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Analysis of Renewable Sources as a Solution to Power Crisis in Bangladesh

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ABSTRACT
The incisive power crisis problem in Bangladesh can be solved through proper implementation of renewable energy technologies. Although Bangladesh is blessed with all types of renewable energy sources, still now renewable energy has not been given priority as a possible solution to power crisis. Existing sources like solar energy, wind energy, hydropower and potential sources like geothermal energy, wave energy, energy from the Bay-of Bengal have been discussed at a detailed manner here in this paper so that maximum possible energy can be extracted through these using the available subsisting technologies. Technology overview, cost analysis and implementation technique get circumstantial interpretation throughout the paper.
Keywords: Power crisis, renewable sources, implementation

1 INTRODUCTION

Renewable energy is generally defined as energy that comes from resources which are naturally replenished on a human timescale such as sunlight, wind, tides, waves and geothermal heat. Renewable energy replaces conventional fuels in four distinct areas: electricity generation, hotwater/spaceheating, motorcycle and rural energy services. About 16% of global final energy consumption presently comes from renewable sources with10 % of all energy from traditional biomass, mainly used for heating, and 3.4% from hydroelectricity. New renewables (small hydro, modern biomass, wind, solar, geothermal, and biofuels) account for another 3% and are growing rapidly. Although Bangladesh have all the above mentioned sources existing, its power generation from renewable sources stands below. The analysis of renewable sources can be an alternative solution to the acute problem of power crisis in Bangladesh.

2 PRESENT ENERGY SITUATION IN BANGLADESH

Bangladesh's energy infrastructure is quite small, insufficient and poorly managed. The per capita energy consumption in Bangladesh is one of the lowest (321 kwh) in the world. Noncommercial energy sources, such as wood fuel, animal waste, and crop residues, are estimated to account for over half of the country's energy consumption. Bangladesh has small reserves of oil and coal, but very large natural gas resources. Commercial energy consumption is mostly natural gas (around 66%), followed by oil, hydropower and coal.

Electricity is the major source of power for most of the country's economic activities. Bangladesh's installed electric generation capacity was 10289 MW in January, 2014; only three-fourth of which is considered to be 'available'. Only 62% of the population has access to electricity with a per capita availability of 321 kWh per annum which is interrupted by power cut.

3 RENEWABLE ENERGY POTENTIAL IN BANGLADESH

Bangladesh is expected to have enormous potentiality in renewable energy development. Country is blessed by considerable solar radiation. Bangladesh receives an average daily solar radiation of 4-6.5 kWh/m2. Solar photovoltaic (PV) are gaining acceptance for providing electricity to households and small businesses in rural areas. Development of off-grid solar home solutions has achieved international benchmark. According to a survey, there is an existing market size of 6 million households for Solar Home Systems (SHS) on a fee-for-service basis in the off-grid areas of Bangladesh.

Table-1: Renewable energy situation in Bangladesh

	Category	Achievement
1.	SHS	150 MW
2.	Solar Irrigation	1 MW
3.	Roof Top solar PV at Government, Power sector office buildings and at newly constructed buildings	14 MW
4.	Wind Energy	2 MW
5.	Biomass based	<1 MW

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	electricity	
6.	Biogas based electricity	5 MW
7.	Hydro power	230 MW
	Total	**403 MW**

Potential of Wind Energy is mainly in coastal areas and offshore islands. Bangladesh has strong potential for biomass gasification based electricity. More common biomass resources available in the country are rice husk, crop residue, wood, jute stick, animal waste, municipal waste, sugarcane bagasse etc. Exploration of these resources for electricity generation is still at preliminary stage. Potentials for utilizing biogas technologies derived mainly from animal, kitchen and municipal wastes may be one of the promising renewable energy resources for Bangladesh.

