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Overview of Power Generation Sector of Bangladesh and Proposed Grid Connected Hybrid Renewable Energy System

Md. Raju Ahmed[*], Subir Ranjan Hazra[**], Md. Kamruzzaman[***]

Department of Electrical & Electronic Engineering, Dhaka University of Engineering and Technology (DUET), Gazipur, Bangladesh

ABSTRACT

Electricity is the most usable form of energy, and one of the most crucial strategic issues for the sustainable development of a country. The projection of demand of electricity is an integral part of the planning process. Severe power crisis compelled the government to enter into contractual agreements for high-cost temporary solution such as rental power and small IPPS, on an emergency basis, most of these are diesel or liquid-fuel based. Load shading is an acute problem for the country. The country is confronting a simultaneous shortage of electricity. However, the country has substantial amount of renewable energy resources. The overview of power generation section of Bangladesh is presented; the potentiality of renewable energy sources in Bangladesh is discussed. Finally, a grid connected hybrid renewable energy system is proposed to overcome the problem of power crisis using sustainable clean energy at rural area.

Keywords– Power generation, renewable energy, biogas, PV system, hybrid system

I. INTRODUCTION

The power sector of Bangladesh is almost dependent on natural-gas fired generation; the percentage of generation using natural gas is almost 65% [1] of the total generation [2]. Due to huge use of natural gas for generation of electricity, their reserve is at alarming condition. At present Bangladesh power development board (BPDB) generates 10445MW [1]. Different government, semi government and nongovernment organization have been working separately or jointly to meet the power demand. Most of the rural areas are not under national grid still now, and socioeconomic development is stacked at a point in rural areas. Locales in remote or isolated areas are meeting their demand with solar home system or kerosene lantern.

There is a good potential of solar energy in Bangladesh. Also, Bangladesh is an agricultural-based country. Therefore, biomass resources are available in plenty and good prospects of generation of electricity by using biogas. In addition, Wind power generation and small scale hydro power generation can change the total power scenario [3]. However, prospective planning and comprehensive understanding of this dynamic field require continuous assessment. Motivated by this objective, in this paper energy scenario of Bangladesh is discussed, and finally proposed a grid connected hybrid renewable system to overcome the problem of power crisis in rural area using green energy.

II. OVERVIEW OF POWER GENERATION OF BANGLADESH

Bangladesh is a fast growing developing country. A booming economic growth, continuing industrialization and development has increased the demand of electricity day by day. To fulfill the demand, government has set the vision to provide access to affordable and reliable electricity to all by the year 2021, and whole area under coverage by 2030. The present generation capacity is nearly 10500MW while the vision is set to 39000MW in 2030.Table-Isummarized the generation report on October 22, 2014 and the data is collected from the official website of Bangladesh Power Development Board (BPDB) [4].

Table I. Owner Wise Daily Generation Report

Owner Name	Derated Capacity (MW)	Day Peak (MW)	Eve. Peak (MW)
Power Development Board	4332.00	1767.00	2702.00
Electricity Generation Company of Bangladesh Ltd.	622.00	0.00	0.00
Ashujganj Power Station Co. Ltd.	682.00	467.00	467.00
Independent Power Producers	1617.00	723.00	896.00
Small Independent Power Producers	325.00	248.00	283.00
Rental Power	1987.00	1269.00	1440.00
Other	825.00	1101.00	1189.00
Total	10390.00	5515.00	6987.00

The total generation on October 22, 2014 was 10390MW [5], 55% of total generation is generated from government owned power plant and 45% is generated from private enterprises. Fig.1 represents the present scenario of generation from private and public enterprises according to the generation capacity.

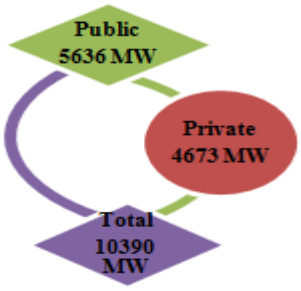

Fig.1. Present power generation capacity

The demand of electricity is rising due to growing population and increasing economic activities. As many new independent power producers have shown their interest in electricity production, a revised target of additional 12,473 MW [6] by 2015 has been fixed together with adoption of different new project. In Fig.2 the energy chain of Bangladesh from supply to demand has been shown.

