A thesis on

"Opportunities in implementation of sustainable and renewable energy policy in Bangladesh"

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Declaration

I am a student of M.S. Renewable Energy Technology, Institute of Energy, University of Dhaka bearing Exam Roll: 511, would like to declare here that this thesis on **"Opportunities in implementation of sustainable and renewable energy policy in Bangladesh"** has been authentically prepared by me.

Exam Roll No. 511, Registration No. HA-231

Session: 2014-2015

Institute of Energy
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Certificate

This is to certify that the M.S. thesis report on **"Opportunities in implementation of sustainable and renewable energy policy in Bangladesh"** submitted for the partial fulfillment of the M.S. degree in Renewable Energy Technology from the University of Dhaka, has been carried out by the student bearing Exam Roll: 511, under my supervision. To the best of my knowledge and as per his declaration, the whole work and the complete thesis report has been prepared by the student and has not been submitted to anywhere else.

The thesis report can be considered for evaluation.

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Professor

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Munshi H.M. Rahat

Abstract

Bangladesh is a developing country which is facing severe energy crisis. The energy consumption over the time will increase also. Aside from that Bangladesh is also one of the vulnerable country due to climate change of the world. In order to satiate the energy crisis Bangladesh need to find an environment friendly way for energy production. Bangladesh has good potential for harnessing renewable energy sources such as solar, biomass, wind, and mini-hydropower. According to Goldman Sachas it is one of the "next 11" country also (Goldman Sachas). Renewable energy is the balanced point for energy production which can produce energy without harming the environment. This Work is focused on to put light on renewable energy sources that can fix our energy crisis in a sustainable way and hence find new opportunities. It does so through a critical review of policy and institutional settings, as well as present status and lessons learnt from pilot demonstration of a number of RET projects undertaken by different organizations. The aim of this study is to help the policy makers in formulating renewable and sustainable energy policies and future plans for Bangladesh through this field oriented argument.

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Introduction

Modern world is approaching towards more sustainable way of living. After the industrial revolution growing industrial urbanization is posing a great threat towards the environment. Harmful effect of this rapid industrialization can be seen in many aspects of nature. Gasses like CFC are depleting the ozone layers [1]. A steady decline of about four percent in the total amount of ozone in Earth's stratosphere (the ozone layer) and a much larger springtime decrease in stratospheric ozone around Earth's Polar Regions [1].

Figure 1: An artistic view of green energy.

Increasing amount of Carbon dioxide is creating problems like greenhouse effect. Carbon dioxide is one of the main culprits behind the climate change. According to the latest Assessment Report from the Intergovernmental Panel on Climate Change (IPCC), "*atmospheric concentrations of carbon dioxide, methane and nitrous oxide are unprecedented in at least the last 800,000 years. Their effects, together with those of other anthropogenic drivers, have been detected throughout the climate system and are extremely likely to have been the dominant cause of the observed warming since the mid-20th century*"[2].

There are many other problems which are can be attributed to the industrialization. However, we just cannot stop this process because the current world thriving on industrialization. If anything happen to this current growth it will stir up the economy of

the whole world. Any kind of economic recession ultimately will lead to a devastating effect on the overall condition of the world population. For this reason current leaders of the world on COP 21 conference in Paris agreed on the matter that they have to adapt a more sustainable form of industrialization [3].

According to German watch Bangladesh is one of the top ten climate change vulnerable country of the world [4]. Therefore Bangladesh is taking the issue of climate change very seriously. However, Bangladesh is a developing country and Bangladesh is not a climate change responsible country but it has to suffer the consequence of climate change. Besides recently Bangladesh has elevated its self to lower middle income country from a lower income country [5]. Bangladesh needs energy that can feed its energy demand of rapidly growing industry. Renewable energy sources like solar radiation, wind, river tide can be a great source that can provide Bangladesh ample energy in sustainable way.

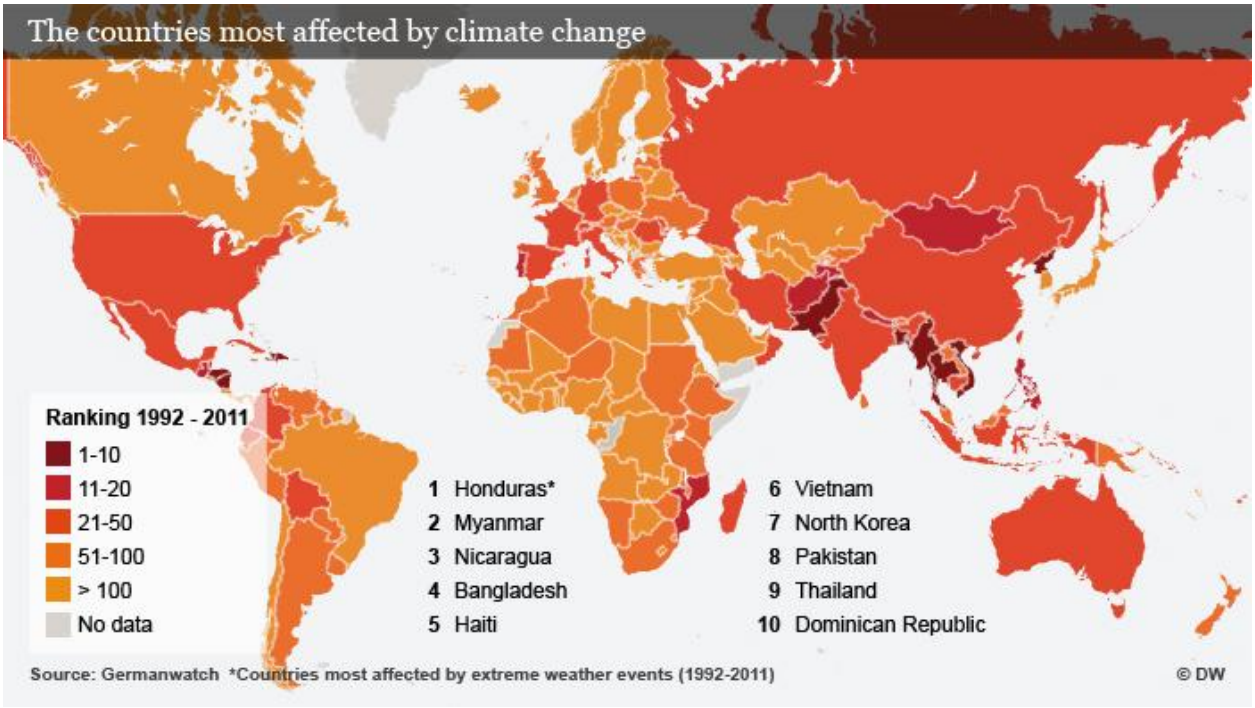
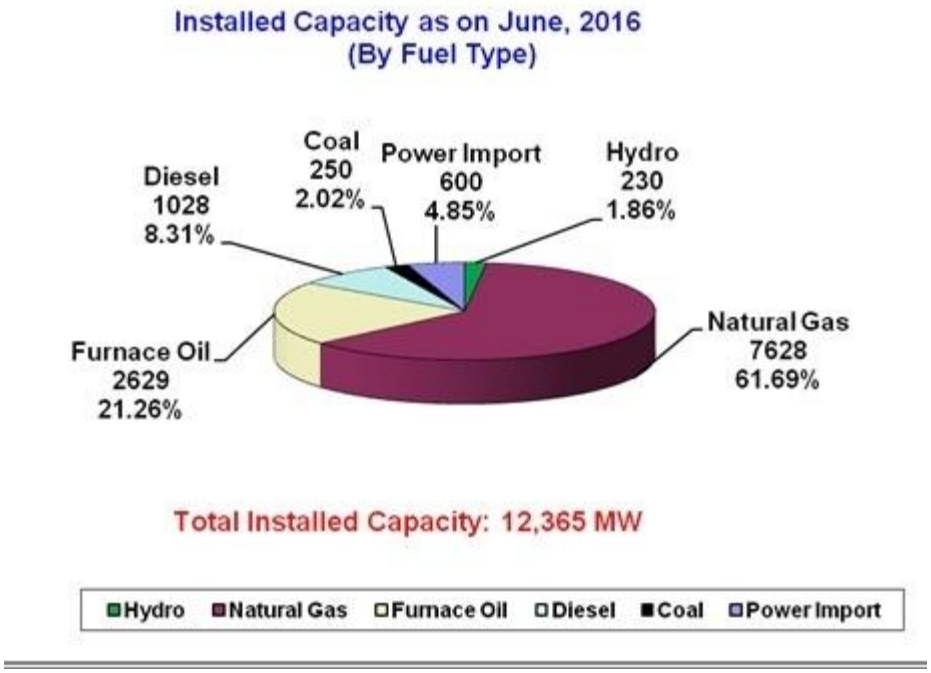


Figure 2: Countries most affected by climate change.

However developing countries like Bangladesh are very much susceptible to the setbacks arising from the ongoing energy crisis. Natural gas lies at the heart of the country's energy usage, accounting for around 72% of the total commercial energy consumption and 81.72% of the total electricity generated [6, 7]. However, the decreasing gas resources suggest that the country has a deficit of 142 million cubic feet per day (MMSCFD) in 2011 and it will rise to 1714 MMSCFD by 2019-20. Even if Bangladesh's GDP growth remains as low as 6.5 percent till 2025, the country will need to add 19,000 MW of additional power, causing the gas demand to spiral up to 4,567 MMSCFD by 2019-20 [8]. Such an overwhelming

dependence on natural gas has brought into focus the substantial amount of renewable energy resources available in the country. The potential non-exhaustive sources of energies, available in the form solar, biomass, biogas, hydropower and wind, can be harnessed to provide an environmentally sustainable energy security, as well as affordable power supply to the country.