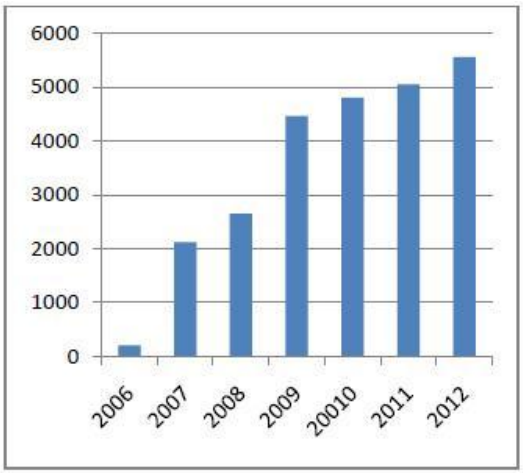

Fig-1:Biogas plants construction in Bangladesh

4 OVER VIEW ON DIFFERENT RENEWABLE ENERGY SOURSES IN BANGLADESH

4.1 BIOPOWER

Biopower, or biomass power, is the use of biomass to generate electricity. It is the third largest form of renewable electricity generation after hydropower and wind energy, and is a mature source of renewable power, with costs on par with conventional fossil energy plants. Electricity produced from biomass can be used as base-load or dispatchable power in the existing electric power sector and in industrial cogeneration.

4.1.1 Resources: Potential biopower resources – wood wastes, mill residues, forest residues, agricultural residues, cattle residues, and dedicated harbecious and woody energy crops are widely distributed through out the country.

4.1.2 Technology overview: Biopower technologies include those that directly combust biomass (direct-fired biomass and co-firing) in a furnace to produce steam that is used in a steam turbine generator (STG) and those that convert solid biomass to an intermediate gas or liquid that is then used in a prime mover to produce electricity.

Biopower system technologies include direct firing fired combustion, co-firing, gasification, pyrolysis, landfill gas generators, and anaerobic digestion generators. RE Futures investigated opportunities for additional technology improvements that can lead to reduced cost, focusing on increasing system efficiencies by combining direct combustion technologies with gasification technologies to produce a dynamic mixed fleet that gradually includes more gasification technologies.

The most important issue for large-scale deployment of biopower is feedstock competition with lignocellulosic biofuels and other uses for wood. In addition to the known air and water quality environmental issues associated with permitting and operation of biopower plants, the primary environmental issues that must be addressed for biopower are overall sustainability and land use change impacts resulting from growing dedicated biomass feedstocks to support large-scale deployment of biopower technologies. Proactive strategies to reduce capital and operating costs for early-generation systems, reduce uncertainty in feedstock cost and supply, standardize policies and incentives, and improve and standardize codes and standards are needed to maximize biopower's contribution to a high-renewable electricity future.

4.1.3 Technology cost and performance: Future capital cost, performance (generally represented as capacity factor or heat rate), and operating costs of electricity generating technologies are influenced by a number of uncertain and somewhat unpredictable factors. As such, to understand the impact of renewable energy technology cost and performance improvements on the modeled scenarios, two main projections of future renewable energy technology development can be evaluated: (1) renewable electricity-evolutionary technology improvement (RE-ETI) and (2) renewable electricity-incremental technology improvement (RE-ITI). In general, RE-ITI estimates reflect only partial achievement of the future technical advancements and cost reductions that may be possible, while the RE-ETI estimates reflect a more complete achievement of that cost-reduction potential considering only evolutionary improvements of currently fewer commercial technologies.

4.2 GEOTHERMAL ENERGY

Geothermal (meaning "earth heat") energy involves using the high temperatures produced beneath the earth to generate electricity from heated water, as well as for various direct uses (such as hot springs spas, lumber drying or aquaculture). The term geothermal is also

applied to the temperatures of the Earth near the surface which are used as a source of consistent temperatures for heating and cooling of buildings. Geothermal applications that involve water heated within the earth are also called hydrothermal processes.

