressure in the concrete vessel, and a pipe delivers the biogas to a modified natural gas engine. The biogas fuels the engine, which in turn spins an electric generator to create electricity. Waste heat from the engine is used to keep the digester warm and offsets fuel purchase on the farm. One cow's waste can produce enough electricity to light two 100-watt light bulbs for 24 hours a day. The energy is fed onto the electrical system for distribution to customers. Cow dung gas is55-65% methane, 30-35% carbon dioxide, with some hydrogen, nitrogen and other traces. Its heating value is around 600 B.T.U. per cubic foot. Cow dung slurry is composed of 1.8-2.4%nitrogen (N2), 1.0-1.2% phosphorus (P2O5), 0.6-0.8% potassium (K2O) and 50-75% organichumus.About one cubic foot of gas may be generated from one pound of cow manure at around 28°C.This is enough gas to cook a day's meals for 4-6 people in Bangladesh. About 1.7 cubic meters of biogas equals one liter of gasoline. The manure produced by one cow in one year can be converted to methane, which is the equivalent of over 200 liters of gasoline. Gas engines require about 0.5 m3 of methane per horsepower per hour. Some care must be taken with the lubrication of engines using solely biogas due to the "dry" nature of the fuel and some residual hydrogen supplied; otherwise these are a simple conversion of a gasoline engine. Power generation by using cow dung consist of several process steps, which are shown in figure7. First, cow dung is stored in biogas digester and produced gas in gasification process in cleaned and supplied it to syngas engine to produce electricity.
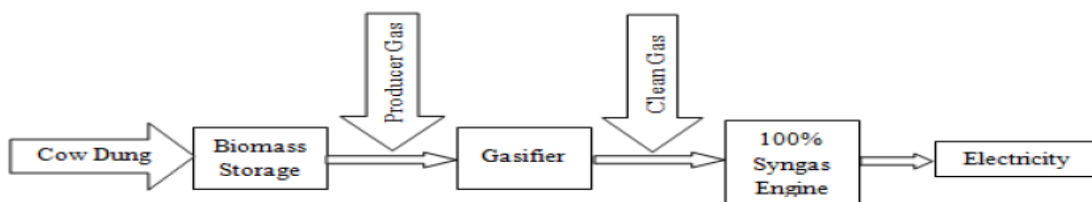

Figure 5: Energy Generation by Using Cow Dung

4. System Components

In this analysis, the major components are PV panels, biogas disaster, bio fuel generators, batteries, and converters. For economic analysis, the number of units to be used, capital cost, replacement and O&M costs and operating hours to be defined in HOMER in order to simulate the system.

5. Results and Discussion

The optimal systems performance analysis has been carried out by using HOMER the results, numerous alternative feasible hybrid set the renewable resources were obtained. Irradiation 4.67 kWh/m2/d. The hybrid system encomgenerator and 75 storage batteries with total net present cost (NPC) of 12,tk.10.183/kWh. Optimized result is represent the annual capacity shortage 0 to1%.COE [8] energy is low comparing to PVSufficient energy can be generated with minimum shortage is considered zero. Cost of unit gene present cost for solar home system is high as Tk. 12,469,464. As project lifetime is considered for 25 years, another 25 years at that time the investment will be around 50% less due to use of existence equipments.

Therefore, for reasonable unit price the life time of project, it hopes that the proposed hybrid model will be commercially viable. this model, biogas generation is 67% of total generation and rest 33% from photovoltaic generation. Ac primary load is 93% and rest 7% is deparameters set-ups with different levels of contribution by The optimized result is calculated for specific solar encompass of 25 kW PV array, two25 kW converter is economically more feasible with a12,469,464 taka and minimum cost of energy (d represented in Figure 8. Here, we calculated the result taking As there is no fuel cost for generation like dieselPV-diesel hybrid system that was analyzed in [9].result for diesel-PV-wind turbine-battery System. Capacity shortage.