To this end, effective utilization of renewable energy resources has been adopted as a policy of the Government of Bangladesh (GOB) [9]. Different government, semi - government and nongovernment organizations (NGOs) have been working separately or jointly to disseminate
renewable energy technologies (RET) throughout the country over a significant period. Bangladesh has a vast population, out of 130.1 million of them, an estimated 77% of the total population lives in rural areas [10]. The rural majority uses mainly traditional energy sources—nearly 70% of total energy consumption comes from traditional biomass sources [11]. People in rural areas do not have access to sufficient commercial energy and electricity, which is needed for economic growth. Per capita consumption of energy, which is a measure of the physical quality of life, is very low in Bangladesh. In 2011, Electricity consumption per capita was 258.62 kWh and oil use per capita 204.72 kg of oil equivalent [12]. Furthermore, the gap between demand and supply is gradually increasing, as is the



dependence c

Figure 3: Energy Fuel mix of Bangladesh.

The rural population, which uses a fair amount of imported diesel and kerosene, is largely disadvantaged because of its low purchasing power [11]. Also, efficiency of energy utilization is generally poor. Grid-based rural electrification in Bangladesh is increasing. However, per capita generation of electricity is still very low at about 321 kWh/year in

2014 [13]. In 2006, still over 62% of the total population was not connected to the unreliable electricity grid [13]. The reason is that it is not economical to extend grid access to lowly populated areas. Electricity supply to low-load rural and remote areas is characterized by high transmission and distribution losses, and heavily subsidized electricity pricing. In 2005, the government of Bangladesh announced its ambitious goal to provide electricity for all by the year 2020 [14]. The government targets of electricity generation by renewable energy technologies (RETs) are 5% of the total power generation by 2015 and 10% by 2020 [15]. The use of solar, biomass, hydro, and wind energy technologies are planned to play a major part in meeting this target. Reaching these ambitious targets will be a major challenge.

Already since the 1970s, attempts have been made to implement RETs in rural areas of Bangladesh [16]. In the last decade both public and private sectors have carried out a number of projects for promoting RETs in Bangladesh. Their experience entails valuable information that could support national policy makers in their on-going attempts at integrating RETs in the power sector of Bangladesh through national energy planning and policies. No integrated review of those experiences, however, exists so far. This paper addresses this gap by providing an overview of the current state of implementation of those projects, analyzing their experiences through the theoretical lens of innovation systems and appropriate technology, identifying barriers and drivers to the successful implementation of RETs in in Bangladesh, and highlighting the policy implications and strategic directions for future work. Motivated by these objectives, we present in this paper a contemporary scenario of the renewable energy related activities in Bangladesh as well an insight for the policy makers.

Geographical Location of Bangladesh and its potentiality

Figure 4: Latitude and longitude map of Bangladesh.

Bangladesh, a south Asian country has a location between 20˚ 34” and 26˚ 38” north latitude and 88˚10” and 92˚ 41” east longitude with an area of 147500 km^2 [17]. Bangladesh is a low-lying, riverine country located in South Asia with a largely marshy jungle coastline of 580 km (360 mi) on the northern littoral of the Bay of Bengal. Formed by a delta plain at the confluence of the Ganges (Padma), Brahmaputra (Jamuna), and Meghna Riversand their tributaries, Bangladesh's alluvial soil is highly fertile, but vulnerable to flood and drought. Hills rise above the plain only in the Chittagong Hill Tracts in the far southeast and the Sylhet division in the northeast. Straddling the Tropic of

Cancer, Bangladesh has a tropical monsoon climate characterized by heavy seasonal rainfall, high temperatures, and high humidity. Natural disasters, such as floods, tornadoes, and tidal bores affect the country yearly. Bangladesh also is affected by major cyclones, on average 16 times a decade. A cyclone struck the southeastern coast in May 1991, killing 136,000 people. Cyclone Sidr struck the southwestern coast on November 15, 2007, affecting not only the coastal districts of the administrative division Khulna but also about half of the tropical forest Sundarbans. Due to the geographical location of Bangladesh, it has huge prospects in renewable energy. Bangladesh has 54 international rivers many of them can be easily used to harness electricity by hydropower plant. Bangladesh has a costal boundary of 711 km where we can get enough amount of wind. This wind energy can be used run wind turbine. At the outer atmosphere of the Earth we receive about 1300 watts worth of power per hour per meter every day. Around 30% of this power is reflected back which still results in a staggering 4.2 Kilowatt-hours of energy per meter each day. Being a semi-tropical region lying in northeastern part of South Asia gets abundant sunlight year round. The average bright sunshine duration in Bangladesh in the dry season is about 7.6 hours a day, and that in the monsoon season is about 4.7 hours [18]. For this reason solar energy is one of the fastest growing energy sources in Bangladesh.

Background and objectives

To meet the requirement of energy, there is no alternative to renewable energies such as solar, wind, biomass, etc., in addition to other existing sources. Renewable energy is generally defined as energy derived from resources that are replenished naturally in a human, such as sunlight, wind, rain, tides, waves and the time scale of the geothermal heat. According to REN21 report data in 2016, renewable energy accounted for 19.2% of overall energy consumption of men and 23.7% of electricity production in 2014 and 2015, respectively. This energy consumption is divided by 8.9% from traditional biomass, 4.2% as heat (modern, geothermal and solar thermal biomass), 3.9% and 2.2% is hydroelectric power energy wind, solar, geothermal and biomass energy. Global investment in renewable technologies totaled more than US $ 286 million in 2015, with countries such large investments in the US China and in the wind, hydropower, solar energy and biofuels [energy]. Worldwide, an estimated 7.7 million jobs related to renewable energy industries, solar PV is the largest employer renewable [19].

Solar energy is simply a process that can provide energy from the sun. In this process, the sun's energy as photons reaching the earth and meets the global demand for energy all year with the solar radiation just a minute. The photovoltaic panel (PV silicon panels) is the tool to use solar energy. Bangladesh is a densely populated country with insufficient energy supply. The current food crisis tips the problematic moment to come along. In Bangladesh, nearly 80% of the population lives in the village and only 32% of the population is connected to the [10] .In view of this grid electricity demand; in 2020 the energy mix will be considerably changed from what it is today. The possibilities of using solar energy are already tested and especially increase. But still, most households to meet their daily needs for fuel biomass. Electrical switchboard of the country is unable to cope with the exponential growth of energy demand in the capital and throughout the country. Therefore, the researchers intend to examine whether there is a future prospect for solar energy in Bangladesh.

The broad purpose of this paper is to explore future prospect of renewable energy in Bangladesh. Moreover, some specific purposes of this exploratory research are –

- To understand the opportunity of renewable energy in Bangladesh and provide a brief discussion on the matter for policy makers
- To evaluate the impact of further growth in the renewable energy sector on present power distribution system of Bangladesh,
- To ascertain if there is a slow growth in the implementation of solar energy and propose recommendation to fix the problem

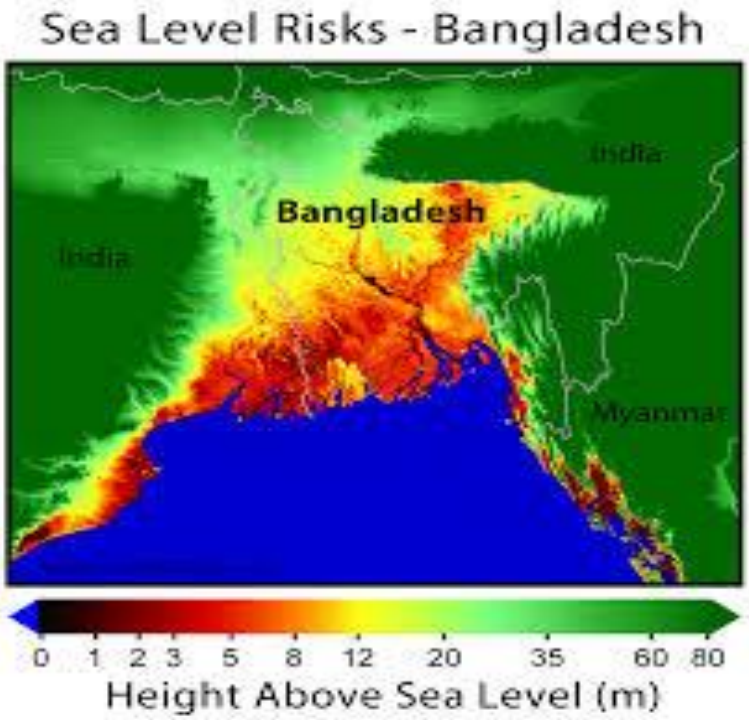


Figure 5: Vulnerabilities of sea level rise.

