Acquisition of Sustainable Economic Growth through Proper Utilization of Renewable Energy Sources – A Study on Various Aspects, Challenges and Prospects of RE in Bangladesh

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Abstract

This paper explores that economic growth and development refers to a process whereby the people of a country or region come to utilize the resources available to bring about sustained and increase in per capita production of goods & services.. Economic growth depends on - rate of national income, technological progress, proper use of available resources, proper utilization of manpower, others. If we see the GDP rating we can see that the countries those are using technological advantages have the top position. So the Economy of a country can be strong with the proper use of technology. This paper then examine that there is a positive relationship between the technological use and economic growth. Energy is one of the most important ingredients required to alleviate poverty, foster economic growth, realize socio-economic and human development. Demand of electrical energy is increasing day by day because of increasing population and industrialization. Energy crisis is considered as one of the major problems all over the world in recent times. In this critical stage, renewable energy is considered as the most important alternative energy source. Renewable energy is energy, which comes from natural resources such as solar, wind, biomass, waste, small hydro, geo-thermal, tidal, wave etc. in different form which are renewable (natural replenished). Bangladesh is facing acute power crisis problem. The main goal is to develop, disseminate, promote and extend the renewable energy technology to meet the energy needs by using sustainable and environment friendly energy sources. This paper also compares the cost of generating renewable energy from different sources and examines the constraints to generate renewable energy. Lastly the paper concludes with exploring the prospects of RE in developing countries like Bangladesh with some suggestions regarding to generate renewable energy to foster the economic growth.

Key words – Sustainable Economic Growth, Sources of Various Renewable Energy, Cost Benefit Analysis, Multiple Energy System.

1. Introduction

Bangladesh has major problems with energy crisis, persisting poverty and environmental degradation. Only 49% of Bangladeshis are having access to electricity. The country can generate about 4500 MW electricity, while peak demand is about 6000 MW (USAID, 2011).Most of the supply is limited to urban areas; access to electricity in rural areas is less than 10%. RET can solve this problem by renewable such as sunshine, wind, tidal waves, waterfalls or river current, sea waves or biomass. Use of renewable energy can increase energy efficiency and enhancement of energy security constitutes a sustainable energy strategy approach. About 80% of the total populations are still un electrified. Usable biomass including cow dung, human excreta, poultry litter, kitchen organic waste, aquatic plants and weeds of a village in Bangladesh can produce the amount of biogas that villagers require for cooking. On the other hand, Bangladesh has one of the highest solar insulation on the earth. The average solar radiation varies here from 5.05 kWh/m2 day in winter to 8.03 kWh/m2 day in summer. As Bangladesh is a compact flat country with a little geographic variation, the solar radiation data collected from one point may be treated as that of the whole country. In other word, affordable availability of RETs to the rural area could be the panacea of poverty reduction and environmental fix in Bangladesh. At present, most of the large International Oil Companies (IOCs) have started serious business with renewable, like Shell and British Petroleum have individually committed US$500million for

renewable energy investment. Renewable Energy Technologies are mostly in the dissemination and demonstration phase in Bangladesh.

2. Objectives of the study

i).To examines the relationship between technological progress and economic development through renewable energy.
ii).To explores the development in the possible renewable energy sources in Bangladesh.
iii).To clarify the need for improve in the energy sector of Bangladesh
iv).Justify the present scenario & potentiality of RE in Bangladesh.
v).To identify the constraints for the improvement of RE in Bangladesh and provide some suggestions.

3. Methodology of the Study

A mixture of qualitative and quantitative methodological approaches was applied, giving explanatory information regarding electricity's influence on the quantifiable socio-economic data. To complete this information with field level data, an extensive household survey and individual short interviews with shopkeepers and owners of small businesses were conducted. The secondary data were collected mainly by reviewing the relevant organizations annual reports, publications, literature, internet searching and discussion with local people.

4. Relation between Technological Progress and Economic Growth

Technological progress is the progress developed by technology and great support from technology.With the progress of technology the economy of a country is growing up. So the GDP rate is increasing. If we see the GDP rating we can see that the countries those are using technological advantages have the top position. So the Economy of a country is being strong with the proper use of technology. There is positive relation between the technological use and Economic growth. The more technological use the more economic growth.

The relationship between energy and economic development is crucial; the process of economic growth requires the substation of energy mix in the performance of agriculture, industrial and domestic tasks. The lack of adequate energy in Bangladesh has economic costs not just at the individual and household level but at the national level as well. Development in Bangladesh without corresponding increase in per capita electricity and gas consumption is, therefore, not feasible. Consequently, energy is to be considered as a basic need along with food, water, shelter and others. The availability of adequate, reliable and reasonably priced source of energy is, therefore, prerequisite for the development of Bangladesh. Suggestions can now be made to the extent that the usage of RETs would launch a new era of appropriate technology, sustainable socio-economic and environmental development in the country.

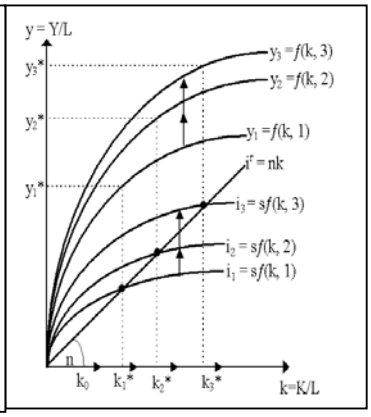

Fig. 1. Technological Progress

5. Importance of Renewable Energy

Energy is needed in the Production Farm, Electricity-Generation-Transmission-Distribution, Communication-Road, River, Train and Air, Telecommunication & Internet. Water supply, Rural Infrastructure.(Accountability and Transparency) e.t.c . Increasing cost of energy and, ,Environmental pollution hitting an obscene high, With the rise in population and more urbanization, commercial and engineering activities are also expected to increase, thus demanding larger share of energy in an already strained energy supply scenario., Provide energy for production, transportation, etc., renewable energy could be employed in a number of ways: for generation of electricity, providing irrigation. One such area is to provide Lamp Lights in far Rural & under Developed areas of the region; the strategy is to provide light without charging money to the villagers for their comfort & development. Electrification allows Rural families to extend workdays beyond sundown, which translates into more money. It encourages Literacy and provides electronic information, education & entertainment in far rural areas as well as to protect societies from Green House Effect, destruction of Ozone Layer and air pollution which cause acid Rain & smog.