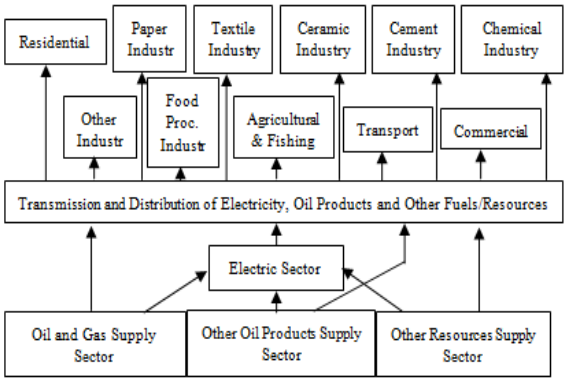

Fig.2. Sectoral energy supply and demand network

2.1 CONSIDERABLE STEPS TAKEN BY THE GOVERNMENT FOR ENERGY SECTOR

To meet the growth of electricity demand, Bangladesh government already takes some initiatives. Government has set the vision 2021 to overcome the energy crisis and set the aim to take the edge off total energy catastrophe in between 2030. As the natural-gas resource is going to concurrent deficiency, government has looking forward to coal based power generation and nuclear power generation.

2.1.1 NUCLEAR POWER STATION

In 2007 the Bangladesh Atomic Energy Commission (BAEC) proposed two 500 MW nuclear reactors for Rooppur by 2015. An agreement with Rosatom was signed in February 2011 for two 1000 MWreactors to be built at Rooppur for the Bangladesh Atomic Energy Commission (BAEC). Another intergovernmental agreement was signed in November 2011 for the project to be built by ASE-Atomstoryexport (which in mid-2012 was merged with Nizhny Novgorod Atomenergoproekt, NIAEP).Site works started in October 2013, and construction of the first unit is expected from 2015, with operation soon after 2020. The proposed second unit construction time is expected from 2020, with operation soon after 2025 [7].

2.1.2 COAL BASED POWER GENERATION

The government promised to set up a total of eight coal-fired power plants under their and private sector. Of them, the local private firm Orion group was supposed to build three 1,088MW coal-based power plants, another two 1450MW power plants under the government initiative, while three more 7960MW plants as joint-venture. The government planned to install one of the plants at Mawa of Munshiganj with a capacity of 522MW while two others with the total capacity of 566MW in Khulna region. There is already a 250MW government-run coal-based power plant at Barapukuria in Dinajpur. Coal for this power plant is supplied from Barapukuria Coal Mining Company Limited. Adjacent to the Barapukuria Power Plant another 250MW plant of the Power Development Board was supposed to be set up. Sites were also chosen for a 1200MW power plant of the state-owned Coal Power Generation Company Limited with a loan from the Japan International Cooperation Agency (Jica) at Matarbari in Cox's Bazar.

The government also initiated to set up a 1320MW coal-fired plants at Rampal with the National Thermal Power Corporation of India and another 1320MW plant in Chittagong in joint venture. These power plants were expected to start production between March 2015 and 2017. Under joint venture, Moheskhali in Cox-Bazar was selected for another coal-fired power plant with the capacity of generating 5320MW of electricity [8].

III. CURRENT RENEWABLE ENERGY SITUATION IN BANGLADESH

In our country renewable energy such as biomass, solar power and wind power are being used since time immemorial; especially in areas which are outside gas coverage, usage of biomass for cooking and solar power and wind for drying of different grains as well as clothes are known to all. However, we are still lagging far behind in the scientific use of such energy. But currently situation is changing; in rural areas where grid connection is out of range, people are using solar home system. In some cases small scale

bio gas power generation is established for private use, but large scale is not yet established. At present, the national capacity of renewable energy based power, excepting hydro-power, is approx. 50 MW [9] as shown in Table-II.

Table II. Renewable Energy Scenario of Bangladesh

Category	Generation (MW)
Solar Home System	45
Other Solar PV Applications	1
Wind Energy	2
Biomass Based Electricity	<1
Biogas Based Electricity	1
Total	50

3.1.1 SOLAR ENERGY

At present, only about 30% of the rural households in Bangladesh have access to grid electricity. For the rest of the areas not connected to the grid, life comes to almost a standstill after sun-set. But, Solar Energy is one of the great sources for work out power crisis in Bangladesh. 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 [8]. The Rural Electrification and Renewable Energy9 Development (RERED) Project, supported by The World Bank, is promoting renewable energy options to provide electricity to these remote areas. Implemented by IDCOL, the project has made solar home systems available to households and village markets. IDCOL partners with NGOs and private sector companies to implement this project and a total of 1,320,965 SHSs having capacity of about more than 36.5 MW have been installed upto February 2012 [10].