Effect of climate change in Bangladesh

Climate Change in Bangladesh is an extremely crucial issue and according to National Geographic, Bangladesh ranks first as the nation most vulnerable to the impacts of Climate Change in the coming decades. Any discussion on the potential of land lost to rising sea levels in Bangladesh should be considered in conjunction with the phenomenon of accumulation of land, or the creation of new land from sediment deposits. The effects of rising sea levels and the accumulation of land in Bangladesh are very regional and varied. Natural accretion of the earth, as well as specific measures to ensure that agricultural land use has the potential to partially mitigate the effects of lost land policies. [20]

As a least developed country (LDC), Bangladesh is exempt from any responsibility for reducing greenhouse gas emissions, which mainly causes global warming. But in recent times has been the convergence factor for policymakers to emit larger amounts of emissions in almost all sectors with environmental neglect. The developed industrialized countries emit large increasing amounts of greenhouse gases. A country cannot go far in their struggle against the reduction of emissions and fight against global warming through sustained funding substantial light and support received by the international community. There are plans such as the National Action Plan for Adaptation "(NAPA) and the 2005" Bangladesh Climate Change Strategy and Action Plan "(BCCSAP) 2009.

BCCSAP indicates that an integrated approach is necessary and the only way to win is sustainable when the economic and social development considered the exclusion of disaster management, a great calamity will destroy all socioeconomic called gain. About 40% - 45% of greenhouse gas emissions must be reduced by 2020 and 90-95% by 2050. This is the use of gas levels to 1990 concentrating effect as a reference point. With the increasing population and rapid industrialization, Bangladesh should be on the way to developing a low-carbon road since originally received financial and technical support from the

international community and national goals of economic growth and hindered social development. But a short-term more comprehensive plan is also required. Bangladesh created the Trust Fund Bangladesh Climate Change (BCCTF) and allocation Bangladesh Resilience Fund Climate Change (BCCRF) of $ 200 million and $ accumulate about 114 million more, respectively. Although 3000 shelters against cyclones have been built with more than 40,000 trained volunteers and 10,000 km of dykes built, Bangladesh must not only focus on capacity building and disaster management, but also institutional strengthening and infrastructure development and research into low carbon technologies to create an inclusive and truly comprehensive mitigation system. While it is agreed that the willingness and cooperation of the current members of the UNFCCC (194 Member States as of 2011) is needed to help the nation, the special climate fund and fund WFP's adaptation should be readily available.

Current renewable energy policy of Bangladesh

A draft renewable energy policy of Bangladesh was released in 2002. This draft policy provided modalities and procedures, tariff regulations, fiscal and other incentives for implementation of
RETs and guidelines for establishment of an independent renewable energy authority, namely the Sustainable Renewable Energy Development Authority (SREDA) [9]. This draft renewable energy policy was revised and finalized by the Ministry of Power, Energy, and Mineral Resources (MPEMR) in December 2008 [9]. The policy is not effective yet; it will become effective from the date of publication in the official gazette. The main objectives of the renewable energy policy are [9]:

1. To harness the potential of renewable energy resources and dissemination of RETs in rural and urban areas;
2. To enable, encourage and facilitate both public and private sector investment in renewable energy projects;
3. To develop sustainable energy supplies to substitute indigenous non-renewable energy supplies;
4. To scale up the contribution of renewable energy to electricity production;
5. To facilitate the use of renewable energy at every level of energy usage;
6. To promote development of local technology in the field of renewable energy;
7. To promote clean energy for clean development mechanism (CDM) in Bangladesh.

The MPEMR of Bangladesh is the sole authority administering all activities related to energy, including rural and renewable energy. Although establishment of SREDA was proposed in 2002 in the draft policy, by the end of 2005, the government of Bangladesh decided to establish an alternative independent unit, the Sustainable Energy Development Authority (SREDA) instead of REDA for expediting the use of renewable energy for power
generation [21]. In the renewable energy policy (REP) of 2008, the government of Bangladesh again recommended to set up an organization called SREDA, to be established under the Companies Act of 1994. The SREDA board will comprise of representatives of stakeholders, including
business community, academics, and/or representative from Bangladesh solar energy society, NGOs, financial institutions, and implementing agencies. The main responsibilities of SREDA as a company shall be:

1. to provide coordination of sustainable energy planning, including action plans linking together activities of several agencies or organizations;
2. to promote awareness of renewable energy and other clean energy technologies and integrate their development within overall national energy policy and development;
3. to support demonstration of new technologies and new business models for renewable energy and other clean energy technologies;
4. to support establishment of small and medium renewable energy enterprises and

providers;
5. to create market opportunities and start-up business models for sustainable energy technologies;
6. to develop financing mechanisms and facilities by using grant, subsidy and/or carbon/CDM fund for public and private sector investments;
7. to collect data and assess the renewable energy resources potential, especially in the context of rural energy master plan. Salient features of the renewable energy policy (REP, 2008) on resource, technology, and program development are:
1. SREDA in conjunction with the power division of the MPEMR shall be responsible for determining the priorities for RET development and program implementation;
2. SREDA shall support capacity building, technology development, and market development sufficient to boost the share of electricity generated from RETs;
3. all power utilities, the Local Government Engineering Department (LGED), other interested government departments, private agencies and NGOs are to develop renewable energy
development program for implementation throughout the country;
4. Electricity generated from renewable energy projects may be purchased by power utilities;
5. renewable energy project sponsors may use existing electricity transmission and distribution systems and the wheeling charges shall be determined by the Bangladesh Energy Regulatory Commission (BERC) in consultation with the power division of MPEMR;
6. In addition to electricity generation, renewable energy for solar heating and biogas or other means like cooking etc. shall be developed.

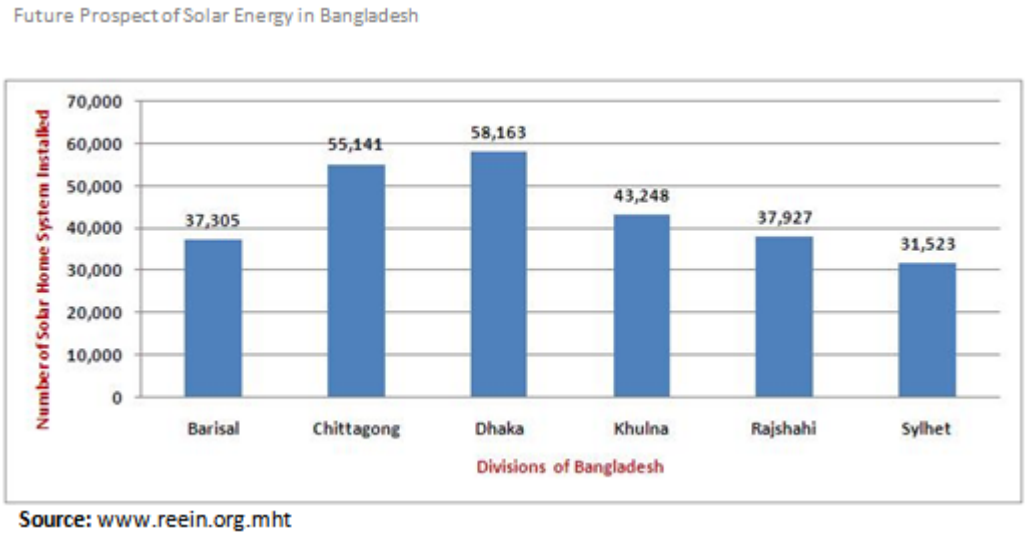


Figure 6: Number of Solar home system installed in Bangladesh.

Available renewable energy technologies and their prospects in Bangladesh

Wind power

Wind power is the use of air flow through mechanical turbines for power generation of electricity. Wind energy as an alternative to burning fossil fuels, is plentiful, renewable, widely distributed, clean, emissions of greenhouse gases during operation, do not consume water and uses little land. [22] The net impact on the environment is much less problematic than those of non-renewable energy sources.

Wind farms consist of a large number of individual wind turbines which are connected to the electricity transmission. Wind ground handling competitive with or places less cheap source of electricity number expensive than coal or gas power plants [23]. Offshore wind is more stable and stronger than on land, and marine farms have less visual impact, but the costs of construction and maintenance are considerably higher. Small onshore wind farms can feed energy into the grid or to provide electricity to isolated areas outside the network.

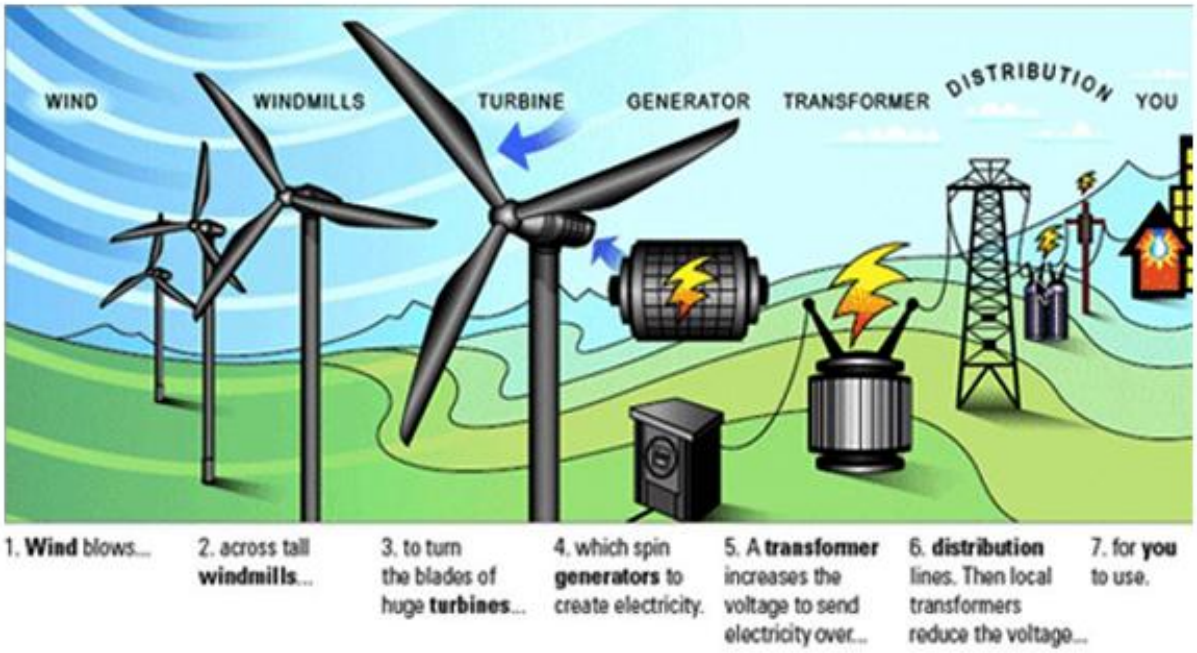


Figure 7: Wind energy diagram.