6. Present scenario of Bangladesh's Power Sector

At present, 53% of the total electricity generation of Bangladesh is from the power plants under public sector and 47% of the net generation of the country is from private sector. Even though many extra units both from public and private sector have been added to the national grid, the power crisis is still a big issue in the country. So due to high demand, maximum generation of 2087 MW in 1995-1996, 2114 MW in 1996-1997, 3218 MW in 2001-2002, 3458 MW in 2002-2003, 3622 MW in 2003-2004, 3751 MW in 2004-05, 3812 in 2005- 06, 3718 in 2006-07, 4130 MW in 2007-08, 4037 MW in 2008-09 could not remove power crisis in the country . The demand of electricity cannot be met due to insufficient production of electricity around the country. And as most of our power stations depend primarily on natural gas as fuel, because of the shortage of gas supply some power plants are unable to produce power of their rated generation capacity. But the insufficient gas supply has decreased the power generation capacity in the whole country. In FY 2009-10 total generation capacity was 5, 376 MW (upto May'10) including 3,331 MW in public sector and 2045 Megawatt in private sector (including REB)

Table 1. Generation Capacity

Sl. No.	Items	FY 2009-10 (Up to May'10)
1.	Generation Capacity, MW	5,376
2.	Maximum Generation, MW (April 14 2010)	4,606
3.	Net Generation, MkWh (FY2008-09)	26,533
4.	Transmission Line, km	8,391
5.	Grid Substation Capacity, MVA	
	(a) 400 KV & 230 KV	6,850
	(b) 132 KV	9,626
6.	Distribution Line, km	2,66,460
7.	Number of Consumers (million)	12.00
8.	Number of Village Electrified	53,281
9.	Per Capita Generation, kWh	220
10.	Access to Electricity	47%

Generation Capacity and Demand

In the public sector, a good number of generation units have become very old and has been operating at a much-reduced capacity. As a result, their reliability and productivity are also poor. For the last few years, actual demand could not be supplied due to shortage of available generation capacity. Besides, due to shortage of gas supply some power plants are unable to reach their usual generation capability. Maximum generation of 4,606 MW (April 14, 2010) was supplied till to-date.

Industrial production and house hold life are regularly hampered due to regular load shedding problem which is hampering our economy as well as making us lag behind. We can get rid of this situation through renewable energy. Renewable energy can help us improve the condition of power crisis and help us move forward economically and environmentally. Moreover, the environmental drawbacks of renewable energy sources are minimum. In the perspective of Bangladesh we can solve the power crisis by bio diesel, biogas, solar energy, micro hydro, wind energy, ocean wave energy, tidal power and geothermal .Renewable energy scenario of Bangladesh is estimated on the basis of primary, secondary, noncommercial, traditional and renewable energy sources. The major sources of renewable energy have been identified as sunshine energy and waterpower. Wind and tidal forces are also expected to be the sources of renewable energy in this delta region. The patterns of total sunshine hours for a long period of time (10 years) have been analyzed by statistical methods. It has been observed that 1 sq. meter area has potential of generating 4~5 kwh/m2/day. Bio-mass and hydropower are in active use and supply about 70% and 0.15% respectively of the total amount of energy demand. Total installed capacity of electricity is 3208 MWand generation is 1385 MkWh. Estimated demand of electricity is 2370 MW and consumption is14003 MkWh. Estimated natural gas reserve is 47.69 MMBBL. The future trend of demand supply situation shows that energy demand is growing at a rate of 10% per annum. The power generated from other sources are, solar PV (800KW), wind turbine (20KW), wind pump(6),micro hydro (10KW) and biogas plants (10,000). The demand-supply situation in 2005 is 4597MW (D), 24,000 GWH (S) and in 2010 is 6779MW (D), 35,000 GWH (S). As solar power remains fairly uniform in this delta region, it is suggested that with suitable tracking system and storage facilities SPV system would be a reliable and environment pollution-free source of renewable energy in Bangladesh.

6.1. Sources of Renewable Energy

6.1.a) Biogas Technology and Bio diesel

Biogas is a proven and widely used source of energy in the country. Biogas can also be used to run small generator to produce electricity for running electrical household appliances like TV, electric light, fridge etc. Biogas technology is the most ideal technology for rural Bangladesh. Biogas plant is built with simple technology and uses raw material easily available with the rural households -- mostly cow dung. Biogas is a kind of gas generated when biomass i.e.

cow dung or other animal dung or biodegradable organic masses are stored in underground chamber in an anaerobic condition (absence of oxygen). It is a kind of anaerobic bacteria that produces the biogas from the organic debris. The composition of biogas is mainly methane (60 to 70%) with lesser amount of carbon dioxide (30 to 40%) and traces of hydrogen and nitrogen. It is a colorless gas and burns in similar way as natural gas (it actually burns at 800 °C compared to natural gas which burns at 1000 °C, both suitable for cooking and any other household application. In Bangladesh about 44 million tons of fuel wood is used in rural areas as cooking fuel each year (Islam and Islam,2011). These destroy our forest and have negative impact on weather, land and environment. Also, as other biomasses like leaves, cow dung and agricultural residues are burnt as cooking fuel, these can no more help as a natural fertilizer as part of the cycle that keeps the balance in the ecosystem. In all the above counts, use of biogas technology will bring about benefits to the environment and the people. It certainly upgrades an age old inefficient and poor energy use practice into a more efficient and scientific one. . In Bangladesh biogas is still a relatively new technology. In most of the places it is used to generate electricity to meet the household demands. But an agro-based country like Bangladesh produces huge amount of waste materials. Converting these waste materials into energy is economically advantageous as well as helpful to solve the issue of power crisis. In Bangladesh, recycling industry wastes raises a total of 436 t/d of material recovery. Moreover around 3,054 ton/d of wastes is expected to be collected in 2015 and cumulative disposal volume is estimated at about 9 million tones by the end of 2015. This huge amount of waste, most of which are compost able and have very good fermentation property can be easily used to produce electricity as well as the generated gas can be used for the cooking purpose. Waste to energy technology can be a huge asset for a developing country like Bangladesh.