3.1.2 WIND ENERGY

Bangladesh has seven hundred kilometer coastal line, analysis of upper air data by Center for Wind Energy Technology (CWET) India show that wind energy resource of Bangladesh is not good enough for grid connected wind parks [11]. At present, several wind resource assessment program (WERM,SWERA, WRAP of BPDB) is ongoing 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 [12]. The wind speed in some regions of Bangladesh is satisfactory for operation pumps and for generation of electricity. It was found that the wind speed in Chittagong is 2.57 m/sec or more for 4000 hours a year. At this available speed a wind plant can be operated both for generation of electricity and for driving pumps. Recently, several small wind generators have been installed by BRAC (11 small wind turbines in various coastal sites) and Grameen Shakti (two wind generators of 300 W and 1 KW at its Chakoria Shrimp Farm).

3.1.3 HYDRO-ELECTRICITY

Bangladesh is a plain delta with having three of the world's major rivers the Ganges, the Brahmaputra and the Meghna flowing through it. Out of all the rivers about 57rivers are transboundary originating from India and Myanmar [13]. During monsoon the flow rate of most of the rivers is high but it reduces substantially during winter. Hence the scope of hydropower generation is very limited in Bangladesh except in some hilly regions in the northeast and southeast parts of the country. The Karnafuly Hydro Power Station is the only hydropower plant in the country (located at kaptai, about 50 km from the port city of Chittagong), having a capacity of 230 MW by 5 units. It is operated by BPDB (Bangladesh Power Development Board). BPDB is considering the increase of production up to 330MW. Two sites have been chosen for another two Hydro power plants at the Sangu and Matamuhuri rivers, one named The Sangu project (140MW) and the other The Matamuhuri Project (75MW). BPDB has designed a 20kW micro-hydro power plant with the help of RETScreen, developed by CANMET Energy Diversification Research Laboratory of Canada (CEDRL) at Barkal (a sub-district in the Chittagong Hill tracts) waterfall [13].

3.1.4 BIOGAS

With increasing industrialization and urbanization the demand for natural gas will continue to grow. It is said that the country would require about 13.6tcf of gas upto 2020, about 26.7tcf upto 2030, and about 62tcf upto 2050. With natural gas as the single significant commercial energy resource available in the country, it appears that the present reserve of 11.6tcf will not run beyond 2020. The above situation leaves the rural population to rely on the traditional biomass sources for household supply of energy. Bangladesh is an agricultural country so biomass is available in huge amount. Cattle dung, agricultural residue, poultry dropping, water hyacinth, rice husk etc. used for biomass power generation are available in Bangladesh [14]. Infrastructure Development Company Limited (IDCOL) will introduce one-lakh bio gas plants in rural areas across the country by 2016. The company already set 25,500 Biogas plants in rural areas through its Partner Organizations (POs) under National Domestic Biogas and Manure Programe (NDBMP) from June 2006.

3.1.5 TIDAL ENERGY

Ocean covers 75 per cent of the earth and has enormous potentiality of generating electricity. It has been estimated that if less than one per cent of total capacity of tidal electricity is generated, it will cover five times of total global requirements. Tidal power plant is a reliable energy source to replace the burning of fossil fuels. In addition, it is a renewable source of

energy that produces no greenhouse gases or any type of waste. Tidal stream generator has little environmental impact and can be built offshore [15]. The coastal of Bangladesh has a tidal rise and fall of between 2 to 5 meters [16]. Among these coastal areas, with 5 meter tides experienced, Sandwip has the best prospect to generate tidal energy [16]. Moreover, according to Reference [13], 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 i n 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.

3.1.6 GEOTHERMAL

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 [17]. Recently, the Ministry of Power, Energy and Mineral Resources has approved the establishment of the first ever geothermal power plant (200MW) in the country. A Dhaka based private company named Anglo MGH Energy has initiated this project at island of Thakurgaon district. The Rangpur saddle, Bogra shelf potentially offers good conditions for geothermal power projects [9].