Wind power provides variable power which is very consistent from year to year, but a significant variation in shorter timescales. Therefore, it is used in conjunction with other sources of electrical energy to feed reliability. As the proportion of wind energy in an area increases, the need to improve the network, and reduced to supplant conventional production may occur capacity [24]. Power management techniques such as having excess

capacity, turbines geographically distributed, dispatch able backup sources, hydropower enough, import and export energy to neighboring areas, using network strategies vehicle or reducing demand when wind production is low, can in many cases to overcome these problems [24]. In addition, weather forecasts allow the grid to be prepared for the expected production changes that occur [25].

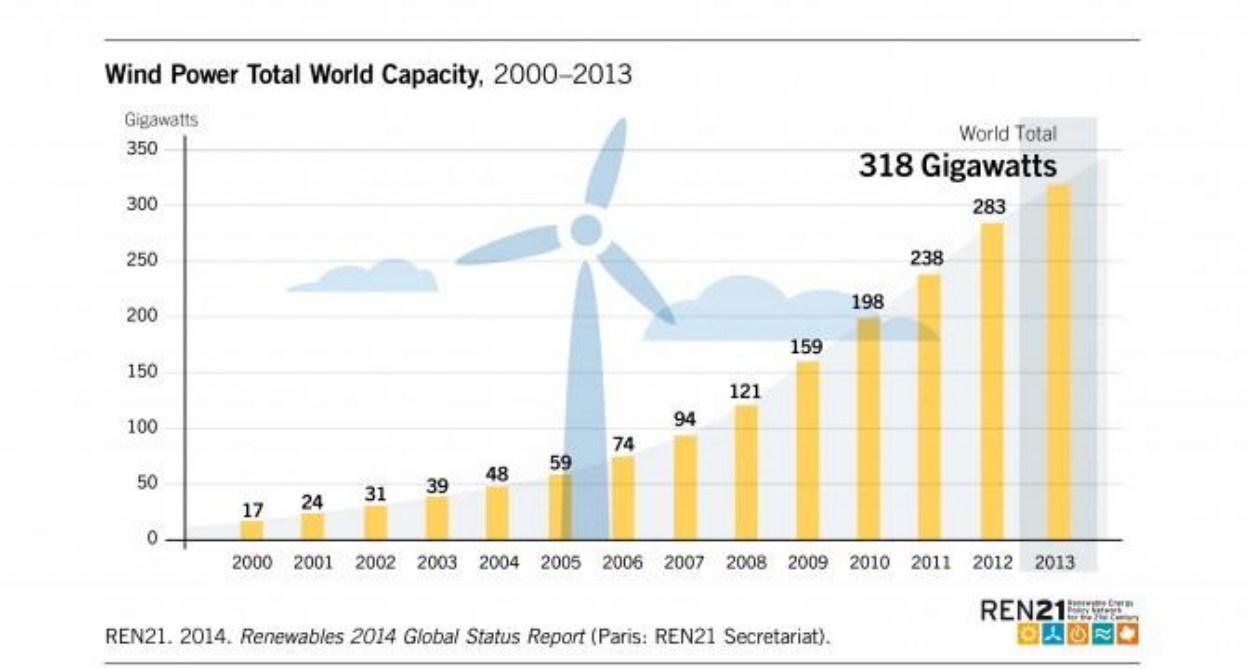


Figure 8: Renewables 2014 global status.

Since 2015, Denmark generates 40% of its electricity from wind, [25], and at least 83 other countries around the world are using wind energy to power their electricity networks. In 2014, the global wind power grew 16% to 369,553 MW. [26] The annual wind energy production is also growing rapidly and reached about 4% of electricity consumption worldwide, [27] 11.4% in the EU. [27]

Wind power in Bangladesh

Bangladesh will produce electricity from wind than the first wind turbine of 60MW power plant in the country Bazar Cox likely to go into production in 2017. The wind farm will be built with an investment of Denmark; according to reports UNB. Danish Employment Minister Jorn Neergaard Larsen expects the Cox Bazar plant will start production in 2017. Larsen also found the wind farm, to be built with an investment of Denmark, will have a capacity of 60 megawatts. [28]

Table 1: Wind power project dissemination by different companies throughout country.

Organization Name	Type of Application	Installed Capacity (Watt)	Location
Grameen Shakti	3 Hybrid	4,500	Grameen Offices in the Coastal Region
	Hybrid	7,500	Cyclone Shelter in the Coastal Region
BRAC	Stand-alone	900	Coastal Region
Bangladesh Army	Stand-alone	400	Chittagong Hill Tracts
IFDR	Stand-alone	1,100	Teknaf
LGED	Wind-PV Hybrid	400	Kuakata
	Total	**19,720**	

There are currently two pilot plants wind Muhuri Dam (0.9 MW) in Feni and Kutubdia Island (1.0 MW) Cox's Bazar, a full evaluation of the potential of wind power plants is ongoing. BCSIR, LGED, Center for Advanced Study in Bangladesh, German Development Cooperation (GIZ) and the Energy Institute of the University of Dhaka has assessed the wind resource in detail in some places. Today, the Energy Division is conducting a project with the support of USAID to expand the wind map for Bangladesh [29].

Fig(a): 900 kW Grid Connected Wind Power Plant at Matamuhuri Dam, Feni.

Fig (b): 1000kW Wind Battery Hybrid Power Plant at Kutbdia.

Figure 9: Wind energy projects in Bangladesh.

Hydropower

In 2015, hydropower generated 16.6% of all the worlds' electricity and 70% of renewable electricity. [30] Since water is about 800 times denser than air, even a slow flowing stream of water, or moderate sea bottom, can produce considerable amounts of energy. There are many forms of energy to water:

1) Historically hydropower comes from large dams and hydroelectric dams, which remain popular in third world countries. The largest is the Three Gorges Dam (2003) in China and Itaipu Dam (1984) built by Brazil and Paraguay.

2) Small hydro systems are hydroelectric facilities which generally produce up to 50 MW. They are often used in small rivers or as a low-impact development in large rivers. China is the largest producer of hydroelectric power in the world and has more than 45,000 small hydro. [31]

3) Hydroelectric run-of-the-river derives kinetic energy from rivers without creating a large reserve. This generation of style can still produce a lot of electricity, as Chief Joseph Dam on the Columbia River in the United States.

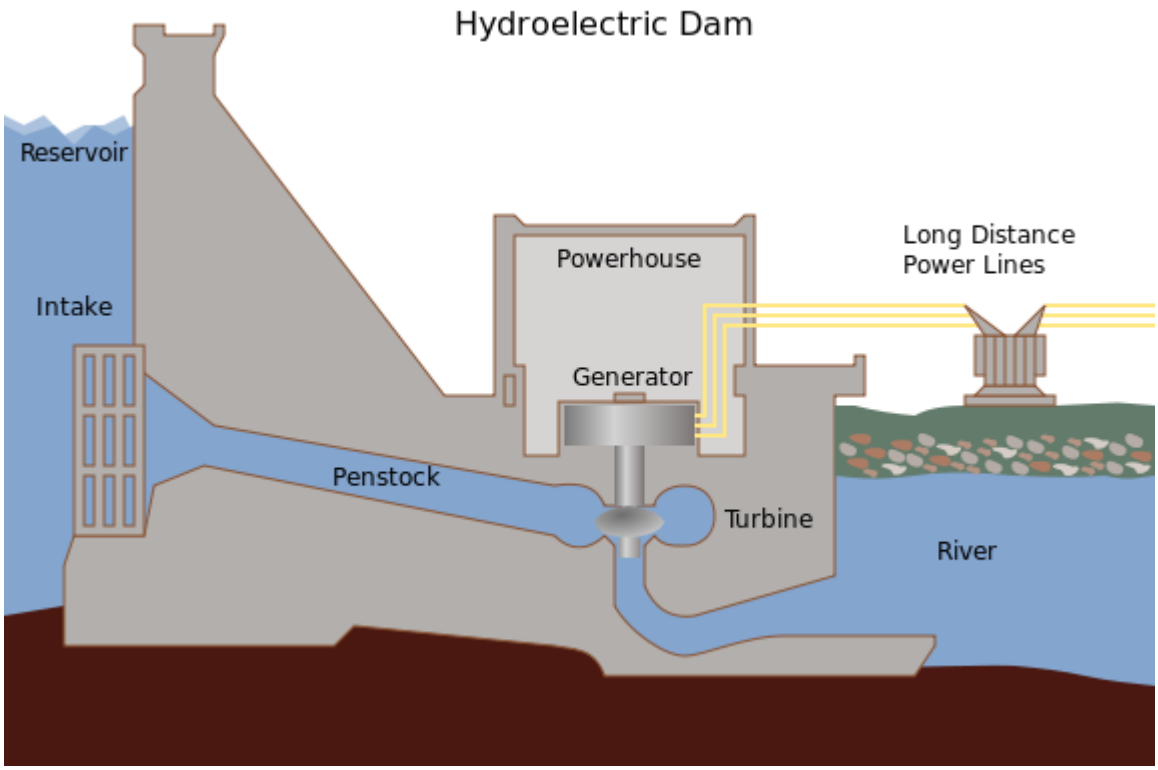


Figure 10: Diagram of Hydropower.