6.1.b) Capacity Calculation of Biomass and Biogas

The potential for power generation from biogas and biomass has been studied together by using gasification technique. For instance, if 500 kgs of rice husk is used for a typical day considering only 50% efficiency and 5 hours of operation; the net power generation can be calculated Pbiomass = 10,000 Watts. This is approximately 10KW of power generation; assuming 2 Kgs of husk is needed in an hour to produce 1 KW of power. By using the same equation and same technique (Gasification), a biogas plant can also generate 10,000W of power in a day considering 5 hours of operation and 500 kgs of animal waste as a plant material. So, the generated power from the biogas plant is 10KW as well for the same amount of plant material.To reduce Carbon emissions and decreasing reserves of fossil fuels, Biofuel can be an attractive source of energy. In comparison to fossil fuels, biofuel can reduce the emission of CO2. Next generation biofuels can be a great solution to the global warming and the crying need of fossil fuels. Biofuel or Biodiesel is clean burning oil produced by Transesterification of oils with short chain alcohols. Now-a-days, researchers are turning their attention into the production of biodiesel from algae because of their higher productivity, abundance in the nature, high Triacylglycerides and they can be a major source for biodiesel production. Production of biodiesel from algae is less time consuming and cheaper than the petroleum diesel. So rather using petroleum diesel in the diesel generators in the power plants, we can use biodiesel which will both save our money and reduce our dependence on the diminishing fossil fuel reserves. This biodiesel can be used in the diesel generator to produce electricity. This will be cost efficient and as well as environment friendly.

6.1.c) Tidal Power

Tidal power or tidal energy is a form of hydropower that converts the energy of tides into electrical power.
As tides are more predictable than wind and sunlight, tidal energy can easily be generated from the changing sea levels. The coastal area of Bangladesh has a tidal rise and fall of between 2 to 5 meters .Among these coastal areas, with 5 meter tides experienced, Sandwip has the best prospect to generate tidal energy. Moreover, according to Reference, Bangladesh can generate tidal power from these coastal tidal resources by applying Low head tidal movements and Medium head tidal movements, low head tidal movements which uses tides of height within 2m to 5m can be used in areas like Khulna, Barisal, Bagerhat, Satkhira and Cox's Bazar regions and the height tidal movements which use more than 5m of tides can be mainly used in Sandwip. So we can say that with suitable tidal height available, this can be a great source of energy for Bangladesh.

6.1.d) Geothermal Energy

The thermal energy which is generated and stored inside the earth surface is called geothermal energy. It is very much cost effective and environmentally friendly. With this technology, we can use the steam and hot water produced inside the earth surface to generate electricity. Geothermal energy is generated about 4,000 miles below the surface, in the earth’s core. The process takes place due to the slow decay of radioactive particles, the high temperature produced inside the earth and it happens in all rocks. About 10,715 megawatts (MW) of geothermal energy is

generated in 24 countries worldwide. The northern districts of Bangladesh show the prospect to explore the geothermal resources. The demand of electricity in urban as well as in the rural areas is increasing, but our production of electricity is not increasing. The rural demand for electricity can be covered by the production of electricity through geothermal energy. According to Reference a Dhaka based private company namely Anglo MGH Energy has initiated a project to setup the country's first geothermal power plant with a capacity to produce 200 MW of electricity close to Saland in Thakurga on district. They have planned to set up 28 deep tube wells to lift hot steam and the lifted steam will be used to run a turbine and the turbine is connected to the generator to generate electricity. From the above discussion it is clear that geothermal energy can also be a great source of harnessing electrical energy in Bangladesh

6.1.e) Micro Hydro

Because of the geographic position, Bangladesh is a river rine country which is a huge advantage for the country. This huge amount of river currents and sources of low head of water falls can be used for generating microhydro-power. Micro hydro means generating up to 5-300 KW of electricity through hydroelectric power. It is a simple technology that converts hydropower to mechanical power. Micro-Hydro technology is very much suitable for a developing country like Bangladesh because it is an special source of energy which can generate energy without of fuel and the technology is very cheap. Because of the presence of many canals and tributaries of main river Karnafuli, Shangu, Matamuhuri which have very good potentials for setting up micro hydropower unit in Chittagong Hill Tracts region , recently Sustainable Rural Energy (SRE) under LGED has successfully demonstrated first micro-hydro power unit at Bamerchara, Chittagong. Although the installed capacity of the unit was 10 kW but due to insufficient water head only 4kW power was generated. A recent study on Sustainable Rural Energy shows that micro hydro power plants are able to provide necessary power supply for rural areas. The study was conducted on the micro hydro power plants of generation capacity starting from 3KW up to 30KW. These plants are in: Nunchari Tholipara, Khagrachari ,Chang-oo-Para, Bandar ban ,Bangchari, Bandar ban ,Liragaon, Bandar ban Kamalchar, Rangamati ,Thang Khrue, Rangamati ,Monjaipara, Bandar ban.

Table 2 . Potential small hydrro sites identifies by BPDB and BWDB

	Potentiality of Electrical energy (kW)
Faiz Lake	4
Chota Kumira	15
Hinguli Chara	12
Sealock	81
Lungichara	10
Budichara	10
Nikhan Chara	26
MadhabChara	78
Banga Pani Gung	616
Bhugai-Kangsa	108
Marisi	55
Badul	24
Chawai	32
Talma	24
Pathraj	32
Tangon	48
Punarhaba	11
Bari Khora	32
Fullkumar	48

6.1.f) Capacity Calculation of Micro Hydro Power

Peak power is used in the evening when the sun is not shining and the wind is not necessarily blowing. Batteries can be completely drained by morning with a solar or wind system. With a hydro system located on a year-round creek or river, power is produced steadily around the clock.