In this system, capacity generated of unit generated is 10.183 BDT where as thein rural areas is 20 to 25 BDT. Here, the total net present cost. and if the project run price, though the net investment is high considering, deferrable load Figure 8. Optimized Sufficient energy can be generated with minimum shortage is considered zero. Cost of unit gene present cost for solar home system iis high as Tk. 12,469,464. As project lifetime is considered for 25 years, another 25 years at that time the investment will be around 50% less due to use of existence equipments. Therefore, for reasonable unit price the life time of project, it hopes that the proposed hybrid model will be commercially viable. this model, biogas generation is 67% of total generation and rest 33% from photovoltaic generation.

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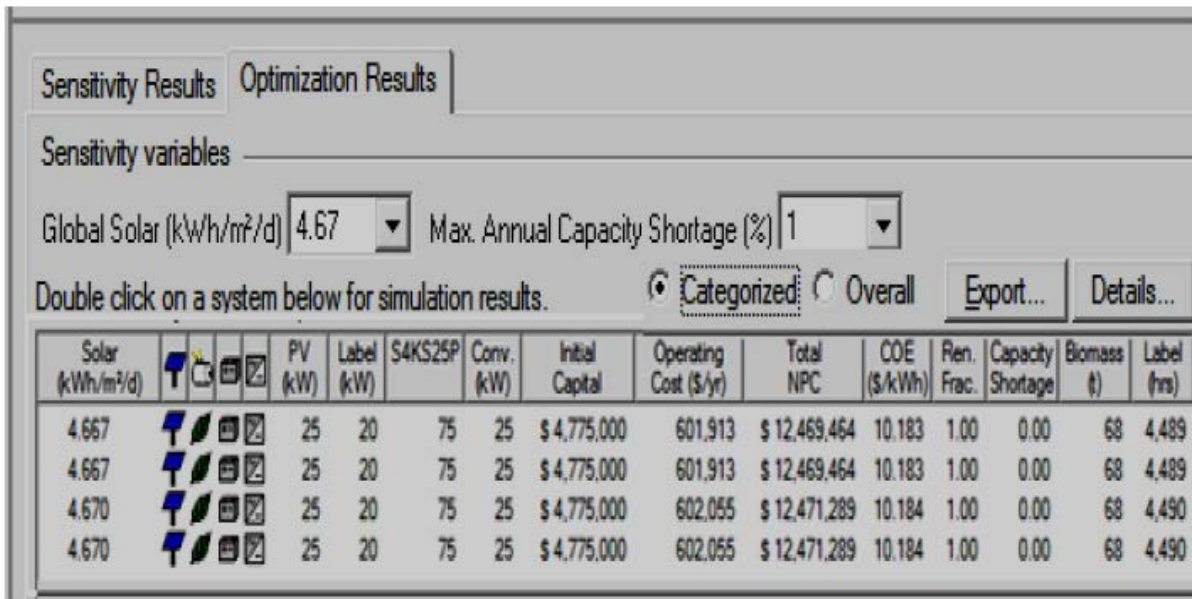
Figure 6: Optimized Sufficient energy can be generated with minimum shortage is considered zero.

6. Conclusion

Bangladesh is running in the crisis zone of power shortage. Sociointo a point for the power crisis. Education is the backbone for the development of a nation. Thereis a great difference in educational level in rural and urban areas electricity in rural area. In Bangladesh nearly 60% people in rural area havnational grid and around 75%electrification of rural area, it is impossible to connect the peoples of those areas to the mainstream of development. Therefore, to solve the In this paper for electrification of rural area, a village in a remote district of Barisal is chosen. The potentiality of solar and biomass is analyzed model community of 100 families and 10 shops has been conducted. The optimize hybrid system was developed considering manufacturing cost and efficiency. of the proposed model is around Though the proposed system is designed considering a model community, the system can be implemented for any community and at any place in Bangladesh. Though the net investment is high considering the life time of project, it hopes that the proposed hybrid model will be commercially viable areas in Bangladesh.

7. References

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