Hydropower is produced in 150 countries, with the Asia-Pacific region, generating 32 percent of global hydropower in 2010. For the counties with the highest percentage of electricity from renewable energy sources, mainly hydroelectric top 50 are primarily hydroelectric. China is the largest producer of hydroelectric power, 721 TWh of production in 2010, representing about 17 percent of national electricity consumption. There are currently three hydroelectric plants of over 10 GW. The Three Gorges Dam in China, Itaipu Dam on the Brazil / Paraguay and Guri in Venezuela [33]

Hydropower in Bangladesh:

Wave power, which captures wave energy from the surface of the ocean, and tidal energy, converting tidal energy are two forms of hydroelectric power with a future potential; however, they are not yet widely used in the market. A demonstration project operated by the Ocean Renewable Power Company on the Maine coast, and connected to the network, uses the energy of the tides of the Bay of Fundy, the location of the highest tidal flow in the world. Conversion of thermal energy that uses the temperature difference between surface water and deep warmer refrigerator currently has no economic viability.

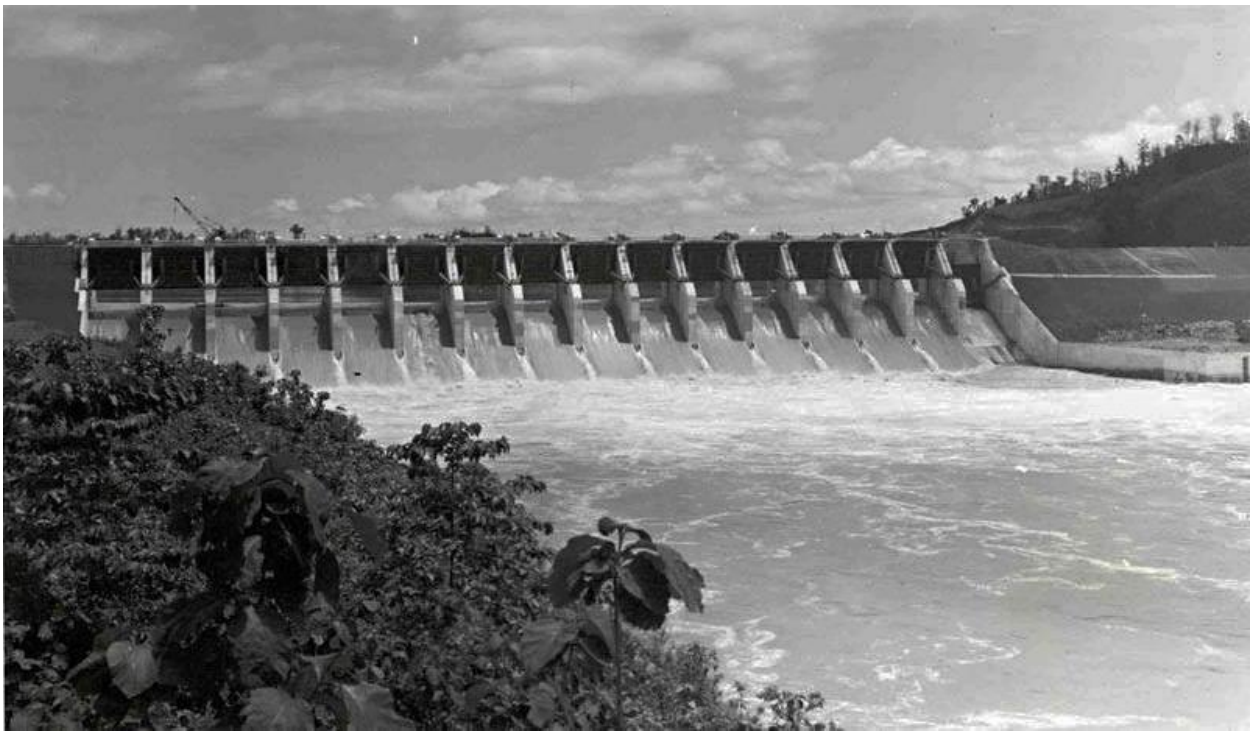


Figure 11: Kaptai dam in Chittagong.

Kaptai Dam is only and one dam of Bangladesh who produce electricity by hydroelectric power plant. Kaptai Dam is on the Karnaphuli River at kaptai. It is 65km away from Chittagong on Rangamati. It is a renewable energy. The contraction on kaptai is start on 1957 and it produces electricity on 1962. The water reservoir's storage capacity is 6477 million cubic meters. It generated 230 megawatts electricity when it runs full capacity [34].

Table 2: Basic features of the Kaptai dam.

Feature	**Size/type**
Type of dam	**Embankment**
Body of the Dam	Earth
Length	670.6 m
Height	45.7 m
Crest width	7.6 m
Maximum water level	33. 5 [110 feet above mean sea level (MSL)]
Minimum water level	20.1 m (66 feet MSL)
Capacity 33 m MSL	6477´ 10 6 m3
Reservoir at 33 m MSL	777 km2
Spillway length	227 m
Spillway type	Controlled 16 gate
Maximum spillway discharge	16 000 cumecs
Installed capacity (five units)	230 MW

Solar Energy

Solar energy, radiant light and heat from the sun, using a series of evolving technologies, such as solar heating, photovoltaic, concentrated solar power (CSP), the concentration of solar photovoltaic (CPV) is used, solar architecture and artificial photosynthesis. [35] [36] solar technologies are generally characterized as passive solar and active solar depending on the way they capture, convert and distribute solar energy. Passive solar techniques include orienting a building to the Sun, selecting materials with favorable thermal mass properties or light diffusion, and designing spaces that naturally circulate air. Active solar technologies include solar thermal energy through solar collectors for heating and solar energy, convert sunlight into electricity directly using photovoltaic (PV), or indirectly using concentrated solar power (CSP).

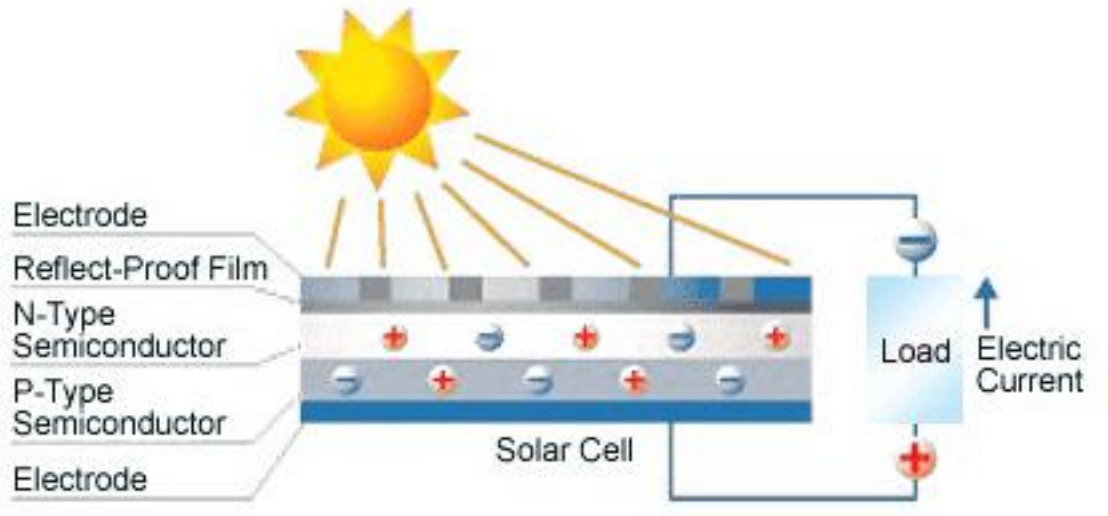


Figure 12: photo electric effect.

A photovoltaic system converts sunlight into electricity in direct current (DC) of the photoelectric effect. [37] The solar photovoltaic industry has become a rapidly growing billion, continues to improve its cost-effectiveness, and has the greatest potential of some renewable technologies with CSP. [38] [39] concentrated solar power systems (CSP) use lenses or mirrors and tracking systems to focus a large part of sunlight into a small beam. Concentrated solar power plant company first developed in the 1980 CSP-Stirling by far the highest efficiency of all solar energy technologies.