The hydro power in a stream or river can be calculated by using the "equation 5" which is as follows:

P (KW) = H × Q × g (in KW) ,Where, H=Gross water head (in meter), Q=Flow of water (in m3/sec), g=Gravitation force i.e. 9.81 (in ms-2) .For example, if the available flow is 0.15 cubic meters per second and the net head is 4.7 meters, then hydro power= 4.7×0.15×9.81 = 6.9 kW

To estimate the electrical power produced by a generator, the efficiency of the system must be taken into consideration. The system efficiency for electricity generation using micro hydro is typically between 50% and 60%.

Electrical Power = Hydro Power x System Efficiency

P hydro = 6.9 x 50% = 6.9 x 0.5 = 3.45 kW

Total Expected Capacity of the Proposed Hybrid Grid ,So the total expected power generation of our proposed on-grid hybrid system is: Ptotal(KW)= Psolar + Pwind + Pbiogas + Pbiomass + Phydro ,Ptotal(KW)=3.6+0.0735+10+10+3.45

Ptotal(KW)= 27.12 KW

Thus a total expected 27.12 KW electrical power can possibly be generated from our hybrid model. The sharing of the sources depends on which renewable source is sufficient at a particular moment. Such hybrid system is useful to provide electricity in all weather conditions. The capital cost for such a system is high but subsequent running costs will be low compared with a pure diesel system. In our proposed system the grid connection helps to provide

flexibility to the system and works as a back-up protection when the renewable sources are insufficient to produce electricity.

6.1.g) Nuclear Power

Going nuclear has also been a much talked about alternative. Earlier this month the government had discussions with Russia for two 1000-megawatt nuclear power projects. Nuclear power is also very capital-intensive, while fuel costs are relatively much more significant for systems based on fossil fuels. Development of nuclear power could provide work for local industries, which build the plant and also minimize long-term commitments to buying fuels abroad. The site is set at Ruppur. Such a project would also require heavy investment in power

6.1.h) Wind Energy

There are many hilly and coastal areas in Bangladesh which have huge potential for wind energy generation. Wind energy is a technique which converts the air flow into mechanical energy which is eventually converted into electricity without generating pollutants. Bangladesh has a 724 km long coast line and many small islands in the Bay of Bengal, where strong south-westerly trade wind and sea-breeze blow in the summer months and there is gentle north-easterly trade wind and land breeze in winter months. Along the coastal area of Bangladesh, the annual average wind speed at 30m height is more than 5 m/s . Wind speed in northeastern parts in Bangladesh is above 4.5 m/s while for the other parts of the country wind speed is around 3.5 m/s . Coastal locations of Bangladesh such as Chittagong, Kutubdia and Cox's Bazar have immense potential to produce electricity from wind energy. By using one year data of Bangladesh Centre for Advanced Studies, it has been found that at 50 meter height in these areas the wind speed varies from 4.1 to 5.8 meter/second with a power density of 100-250 w/m2 .An analysis of wind energy measurement done by RISOE shows locations with power density above 200 w/m2 over 2000 km2 which is very good to set up wind turbines and expand wind energy in Bangladesh We cannot convert all the wind energy into electricity: we can convert only 59%, according to Betz limit .The output equation for a wind generator is given by:
$P = (1/2) \times \rho \times A \times v3$(in Watts) , Where, A=area perpendicular to the direction of flow (in m2), v=wind velocity (ms-1), ρ =density of air (in Kgm-3) and P=power generation. To check whether wind energy can be a potential renewable source of electricity, small-scale wind turbines can be installed in areas in Bangladesh such as St. Martins Island, Patenga, Bhola, Barguna, Dinajpur, Thakurgaon and Panchagar . So from the above discussion we see that there is a huge possibility of extracting electrical or mechanical energy from the wind in Bangladesh.

Table 3 . Annual average wind speed of different sites of Bangladesh

Site	Annual average wind speed (m/s)
Teknaf	2.16
Cox's Bazar	2,42
Patenga Airport	2.45
Kutubdia Island	2.09
Sandip Island	2.16
Hatia Island	2.08
Bhola Island	2.44
Khepupara	2.36
Comilla Airport	2.21

Table 4 . Wind turbine installations in Bangladesh by different organizations

	Installed Capacity(Watt)
Grameen Shakti	12000
BRAC	5220
Bangladesh Army	900
IFDR	1700
LGED	400

In practice, the efficiency of commercially-manufactured wind rotors is typically 25% to 45%. Small wind turbines tend to have efficiencies at the lower end of this range. For instance, for a wind turbine with a blade diameter of 1.7 m and an operating efficiency of 25% at a wind speed of 6 ms-1. Then, to calculate how much power the turbine can generate at this wind speed: Rotor swept area: Area (A) = $\Pi \times (\text{Diameter}/2)2 = 3.14 \times (1.7/2)2 = 2.27$ m2 , Available wind power: , $P\text{wind} = (1/2) \times \rho \times A \times v3$, Where, A=area perpendicular to the direction of flow (m2), v=wind velocity (in ms-1), ρ =density of air which is about 1.2 Kgm-3. , Pwind= $(1/2) \times 1.2 \times 2.27 \times 63$,Pwind= 294.2 watts .Then the power that can be extracted from the wind assuming 25% turbine efficiency is: Pturbine=$0.25 \times 294.2 =$ 73.55watts.