Table-2: Geothermal gradients as noted in some deep wells of Bangladesh

Well Name	**Depth (Km)**	**Gradient (K/km)**
Hazipur	3,816	30,9
Bakhrabad	12,837	25.0
Titas	13,758	30,1
Habigonj	13,509	31,16
Rashidpur	13,851	26,8
Biyanibazar	14,107	28,7
Kailas Tila	14,139	27,8
Sylhet	12,377	31,1
Chhatak	12,33	33,8
Semutang	14,88	30,3

4.2.1 Resources: Naturally occurring large areas of hydrothermal resources are called geothermal reservoirs. Most geothermal reservoirs are deep underground with no visible clues showing above ground. But geothermal energy sometimes finds its way to the surface in the form of: volcanoes and fumaroles (holes where volcanic gases are released), hot springs, geysers. Most Geothermal Resources Are Near Plate Boundaries. The most active geothermal resources are usually found along major plate boundaries where earthquakes and volcanoes are concentrated. Most of the geothermal activity in the world occurs in an area called the Ring of Fire. This area encircles the Pacific Ocean.
When magma comes close to the surface, it heats ground water found trapped in porous rock or water running along fractured rock surfaces and faults. These features are called hydrothermal. They have two common ingredients: water (hydro) and heat (thermal). Geologists use various methods to look for geothermal reservoirs. Drilling a well and testing the temperature deep underground is the most reliable method for finding a geothermal reservoir.

4.2.2 Technology overview: Geothermal power plants use steam produced from reservoirs of hot water found a couple of miles or more below the Earth's surface. There are three types of geothermal power plants: *dry steam*, *flash steam*, and binary *cycle*.

Dry steam power plants draw from underground resources of steam. The steam is piped directly from underground wells to the power plant, where it is directed into a turbine/generator unit. There are only two known underground resources of steam in the United States: The Geysers in northern California and Yellowstone National Park in Wyoming, where there's a well-known geyser called Old Faithful. Since Yellowstone is protected from development, the only dry steam plants in the country are at The Geysers.

Flash steam power plants are the most common. They use geothermal reservoirs of water with temperatures greater than 360°F (182°C). This very hot water flows up through wells in the ground under its own pressure. As it flows upward, the pressure decreases and some of the hot water boils into steam. The steam is then separated from the water and used to power a turbine/generator. Any leftover water and condensed steam are injected back into the reservoir, making this a sustainable resource.

Binary cycle power plants operate on water at lower temperatures of about 225°-360°F (107°-182°C). These plants use the heat from the hot water to boil a *working fluid*, usually an organic compound with a low boiling point. The working fluid is vaporized in a *heat exchanger* and used to turn a turbine. The water is then injected back into the ground to be reheated. The water and the working fluid are kept separated during the whole process, so there are little or no air emissions.

Small-scale geothermal power plants (under 5 megawatts) have the potential for widespread application in rural areas, possibly even as distributed energy resources. Distributed energy resources refer to a variety of small, modular power-generating technologies that can be combined to improve the operation of the electricity delivery system.

4.2.3 Technology cost and performance: The capital costs for geothermal power plant projects are normally broken down by project phase: resource identification (permitting, leasing, surface and non-drilling exploration); drilling (exploration, confirmation, and production well drilling); and power plant construction. Hydrothermal costs vary widely. In general, the LCOE for hydrothermal projects typically range from $60/MWh to $90/MWh but can range from $40/MWh to $150/MWh depending on the resource characteristics and project development finance structure.

4.3 HYDROPOWER

Flowing water creates energy that can be captured and turned into electricity. This is called hydroelectric power or hydropower.

The most common type of hydroelectric power plant uses a dam on a river to store water in a reservoir. Water released from the reservoir flows through a turbine, spinning it, which in turn activates a generator to produce electricity. But hydroelectric power doesn't necessarily require a large dam. Some hydroelectric power plants just use a small canal to channel the river water through a turbine.