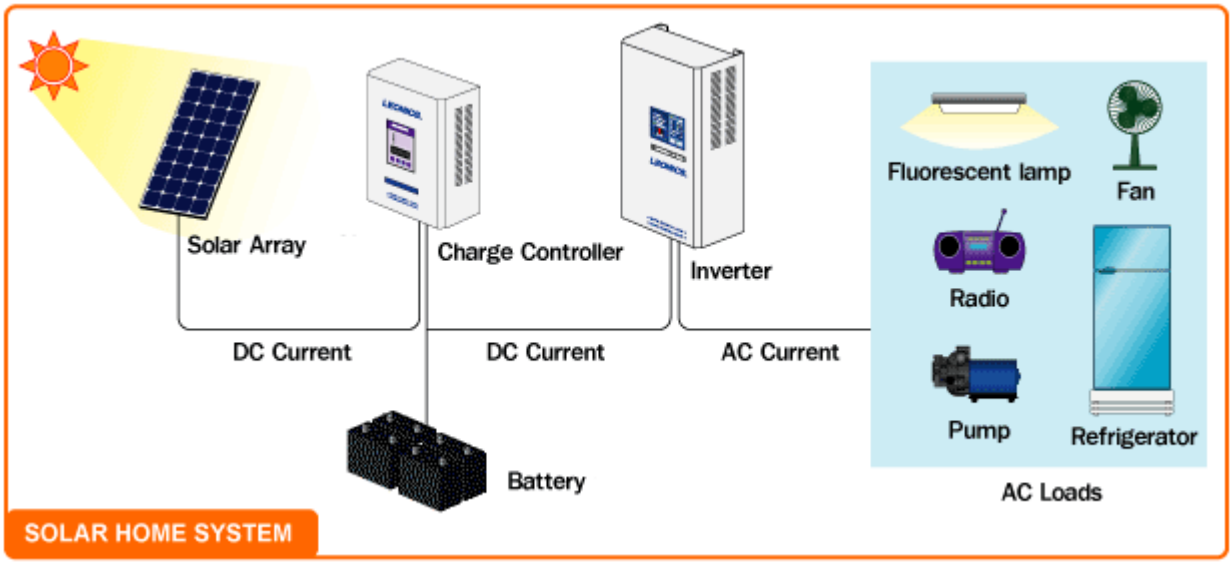


Figure 13: Basic solar home system.

In 2011, the International Energy Agency said that "the development of technologies affordable solar energy, inexhaustible and clean will have enormous long-term benefits. This will increase the energy security of the country through the use of indigenous and inexhaustible resource mostly import-independent time, enhance sustainability, reduce pollution, reduce the costs of mitigating climate change, and keep the price down fossil fuel that would otherwise These advantages are global additional costs are incentives for early deployment should be considered learning investments. They must be used wisely and should be widely shared. "[35] In 2014, the global production of solar energy was 186 terawatt hours, or slightly less than 1% of the worlds of grid electricity. [31]

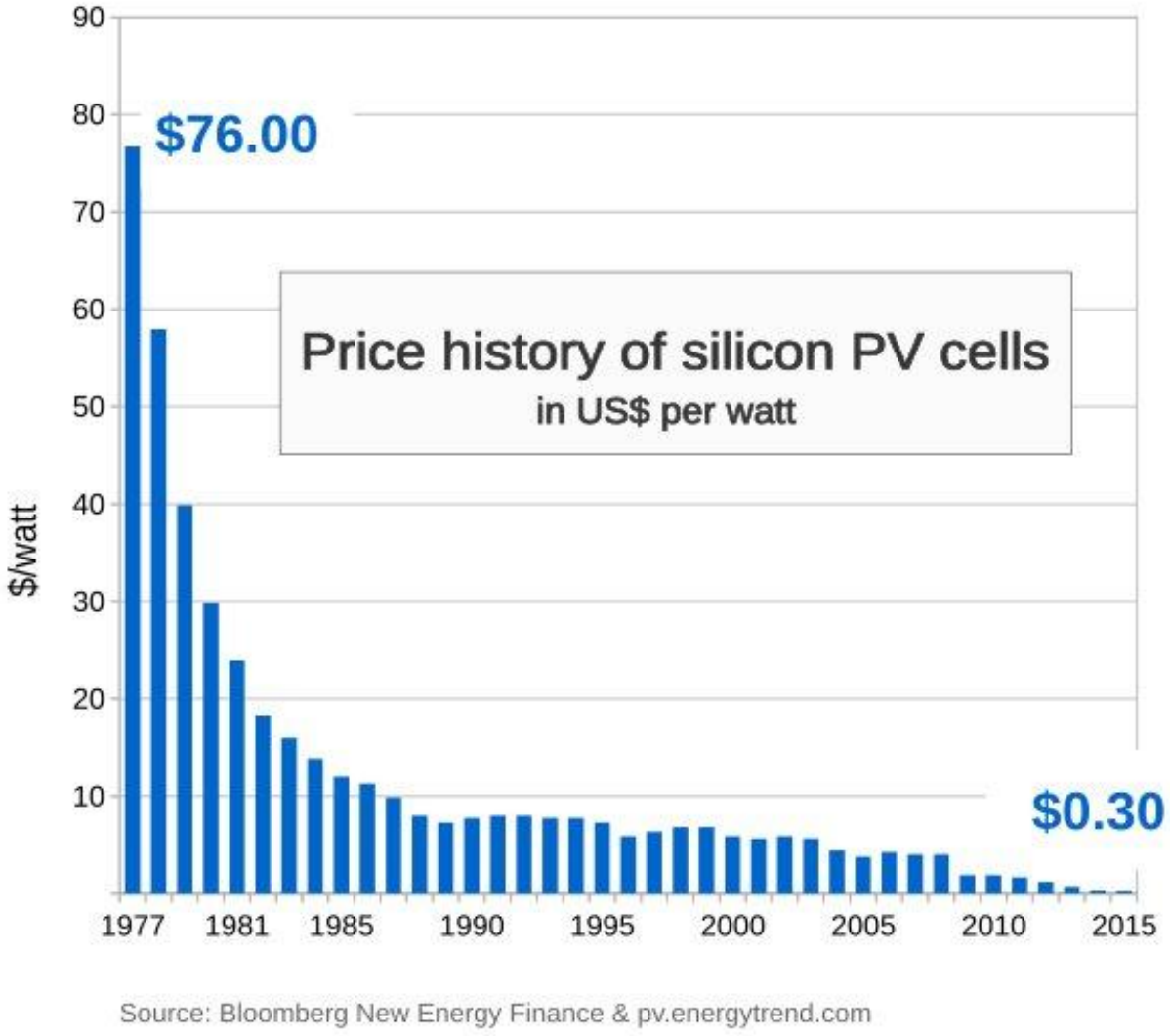


Figure 14: Price history of silicon PV cells.

Solar Energy in Bangladesh

Solar thermal energy is conventionally used for drying laundry, cereals, fish, vegetables, etc for century's raw jute in Bangladesh. Locally, this energy is used to evaporate brine for the production of salt in the coastal region. In the average insolation data in the long term, it indicates that the sunlight is available for 3-11 hours a day in the coastal region of Bangladesh. Solar radiation varies from 3.8 kWh / m² / day to 6.4 kWh / m² / day throughout the country. According to these data, Bangladesh has a high potential for solar thermal and photovoltaic applications of solar energy potential offers a huge opportunity for .This off-grid rural electrification through the use of photovoltaic technology. Conventional solar thermal applications are cooking, drying, hot water and others. Bangladesh has a rich potential and solar sunlight available throughout the year.

Bangladesh receives 900 x 1018 joules of solar energy per year and the availability of solar energy per square meter is 193 W while consumption per square meter is only 0.17 W [40]. This implies the abundance of solar energy in Bangladesh. The monthly solar radiation in different parts of Bangladesh is given in Table 1(Monthly Solar Insulation at different locations of Bangladesh (in kWh/m²/day).

Table 3: Solar Energy received in different places and different month of the year in kWh / m² / day.

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Month	Dhaka	Rajshahi	Sylhet	Bogra	Barisal	Jessore
January	4.03	3.96	4	4.01	4.17	4.25
February	4.78	4.47	4.63	4.69	4.81	4.85
March	5.33	5.88	5.2	5.68	5.3	4.5
April	5.71	6.24	5.24	5.87	5.94	6.23
May	5.71	6.17	5.37	6.02	5.75	6.09
June	4.8	5.25	4.53	5.26	4.39	5.12
July	4.41	4.79	4.14	4.34	4.2	4.81
August	4.82	5.16	4.56	4.84	4.42	4.93
September	4.41	4.96	4.07	4.67	4.48	4.57
October	4.61	4.88	4.61	4.65	4.71	4.68
November	4.27	4.42	4.32	4.35	4.35	4.24
December	3.92	3.82	3.85	3.87	3.95	3.97
Average	4.73	5	4.54	4.85	4.71	4.85

Bangladesh is a shortage of electricity production and about 70% of the population has no access to electricity. For a developing country like Bangladesh is not possible to bring the entire country under a common grid network and also economically and technically impracticable. To reduce the adverse environmental impact of various government agencies to conventional power production, NGOs and educational institutions engaged in the promotion of the diverse application of renewable energy for rural electrification. The commercial application of photovoltaic was launched in Bangladesh in the late eighties. The EDM is a proven technology for the electrification outside the network in rural areas of Bangladesh, while the centralized PV system is relatively new concept of rural electrification [41].