6.1.i) Solar Energy

SHS has been a successful story in Bangladesh. Our rural people have accepted SHS on a mass scale. Once it was thought that solar energy was not affordable for the rural people. This myth has been broken. Along with thirty partner organizations in the country, as of August 2011, over one million SHS have been installed in Bangladesh, benefiting over 6 million rural people (IDCOL, 2011). On average, more than 35,000 systems are installed every month and within the next 1 to 3 years, this rate is likely to be triple. Bangladesh is situated between 20.30 and 26.38 degrees north latitude and 88.04 and 92.44 degrees east which is an ideal location for solar energy utilization. At this position the amount of hours of sunlight each day throughout a year is shown in the following graph .The highest and the lowest intensity of direct radiation in W/m² . Due to geographical location Bangladesh receives strong sunshine throughout the whole year. The average sunshine hour and average day length in various seasons are 6.69h (SH) & 10.05h(DL) in winter, 6.16h (SH) & 11.99 (DL) in summer and 4.81h (SH) & 11.67 (DL) in monsoon respectively. The average received global radiation is 3.69 kWh/m2 per day (winter), 5.065 kWh/m2 per day (summer) and 4.22 kWh/m2 per day (monsoon).

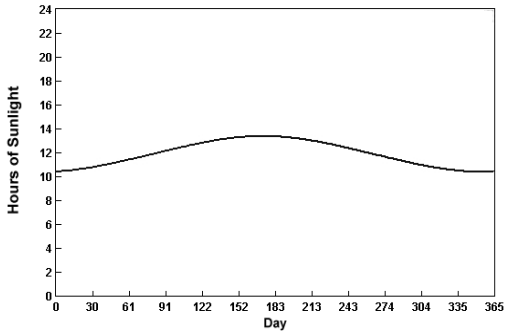

Fig 2 . The amount of hours of sunlight in Bangladesh

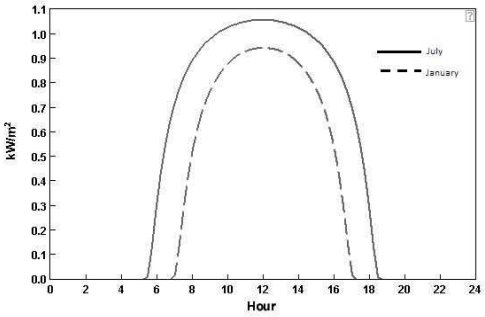

Fig 3. The highest and the lowest intensity of direct radiation in W/m²

In a recent study conducted by Renewable Energy Research Centre, it is found that average solar radiation varies between 4 to 6.5 kWhm-2 day-1 and maximum amounts of radiation are available in the month of March-April and minimum in December-January . So from the above figure and discussion we can say that there is a good prospect of harnessing solar power in Bangladesh. Moreover, in the rural areas where there is no electricity connection, photovoltaic technology can be a blessing. Although, the installment cost of solar systems in the house is very much costly, but once installed it can give service up to 20-25 years with proper maintenance. Moreover, in the northern territories of Bangladesh where the solar intensity is very high, solar thermal power plant can be installed. For both photovoltaic technology and solar thermal technology, Bangladesh is at a perfect location. In fact, Bangladesh government has recently taken many steps to encourage people to use photovoltaic energy. Almost every newly built apartment building is now using solar panels along with the grid connection to get support during the load shedding period.

6.1.j) Capacity Calculation of Solar Power

The solar network will come into operation when there is a direct sun condition of the day. On average (as a general "rule of thumb") modern photovoltaic (PV) solar panels will produce 8 - 10 watts per square foot of solar panel area.
For example, let us consider an area of 20 feet by 20 feet which is 400 square-feet (20 ft x 20 ft).
In our calculation we are assuming that the solar panel will produce roughly 9 Watts per square foot of area. So, the generated power is: Psolar = (Area per sq- ft × watts per sq-ft) , Psolar= (400 × 9) , Psolar= 3,600 Watts.
The sunlight impinging on panels, i.e. irradiance or isolation (incoming solar radiation), is measured in units of watts per square meter (W/m2).We can use only 25% of sunlight radiation for PV module. The PV system power output (DC) has approximately a linear relationship to the isolation. Using the solar radiation available on the tilted surface the hourly energy output of the PV generator can be calculated according to following equation: $P = A \cdot x2 + B \cdot x + C$ (in Watts) (1) ,Where, x= solar radiation, P=power generation, and A, B, C are constants, which can be derived from measured data. By using above formula, we can predict solar power generation at any solar radiation.

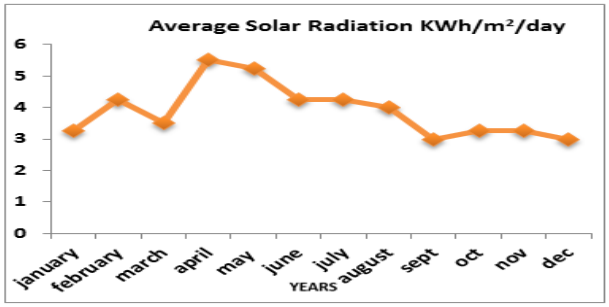

Fig. 4. Average solar radiation

Daily average solar radiation varies between 4 to 6.5 KWh per square meter. Maximum amount of radiation are available in the month of March-April and minimum in December-January. According to IDCOL, the total capacity of solar energy based installations in Bangladesh appears to be 20.75 MW .The amount is significant considering the upward trend of the number of SHSs (Solar Home System) installations in the country.

Solar panels are the medium to convert solar power into the electrical power. Sun beam is absorbed with the panel material and electrons are emitted from the atoms that they are bounded. This releases current thus solar power is converted into electrical power .When PV cells are joined physically and electrically and placed into a frame they form a solar panel or PV module. Panels joined together form a solar array. A powerful economic model has been created to make solar energy a part of rural life, integrating one of most sophisticated technologies with the aspirations, toils and successes of the rural people. A rural family can have bright light, watch TV and power their mobile phones at the same cost as kerosene, while escaping from dim light, foul smelling smoke including health and fire hazards. Rural businesses can increase their productivity and income through extended working hours and attracting more customers. This sector has been creating green jobs and linkage businesses especially in the rural areas. Hundreds of local youths are working in the rural areas as solar technicians. Rural women are assembling solar accessories in village based Technology Centers. Solar engineers are increasingly employed in designing SHS, working in battery factories, and other accessory related businesses. Bangladesh is on the verge of a Solar Revolution. Increased aspirations, failure of grid electricity, growing machination and disposable income have created huge potential for solar energy in rural areas. Solar Energy can be a great source for solving power crisis in Bangladesh.