Another type of hydroelectric power plant - called a pumped storage plant - can even store power. The power is sent from a power grid into the electric generators. The generators then spin the turbines backward, which causes the turbines to pump water from a river or lower reservoir to an upper reservoir, where the power is stored. To use the power, the water is released from the upper reservoir back down into the river or lower reservoir. This spins the turbines forward, activating the generators to produce electricity.

A small or micro-hydroelectric power system can produce enough electricity for a home, farm, or ranch.

4.3.1 Implementation in Bangladesh: Micro Hydro Power Plants can be installed in the north-eastern hilly regions and in the existing irrigation canal system with sufficient head. Currently there is a Micro Hydro Power Plant with a 50 kW generator at Barkal area of Rangamati district implemented by the Bangladesh Power Development Board (BPDB). A larger hydroelectric plant was built in the Kaptai region using the Karnaphuli river during the 1960s, and was Bangladesh's only hydroelectric power plant for a long time. It is capable of producing a total of 230 MW of electricity.

4.4 OCEAN ENERGY: ENERGY FROM BAY OF BENGAL

The ocean can produce two types of energy: thermal energy from the sun's heat, and mechanical energy from the tides and waves. Oceans cover more than 70% of Earth's surface, making them the world's largest solar collectors. The sun's heat warms the surface water a lot more than the deep ocean water, and this temperature difference creates thermal energy. Just a small portion of the heat trapped in the ocean could power the world. Ocean thermal energy is used for many applications, including electricity generation. There are three types of electricity conversion systems: closed-cycle, open-cycle**,** and hybrid. Closed-cycle systems use the ocean's warm surface water to vaporize a working fluid, which has a low-boiling point, such as ammonia. The vapor expands and turns a turbine. The turbine then activates a generator to produce electricity. Open-cycle systems actually boil the seawater by operating at low pressures. This produces steam that passes through a turbine/generator. And hybrid systems combine both closed-cycle and open-cycle systems. Ocean mechanical energy is quite different from ocean thermal energy. Even though the sun affects all ocean activity, tides are driven primarily by the gravitational pull of the moon, and waves are driven primarily by the winds. As a result, tides and waves are intermittent sources of energy, while ocean thermal energy is fairly constant. Also, unlike thermal energy, the electricity conversion of both tidal and wave energy usually involves mechanical devices. A barrage (dam) is typically used to convert tidal energy into electricity by forcing the water through turbines, activating a generator. For wave energy conversion, there are three basic systems: channel systems that funnel the waves into reservoirs; float systems that drive hydraulic pumps; and oscillating water column systems that use the waves to compress air within a container. The mechanical power created from these systems either directly activates a generator or transfers to a working fluid, water, or air, which then drives a turbine/generator.

4.4.1 Resources: Bangladesh is blessed to be situated on the shore of Bay-of Bengal. So enormous amount of renewable energy can be extracted from the sea in following form:

(A) Natural Wave Energy: Ocean waves can be considered as a form of solar energy because they are formed by the far-field interaction of ocean surfaces and wind currents, which in turn, are the result of differential heating of Earth's surface. There is greater wave resource on the coast of Bay of Bengal.

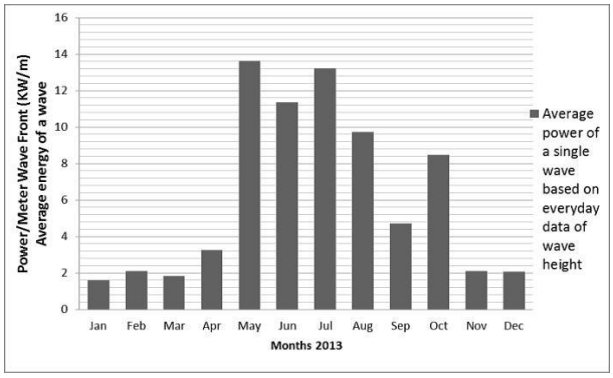

Fig-2: Average power of a wave based on everyday data of significant wave height in the year of 2013.