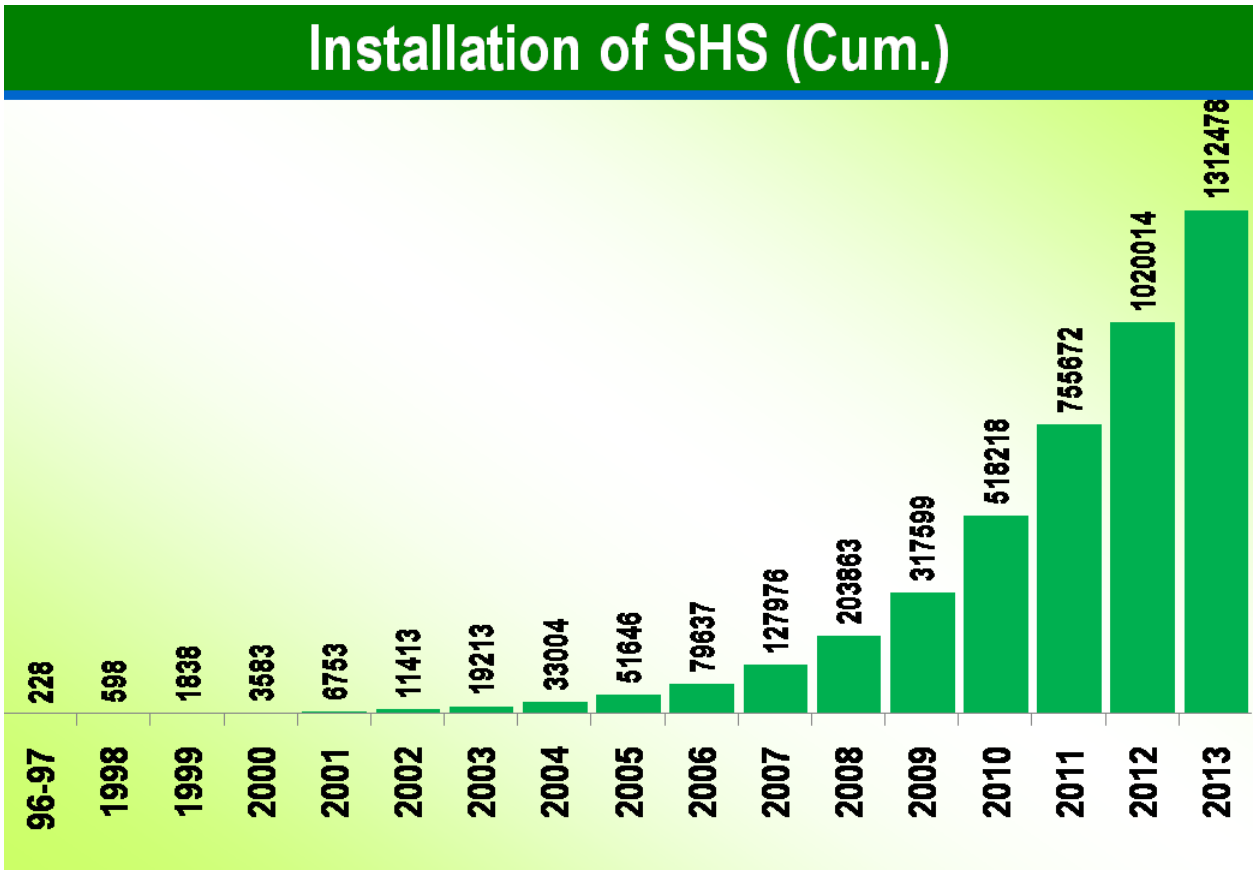

Figure 15: Installation of solar home system by Grameen Shakti.

Organizations Engaged in Dissemination of PV technology: The heart of the solar photovoltaic system is the solar panel in Bangladesh and solar panels for photovoltaic applications are imported from other countries. However, conventional storage batteries SSDs are produced by local manufacturers. However, for photovoltaic applications as centralized, batteries and storage Investors are imported from foreign countries. Most of the CCU for EDM applications locally produced and some of them are imported from outside Bangladesh. Unlike the government, nongovernmental organizations and educational institutions, engaged in the distribution of photovoltaic technology in Bangladesh.

Figure 16: SHS in rural area of CHT.

Figure 17: Solar pump in Bogura and Solar roof-top in Dhaka city.

Bio energy

Biomass is biological material derived from living, or recently living organisms. Most often, it refers to plants or plant-derived materials that are specifically called lignocellulose biomass. [41] As a source of energy, the biomass can be used directly by the combustion to produce heat, or indirectly after the conversion of various types of biofuels. The conversion of biomass into biofuel can be achieved by different methods classified as: thermal, chemical, and biochemical methods. Wood is still the main source of biomass energy today; [41] Examples include forestry residues - such as dead trees, branches and tree trunks - yard clippings, wood chips and municipal solid waste, even. In the second direction, the biomass comprises plant or animal material which can be formed into fibers or other industrial chemicals, including biofuels. Industrial biomass can be grown from numerous types of plants, including miscanthus, switch grass, hemp, corn, poplar, willow, sorghum, sugarcane, bamboo, [42] and a variety of tree species, ranging from eucalyptus to oil palm (palm oil).

Power plant is produced by crops grown specifically for use as fuel outlet offering high biomass per hectare with low energy input. Examples of these plants are wheat, which usually give 7.5-8 tons of grain per hectare, and straw, which usually 3.5-5 tons per hectare yield in the UK. [43] The grain can be used for liquid transportation fuels while the straw can be burned to produce heat or electricity. Plant biomass can also be degraded cellulose to glucose through a series of chemical treatments, and the resulting sugar can be used as a first-generation biofuels.

The biomass can be converted into other forms of energy used in transportation fuels or methane gas, such as ethanol and biodiesel. Rotting garbage, and agricultural and human waste, all release methane gas - also called landfill gas or biogas. Crops like corn and sugar cane can be fermented to produce the transportation fuel, ethanol. Biodiesel, another transportation fuel, can be produced from food waste such as vegetable oils and animal fats. [44]

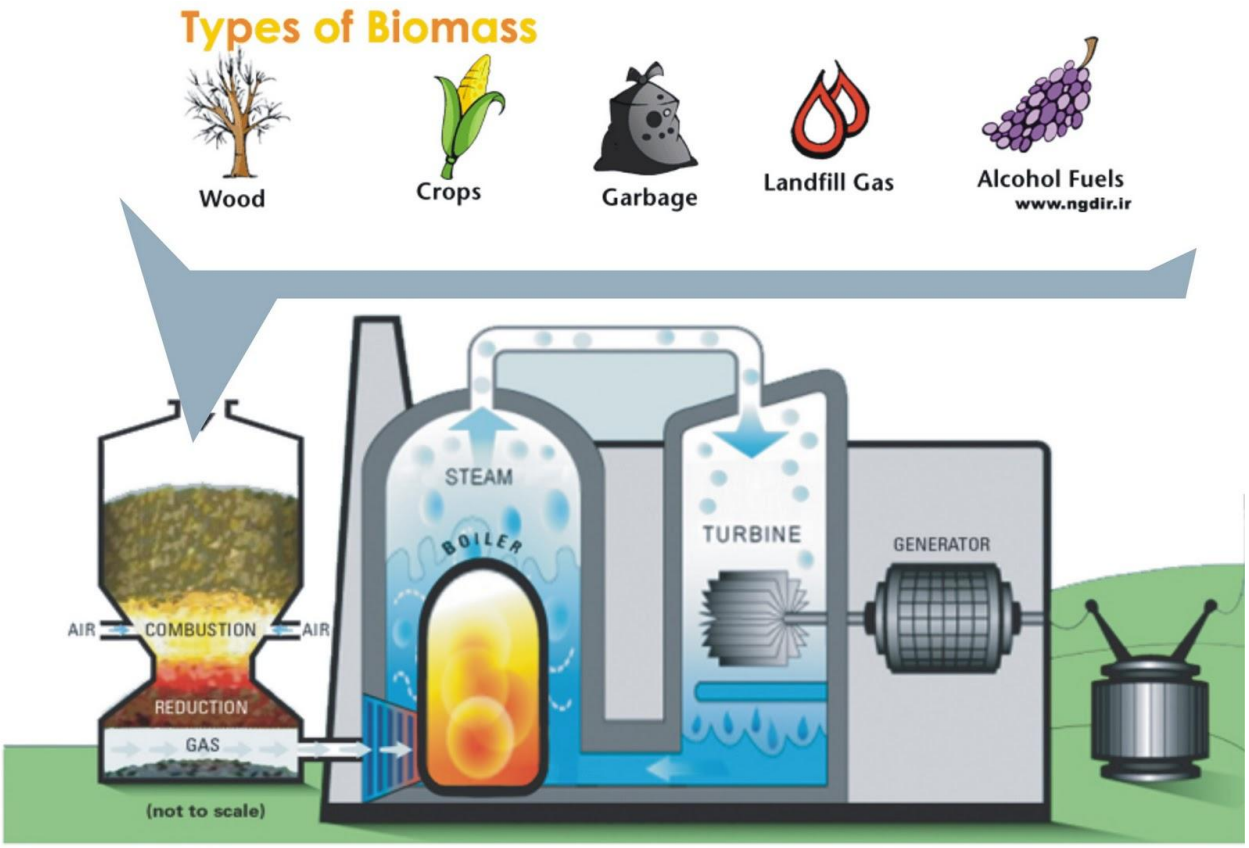

Figure 18: Process of energy production through bio mass.