6.2) Cost-Benefit Analysis of Solar Energy

The study based on cost-benefit analysis on data collected during field trip to typical SHS projects in village of Gazipur and Mymansingh district. Assume lifetime of SHS and kerosene lamp are 20 years and 3 years respectively. Repair and maintenance cost for SHS and kerosene lamp are 500tk/yr and 120 tk/yr. battery lives is 5 years and after five additional 10000 tk is needed to replace the battery for SHS. Number of family used 3 kerosene lamps for lighting. Each lamp consumes 2 liters kerosene per month. Assuming, Price of the kerosene at present market is 65 tk/liters. The price of SHS is 18000tk including installation charge, where the price of each kerosene lamp is 300tk only. Consider the discount factors at 10% interest. The fundamental principle of appraisal methods is to compare costs against benefits. Although the principle sounds simple but the analysis become somewhat difficult because of the fact that the costs and benefits are spread over a very long period of the time for solar home system, over a period of 20 years. The cost of the system has to be made up front. But the cost of replacement will be made some time in distant future, which makes the estimation difficult. But the more controversial issue is to estimate benefit or cost savings over a period of 20 years.

Kerosene lamp

1. No of lamps= 3 , 2. Fuel consumption= 2 lit/lamp/month*12 month* 3 lamp = 72 liter
3. Initial cost = 300taka*3 lamp= 900 taka , 4. Maintenance cost= 120 taka/year
5. Fuel cost= 65taka/lit* 72 lit =4680 taka , 6. Total cost= 4680 taka+120 taka= 4800 taka
7. Life time= 3 years

Solar Home system

1. Initial cost =18000 taka , 2. Maintenance cost=500 taka/year, 3. Battery cost= 10000 taka/each per 5 years
4. Life time of panel = 20 years

We know that,

$$\text{Benefit cost ratio} = \frac{\text{PV of cash inflow (Return)}}{\text{PV of cash outflow (cost)}}$$

$$\text{Discount factor} = 1/(1+i)^n$$

$$\text{PV (Present Value)} = FV/(1+i)^n$$

However, unlike the initial cost, the operational cost 500 taka/year SHSs are extremely low and On the other hand, households using kerosene, has to spend around 120 taka/year. This indicates a significant amount of savings on kerosene usage due to the installation of SHSs. After 20 years calculating a typical household's costs and savings, calculate the net benefits by subtracting the operational cost from the savings on kerosene, i.e. BDT 44023.14-BDT 34714.7 = BDT 9308.44. The breakdown of typical household's initial cost and details of the net benefit calculations have been summarized in the table. Apart from the standard monthly operational costs, users also have to pay for periodic replacement costs for the storage batteries. Provide solar panels to the villagers in a cheap price.

Table 5. Discounted Cash Flow Analysis for a Typical Solar Home System in Bangladesh

Year	Cash out flow (SHS)	Cash in flow (kerosene)	Discount factor	PV of Cash out flow	PV of Cash in flow
0	18000	900	1.0000	18000	900
1	500	4800	0.9091	454.55	4363.68
2	500	4800	0.8264	413.23	3966.72
3	500	5700	0.7513	375.65	4282.41
4	500	4800	0.6830	341.50	3278.20
5	10500	4800	0.6209	6519.45	2980.32
6	500	5700	0.5645	282.25	3217.62
7	500	4800	0.5132	256.6	2463.36
8	500	4800	0.4665	233.25	2239.2
9	500	5700	0.4241	212.05	2417.37
10	10500	4800	0.3855	4047.75	1850.4
11	500	4800	0.3505	175.25	1682.4
12	500	5700	0.3186	159.30	1816.02
13	500	4800	0.2897	144.85	1390.56
14	500	4800	0.2633	131.65	1292.64
15	10500	5700	0.2394	2513.70	1364.58
16	500	4800	0.2176	108.80	1044.68
17	500	4800	0.1978	98.90	949.44
18	500	5700	0.1799	89.95	1025.43
19	500	4800	0.1635	81.75	784.8
20	500	4800	0.1486	74.3	713.28
				Σ=34714.7	Σ=44023.14

6.3.Multiple energy generation system

The initial cost of solar energy system is high rather than other sources. So we need to establish multiple energy system for the development of energy sector as well as production of energy.

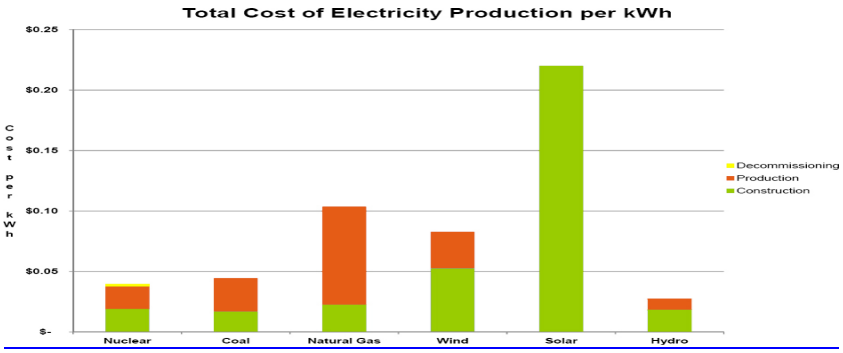

Fig .5 . Cost of electricity production

The following flow chart is exploring the multiple energy system.