(B) Natural Tidal Energy: The current approach for computing the natural tidal energy resource at a site is to estimate the mean natural kinetic energy of the flow

through the channel at the site of interest without considering the interaction of the flow and the device. The natural tidal energy is then taken as some fraction of this mean energy accounting for any known access restrictions.

(C) Natural Ocean Current Energy: An ocean current is a continuous, directed movement of ocean water generated by the forces acting upon the mean flow, such as breaking waves, wind, Coriolis force, temperature and salinity differences, and tidal forces.

(D) Ocean Thermal Energy: Ocean thermal gradient energy is created by a temperature difference between surface water and deep water in the ocean. OTEC requires a temperature difference of approximately 20°C for practicable generation. Basically it may be a great source of energy because the required temperature difference can be easily maintained at the Bay of Bengal.

(E) Salinity Gradient Energy: At the mouth of rivers where freshwater mixes with saltwater in the ocean, energy is released from the mixing, resulting in a very small increase in the local temperature of the water. Actually research is undergoing on this but the salinity gradient conversion is discussed here for complete coverage of ocean energy technologies.

4.5 SOLAR ENERGY

Solar energy is radiant light and heat from the sun harnessed using a range of ever-evolving technologies such as solar heating, solar photovoltaics, solar thermal electricity, solar architecture and artificial photosynthesis.

4.5.1 Solar Energy in Bangladesh: Solar energy is the most easily available renewable source of energy in Bangladesh which can be implemented at comparatively low cost in a huge amount. The long term average sunshine data indicates that the period of bright sunshine hours in the coastal regions of Bangladesh varies from 3 to 11 hours daily.

The insolation in Bangladesh varies from 3.8 kwh/m2/day to 6.4 kwh/m2/day at an average of 5 kwh/m2/day. These indicate that there are good prospects for solar thermal and photovoltaic application in the country.

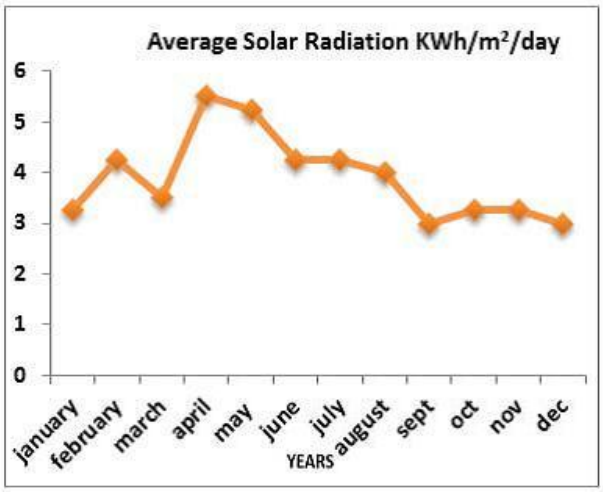

Fig-3: Monthly average solar radiation profile in Bangladesh

4.5.2 Technology Overview

(A) Solar photovoltaics: Photovoltaic technologies convert sunlight directly into electricity by enabling solar photons to "excite" electrons from their ground state, producing a freed (photo-excited) electron and a "hole" pair. The electron and hole are then separated by an electric field that is formed by the design of the PV cell and pulled toward positive and negative electrodes, generating DC electricity.

(B) Concentrating Solar Power: CSP technologies use mirrors or lenses to focus sunlight onto a receiver. The receiver contains a working fluid,78 which transfers the thermal energy to a heat engine that drives an electrical generator.

(C) Other Solar Technologies: Several additional solar technologies—including water heating, space heating, cooling, and lighting—do not generate electricity but do displace end-use electricity and fossil fuel consumption. Although these technologies are not explicitly modeled in RE Futures, they are likely to be an important complement to energy-efficiency investments for stabilizing or reducing end-use electricity demand as envisioned in several RE Futures modeling scenarios.