IV. PROPOSED GRID RENEWABLE HYBRID SYSTEM

To meet the demand and solve the present crisis of electrical power, we are proposing a hybrid system represented in Fig.3 that will work both on grid and off grid to reduce the dependency on national grid. In this system hydro and biomass generation is connected to ac bus which is fed by converting them ac to dc and connected to dc bus and input from PV and wind generator is directly connected to dc bus. One line of dc bus fed by load controller connects directly to dc loads and another line is connected to ac line fed by inverter, transformer and controller. Dump load is used when the batteries are fully charged and controller is used to control charge, load and inverter. When the load demand is greater than the proposed system power (output of transformer) then the additional power is added from the grid. On the contrary, when the demand of the load power is less than the proposed system power, than the extra power is fed to the national grid. In this research, we proposed a plan, where the grid can use the residue power, which is left out after the load is supplied completely. To maintain the mechanism when the load take power from the grid and when the proposed system supply to the national grid, there is a controller. Our proposed hybrid system will be very effective especially for remote areas of Bangladesh like Chittagong hill track, Cox-bazaar hill side and sea side, Islands and so on.

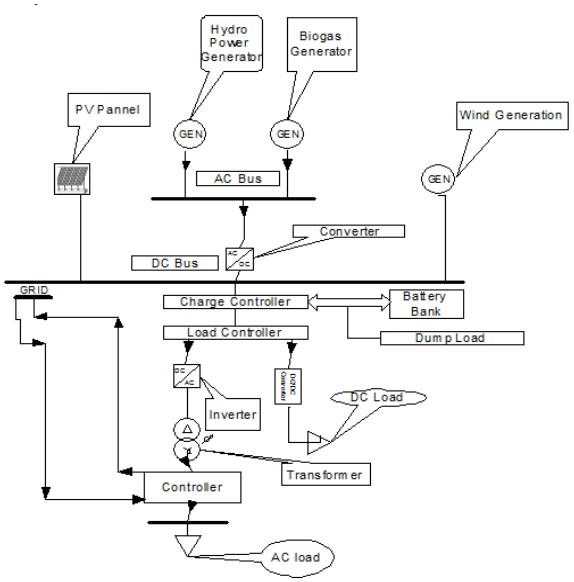

Fig.3. Proposed Plan for Hybrid System

4.1.1 CHARGE CONTROLLER

A charge controller, or charge regulator is basically a voltage and/or current regulator to keep batteries from overcharging. It regulates the voltage and current coming from the solar panels going to the battery. It is used to sense when the batteries are full y charged and to stop or decrease the amount of energy fl lowing from the energy source to the batteries [18]. Most quality charge controller units have what is known as a 3 stage charge cycle that goes like this:

1) Bulk: During the Bulk phase of the charge cycle, the voltage gradually rises to the Bulk level (usually 14.4 to 14.6 volts) while the batteries draw maximum current. When Bulk level voltage is reached the absorption stage begins.
2) Absorption: During this phase the voltage is maintained at Bulk voltage level for a specified time (usually an hour) whiles the current gradually tapers off as the batteries charge up.
3) Float: After the absorption time passes the voltage is lowered to float level (usually 13.4 to 13.7 volts) and the batteries draw a small maintenance current until the next cycle.

The relationship between the current and the voltage during the 3 phases of the charge cycle can be shown visually in Fig.4.

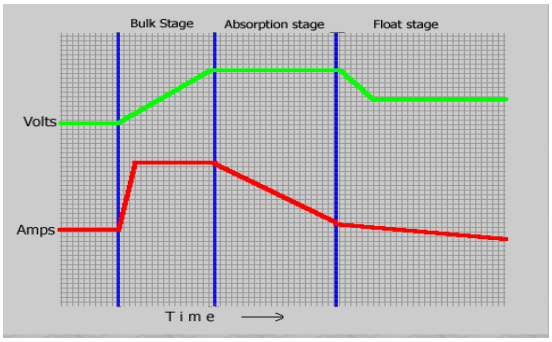

Fig.4. Charge Cycle [19]

4.1.2 LOAD CONTROLLER

A load controller is an outdoor mounted computer that measures power usage and controls peak demand by load shedding. Quite simply, a load controller is like a cruise control for electric system. In this research, dc load controllers is used to find the priority of dc loads and another controller is used to maintain the mechanism when the load take power from the grid and when the proposed system supply to the national grid.