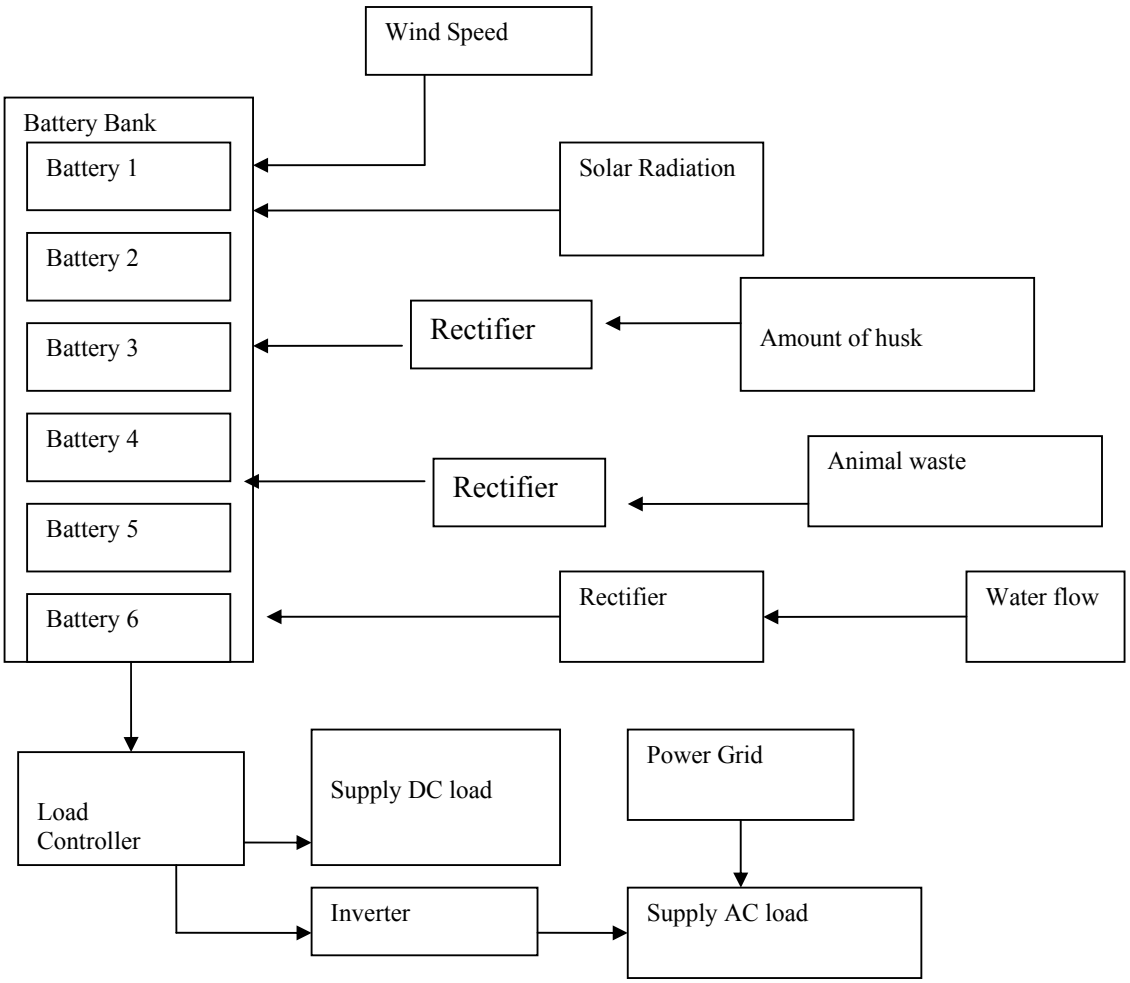

Fig. 6 . Flow Chart of Multiple Energy System

According to this flow chart we can see that at first we will measure the wind speed from wind generator; if the wind speed is greater than 4 ms-1 then the battery bank will charge, if not then it will go to measure the solar radiation. If the radiation is sufficient to produce electricity then the battery bank will charge or else it will go to measure rice husk (biomass) .If the rice husk is more than 10kgs then again the battery bank will charge or then will go to the biogas scheme. In case of the failure of biogas scheme eventually it will measure the speed of water flow of micro hydro generator. If the water flow is greater than 1000 ms-1 then the battery will charge or else the loads will take power directly from the grid if the grid power is available. However, in case of unavailability of the grid power, the system will again go to measure the wind speed and thus will repeat the entire process. Here the battery bank can feed electricity to the DC loads and to AC loads using an inverter in between loads and the battery bank as well. It has to be mentioned that the output voltage of the power system generator is 12v and the consumer uses 60% of the available power while the rest is being used for battery charging.

7. Main Constraints

- RETs have high initial cost, low level of technological development, availability and site dependence.
- Absence of approved policy framework.
- Absence of agency to handle the RE issues.
- Renewable energy activities are going on without any coordination.
- Bangladesh is failing to avail of the opportunities offered by international organizations.
- Lack of national and foreign investment in the RE sectors.

8. Govt. Policy for the improvement in RE

The prospects of solar PV and other renewable energy utilization depend on the role of the Government. The Government is facilitating RE development, which should be enhanced so that private entrepreneurs come forward to take the initiatives to disseminate renewable energy technologies. It is expected that RE will play a more extensive role in meeting the energy needs. Renewable Energy policy is adopted in 2008. The policy identifies the following major renewable energy sources namely – solar photo voltaic, solar thermal power/concentrating solar power, wind energy, biomass, biogas, micro hydro and mini hydro. The objectives of the policy are to harness the potential of RE, dissemination of RE technologies, facilitate both public and private investment in this sector, increase energy supplies to substitute indigenous non-renewable energy. To achieve the objective government has set targets for developing renewable energy resources to 5% of total power demand by 2015 and 10% by 2020.Energy is one of the serious problems in Bangladesh. It is a global crisis as of today. Now we are facing global warming issue especially in the developing Countries. Bangladesh could be one of the most effected Countries from the impact of pollution. That's why; CMB Power stands with the Government and the people of Bangladesh. The Government of Bangladesh is concerned about the impact of pollution, necessity of power for economic growth and stability, poverty, food, health and the current way of life. As a proud nation, Bangladesh has the responsibility to contribute to the war against global warming. By implementing green energy projects and proper irrigation systems in this agriculture based Country, Bangladesh can achieve the goal. At Copenhagen on December 18th, 2009 the US President Mr. Barack Obama expressed concern about global warming and its impact in the developing Countries especially in Bangladesh. He mentioned to cut down the emission 17% by 2020, and 80% by 2050. He also promised to help any developing countries which are willing to contribute to global warming. He promised to donate $10 billion by 2012, and $100 billion by 2020. Besides, Bangladesh is one of the fastest growing developing Countries in south Asia. We are providing the following snapshot to understand our project background, local market and economic structure of Bangladesh.