4.5.3 Technology cost: the cost of concentrating solar power generation depends greatly on the technology in question. The levelized cost of energy for concentrating solar plants range from USD 0.14 to USD 0.36/kWh for parabolic trough installations and USD 0.17/kWh to USD 0.29/kWh for solar tower installations.

4.6 WIND ENERGY

Wind power is the conversion of wind energy into a useful form of energy, such as using wind turbines to produce electrical power, windmills for mechanical power, wind pumps for water pumping or drainage, or sails to propel ships.

A blade acts much like an airplane wing. When the wind blows, a pocket of low-pressure air forms on the downwind side of the blade. The low-pressure air pocket then pulls the blade toward it, causing the rotor to turn. This is called lift. The force of the lift is actually much stronger than the wind's force against the front side of the blade, which is called drag. The combination of lift and drag causes the rotor to spin like a propeller, and the turning shaft spins a generator to make electricity.

Wind turbines can be used as stand-alone applications, or they can be connected to a utility power grid or even combined with a photovoltaic (solar cell) system. For utility-scale sources of wind energy, a large number of wind turbines are usually built close together to form awind plant. Several electricity providers today use wind plants to supply power to their customers.

Stand-alone wind turbines are typically used for water pumping or communications. However, homeowners, farmers, and ranchers in windy areas can also use wind turbines as a way to cut their electric bills.

Small wind systems also have potential as distributed energy resources. Distributed energy resources refer to a variety of small, modular power-generating technologies that can be combined to improve the operation of the electricity delivery system. Wind turbines, like windmills, are mounted on a tower to capture the most energy. At 100 feet (30 meters) or more aboveground, they can take advantage of the faster and less turbulent wind. Turbines catch the wind's energy with their propeller-like blades. Usually, two or three blades are mounted on a shaft to form a rotor.

4.6.1 Wind Energy in Bangladesh: The long term wind flow, especially in the islands and the southern coastal belt of Bangladesh indicate that the average wind speed remains between 3 to 4.5 m/s for the months of March to September and 1.7 to 2.3 for remaining period of the year. There is a good opportunity in island and coastal areas for the application of wind mills for pumping and electrification. But during the summer and monsoon seasons (March to October) there can be very low pressure areas and storm wind speeds 200 to 300 kmph can be expected. Wind turbines have to be strong enough to withstand these high wind speeds.

Table-3: Feasibility of wind condition at different places of Bangladesh

Site	Reference height(m)	Annual average speed(m/s)
Cox's Bazar	10	2.42
Sandip Island	5	2.16
Teknaf	5	2.16
Patenga Airport	5	2.45
Comolla Airport	6	2.21
Kheppura	10	2.36
Kutubdia Island	6	2.09
Bhola Island	7	2.44
Hatia Island	6	2.08

5 DISCUSSION AND CONCLUSION

Only 62% people of Bangladesh have access to electricity and it is interrupted by power cut. Moreover, the existing sources of power are non-renewable. So an initiative is taken to look back at our power sector and searching for alternative options. No doubt renewable energy is the most promising and most dependable one for this case of our country as it is blessed with adequate renewable energy sources. Biopower or biomass power has not yet been implemented most recently but it can be a great source of energy in upcoming future since power production cost is moderately lower. Geothermal energy is a great source of energy for developed countries. But for Bangladesh electricity from geothermal sources is pretty difficult and costlier. Since Bangladesh is bestowed with a good number of rivers and is located on the shore of Bay of Bengal, a lot of micro- power plants are possible which will be run by hydrow power and wave power. The vast field of renewable energy is still left for solar power. Solar energy is the most effective, most powerful and most promising source to cover extra amount of power. Implementation of wind turbine has to be given a wise rethink. Actually all the existing and auspicious sources of renewable energy in Bangladesh have been discussed through out the paper to show what types of sources we do have, what technology should be implemented and

what will be the costing nature for the implementation of renewable energy technology.

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