4.1.3 DUMP LOAD

Dump loads are an important part of the off grid electric system. Most wind and water turbine installations will require them and most solar installations will benefit from a dump load. A dump load is simply an electrical device (load) to send electricity to when the batteries are full or the extra power is not required. Simply the dump load takes the power when the charge controller senses that the batteries are full, to protect them [20]. Once the power has been diverted, the dump load uses the power for something productive rather than lose it directly into the ground.

V. TOTAL POWER CALCULATION

We can calculate individual power equations and total power equation [21].

Solar power, P_{solar} =Area per sq-ft × watts per sq-ft

Wind power, $P_{wind} = 0.5 \times \rho \times A \times v^3$

Where,

A=area perpendicular to the direction of flow (m^2),

v=wind velocity (in ms^{-1}),

ρ =density of air which is about 1.2 Kgm^{-3}

Biogas generator power, $P_{biomass}$(W)=

$$\frac{50\%\text{ of }100\text{ kgs animal waste} \times 1000}{2\text{ kgs animal}\frac{\text{waste}}{\text{kWh}} \times 5\text{ hours operation a day/year}}$$

Hydro power, $P_{hydro}(W) = H \times Q \times g \times 1000$

Where,

H=Gross water head (in meter),

Q=Flow of water (in m^3/sec) and

g=Gravitation force i.e. 9.81 (in ms^{-2})

Now,

The total power, $P_T(W) = P_{solar} + P_{wind} + P_{hydro} + P_{biogas}$

VI. CONCLUSION

Electrical energy plays a vital role in development of a country. The advancement of a country is measured in terms of per capital consumption of electrical energy. It is quite impossible to solve over all power crisis at present moment, however, possible to minimize the crisis by using the proposed grid renewable system.

Bangladesh is lacking continuous supply of power from national grid especially in rural and remote areas. A new model of an efficient, suitable and robust hybrid system has been proposed in this paper to overcome this problem.

Isolated area like Saint Martin Island and other islands, where grid connection is totally impossible, off grid hybrid system is proposed for those areas. Remote areas where grid connected is present but facing massive load shedding, on grid connection is proposed for those areas.

In this paper, the present electricity generation scenario of Bangladesh is clarified, the available renewable energy sources is discussed and finally design and proposed a grid connected hybrid renewable energy system to overcome the problem of power crisis at rural area. Government has already taken some initiatives. However, that's not kind enough to unravel the present power crisis. The proposed system can be implementing to solve the problem of power crisis, at the same time the proposed system will have a positive impact over social and economical status of rural society using green energy technology.

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BIOGRAPHIES

Md. Raju Ahmed received B.Sc. from Chittagong University of Engineering and Technology, Bangladesh, M.Sc. from Bangladesh University of Engineering and Technology, Bangladesh, and Dr. of Engg. Degree from the University of Tokyo, Japan in 2003, 2006 and 2013 respectively, all in Electrical and Electronic Engineering. He joined Dhaka University of Engineering and Technology, Bangladesh in 2004, and has been an associate professor since 2013. Dr. Ahmed is a member of Institution of Engineers of Bangladesh (IEB)

Subir Ranjan Hazra was born in Barisal, Bangladesh on 25th July, 1985. He obtained his B.Sc. in Electrical and Electronic Engineering from Stamford University, Bangladesh in 2008. Currently he is pursuing his post graduate study under the department of Electrical & Electronic Engineering in Dhaka University of Engineering and Technology; Bangladesh. His research interests include Power System and Renewable Energy.

Md. Kamruzzaman obtained his B.Sc. in Electrical and Electronic Engineering from Ahsanullah University of Science and Technology, in 2009. At present he is continuing post graduate study under the department of Electrical & Electronic Engineering in Dhaka University of Engineering and Technology, Bangladesh. He is currently Sr. Lecturer of Electrical and Electronic Engineering department at Atish Dipankar University of Science and Technology, Dhaka, Bangladesh. His research interests include RF Engineering, Power System and Renewable Energy. Kamruzzaman is a member of Institution of Engineers of Bangladesh (IEB).