9.Recent Initiatives on RE:

Renewable Energy policy is adopted in 2008. The policy identifies the following major renewable energy sources namely – solar photo voltaic, solar thermal power/concentrating solar power, wind energy, biomass, biogas, micro hydro and minihydro. Present Solar Power Generation: 15-20 MW PDB, REB and IDCOL are distributing Solar Home System (SHS) to the people living in the off-grid areas. IDCOL through different NGO has already distributed 4.5 lakhs SHS through out the country. PDB has already installed nearly 11 KW solar power to the CHT area, nearly 230 W solar power in Angorpot and Dahagram chitmahal Aarea , installed 115 W in the WAPDA office building..A Solar Panel with capacity of 21.2 KW is installed at the Hon'ble Prime Minister's office.Nearly 10MW solar plant will be installed by PDB in Sarihabari (2-4 MW), Rigional Training Office, Rajshahi (1 MW), Rajabarihat, Godagari (2-4 MW), Kaptai Power Plant (4-5 MW) in IPP model. Preparation of tender documents is underway.PDPP has been prepared to cover 4 isolated islands under solar and wind power.REB has taken project for Solar Irrigation System. 20 irrigation pumps will be brought under solar power under this project Installed wind mill at Kutubdia and Feni: 2MW PDPP has been prepared for wind mapping.100 MW of wind power will be generated in the off-shore area of Anwara, Chittagong in IPP model. PQ has already been prepared, tendering is under process. Govt. has exempted income tax for next 5 years from commercial production from RE.

10. Suggestions for Creating a Sustainable Energy Future

- Need to increase access to electricity among the people living in off grid, isolated and in accessible remote areas by solar home systems (SHS).Improve the standard of living and increase income by introducing solar power and wind power.
- Need to increase the supply of power by installing offshore wind turbines.
- Explore the potential of other firms of renewable energy such as micro hydro, tidal energy, bio-mass and bio-diesel to meet the power and energy demand of the rural people and
- Must explore the potential of municipal wastes to generate electricity.
- Increase fuel efficiency standards for vehicle, appliances, buildings
- Need to reconstruct tax and other financial incentives for energy efficiency
- Provide facility to Subsidize renewable energy use, research and development
- Internalize externalities for fossil fuels
- By 2050: Increase renewable energy to 50%
- Cut coal use by 50%

- Phase out nuclear altogether
- Make project profile to seek FDI and Foreign aid.
- Increase Technological experiments
- Have to provide facilities & incentives to generate renewable energy in private sectors.
- Utilize the natural resources, solar, wind, rivers etc
- Building a Cutting Edge Entrepreneur Based Structure
- We can create village based SME entrepreneurs to popularize solar pumps, mini grids and biogas plants etc.
- Focusing on an Efficient, Cost effective Supply Chain.
- Passing Pro -renewable energy Laws.
- Investing in Capacity Development and R & D.

11. Conclusion

There are quite significant untapped renewable energy resources in Bangladesh, although the utilization is minimal today. Remote & rural households and other establishments can benefit from off-grid services of RETs. The solar industry has begun to develop commercially. The popularity of PV is increasing. To harness the potential of RE, concerted effort is urgently needed. Renewable energy is energy, which comes from natural resources such as sunlight, wind, rain, tides, and geo thermal heat, which are renewable (natural replenished). Solar home system (SHS) is becoming increasingly popular and a project is taken to generate electricity from wind power. The main goal is to develop, disseminate, promote and extend the renewable energy technology to the rural as well as urban people to meet their energy needs by using sustainable and environment friendly energy sources. A contemporary scenario of Bangladesh's renewable energy sector has been presented using data and illustrations, on the basis of careful literature review and fieldworks. It can be an excellent, cost effective and also a reliable solution to mitigate the existing power crisis if we can implement this project properly. It has a great impact on improving the socio-economic condition of rural people as well as will be a good sign of green energy technology. Bangladesh has got ample solar isolation throughout the country. Daily average solar radiation varies between 4 to 6.5 kWh/m2. Maximum amount of radiation is available on the month of March-April and minimum on December-January. There is bright prospect for applications of solar thermal and photovoltaic systems in the country. From the previous studies, it can be inferred that the small wind turbines can be installed in the coastal regions of the country. LGED's ongoing WERM project under "Sustainable Rural Energy(SRE)" program is expected to provide more valuable information regarding Wind Energy potential of Bangladesh for larger projects. There is limited potential of small hydro power plants in the hilly regions and existing irrigation project locations. BPDB and Bangladesh Water Development Board (BWDB) should work together to implement a pilot project at any of the prospective regulating structures of Tista Canal system. A comprehensive study should be carried out to assess the biomass potential of the country for modern applications like gasification. Waste-to-energy project should be given serious contemplation which will not only provide electricity, but also reduce the unpleasant waste disposal problems of metropolitan cities of the country. Recently, an initiative has been taken to explore the scope of integrated tidal power plants in the island of Sandwip. If the pilot project becomes successful, similar projects can be replicated to other coastal islands of the country. Most wanted UNEP´s Solar and Wind Energy Resource Assessment (SWERA) project will be finished very soon. It is expected that from the middle of the year 2014, energy planners or private entrepreneurs will have clear understanding regarding the solar and wind energy potentials at different parts of the country. Projects concerning multiple energy system can be a great innovation and achievement to the energy sector of Bangladesh. Renewable energy sources discussed above can help Bangladesh produce more power. Time has come to look forward and work in these renewable energy fields to produce electricity rather than depending wholly on conventional method. With the help of these resources Bangladesh can export electricity meeting the internal demand in the future. Therefore, the Government and the Private sector should work and in hand to emphasize more on renewable energy source to produce electricity to solve our power crisis problem.

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