In addition, biomass to liquids () and trauma of cellulosic ethanol are still under investigation. [45] [47] There is a lot of research with algae fuel or biomass from algae because of the fact that it is a non-food source and can be produced at a rate of 5 to 10 times higher than for other types of agricultural land, such as corn and soybeans. Once harvested, it can be fermented to produce biofuels such as ethanol, butanol, and methane, as well as biodiesel and hydrogen. The biomass used for electricity generation varies by region. Forestry, such as wood waste, by-products are common in the United States. Agricultural waste is common in Mauritius (sugar cane residue) and Southeast Asia (from rice husks). Animal residues, such as domestic poultry litter, are common in the UK. [48]

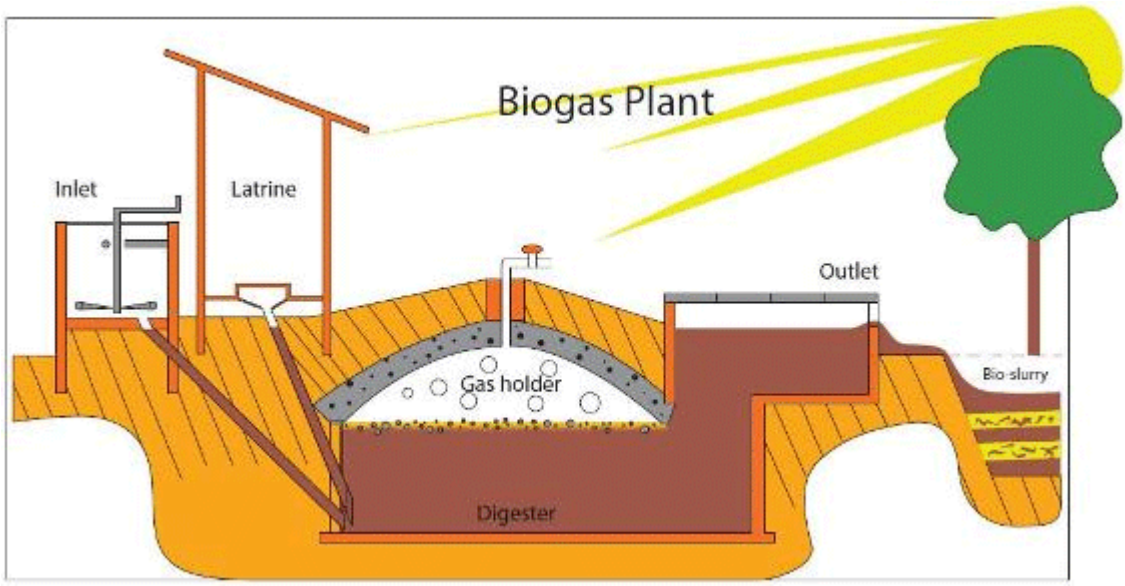

Figure 19: Biogas plant diagram.

Biofuels include a wide range of fuels from biomass. The term applies to solid, liquid and gas. [48] Biofuels include organic alcohols such as ethanol and oils such as biodiesel. gaseous biofuels include biogas, landfill gas and syngas. Bioethanol is an alcohol produced by fermenting sugar components of plant materials and consists mainly of sugar and starch crops. These include corn, sugar cane and, more recently, sweet sorghum. The last harvest is particularly suited for cultivation in dry conditions, and is under consideration by the International Research Institute for crop for semi-arid tropics for its potential to deliver fuel and food and feed in arid regions of Asia and Africa. [49]

Through being developed advanced technology, cellulose, such as trees and grasses for biomass are also used as raw material for ethanol production. Ethanol can be used as fuel for vehicles in its pure form, but is usually used as a gasoline additive to increase octane and improve vehicle emissions. Bioethanol is widely used in the United States and Brazil. Energy costs for bioethanol production are almost equal to the energy performance of bio-ethanol. However, according to the European Environment Agency, biofuels will not solve the problems of global warming. [50] The biodiesel made from vegetable oils, animal fats or recycled greases. It can be used as fuel for vehicles in its pure form, or more commonly as a diesel fuel additive to reduce levels of particulates, carbon monoxide and hydrocarbons from diesel vehicles. Biodiesel is produced from oils or fats using transesterificationand is the most common biofuel in Europe. Biofuels provided 2.7% of transport fuel in the world in 2010. [51]

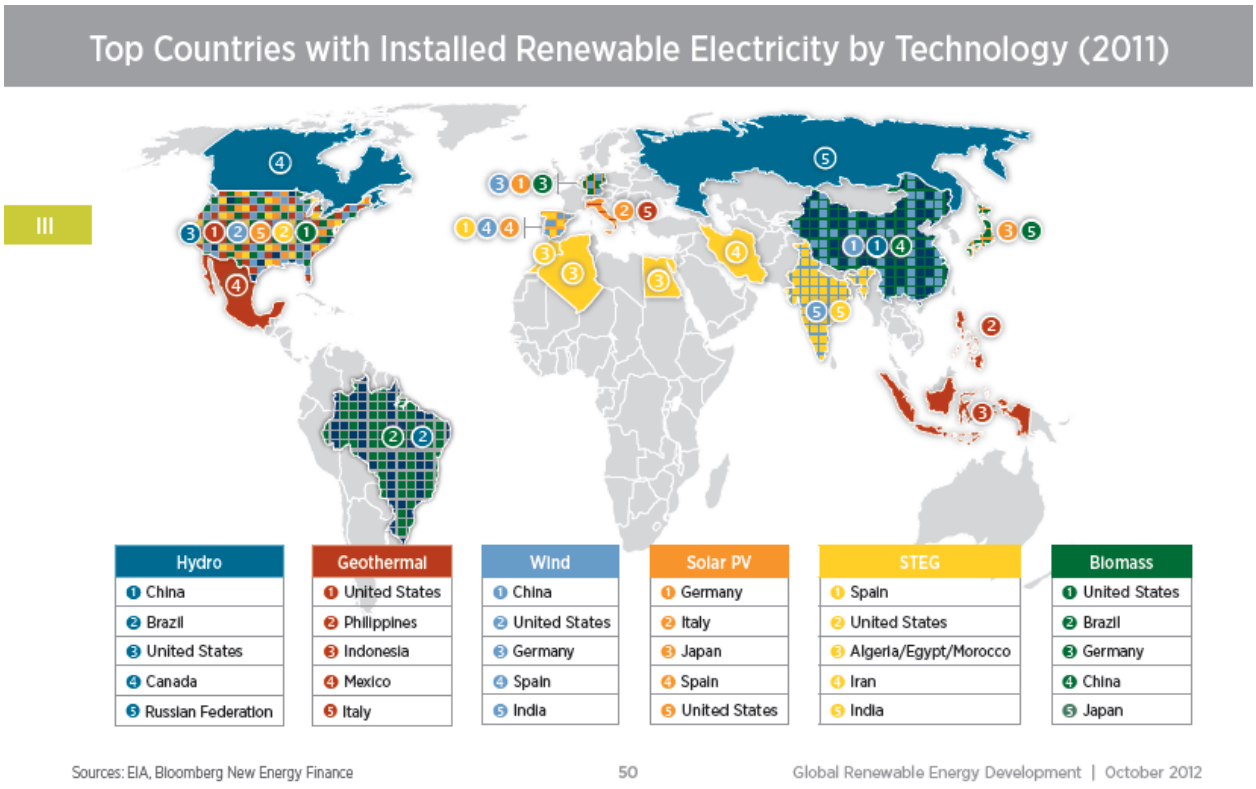

Figure 20: Top Countries with installed RET.

Biomass, biogas and biofuels are burned to produce heat / power and thereby damaging the environment. Of pollutants such as sulfur oxides (SOx), nitrogen oxides (NOx) and particulate matter (PM) are produced by the combustion of biomass; The World Health Organization estimates that 7 million premature deaths each year are caused by air pollution. [51] Biomass burning is a major contributor [51] [52] [53]. The plant life cycle is sustainable, the lives of people less.

Figure 21: Rice husk fired 250 KW gasifier power plant at Kapasia, Bangladesh.

Bio mass in Bangladesh

Biomass energy is the only one that has both the property fossil fuels and characteristics which means you can store, renewed and transferred. In Bangladesh, biomass is the main renewable energy source used primarily for rural cuisine heating. In India, the consumption of biomass fuels in rural areas is about 80% of the total energy consumption and fuel is wood more dominant accounting for 54% of biofuels [54]. Bangladesh is with a huge amount of biomass resources, because of its noncommercial extensive use. In addition, rained ecosystem it produces large amounts of biomass resources. Biomass is preferable as a clean energy including: agricultural waste, forest residues, manure and municipal solid waste. In the country, biomass is commonly used as fuel for most in rural areas. The usage pattern of the most common sources of biomass Bangladesh are wood, cow dung and leaves twigs, branches, rice straw and rice husks are used as biomass fuels, mainly for cooking purposes in the rural areas of Bangladesh. The energy resources of biomass are beneficial to many advantages such as the ability of the vast resources, lower prices, less sulfur composition, ash content and lower the renewal function. In On the other hand, it also has some negative aspects such as higher water content, lower heat production unit, and high volume, decentralized and insufficient resources for the collection, storage and transport [82]. However, a combination of appropriate measures potential local conditions, the use of available scientific data and Technology, selecting a reasonable technical program, adoption Advanced techniques, development of new energy conversion methods, attention to the efficiency of the use of energy and the economy of the biological system can cause more biomass resources efficient and effective for the country to meet the energy future the demand.

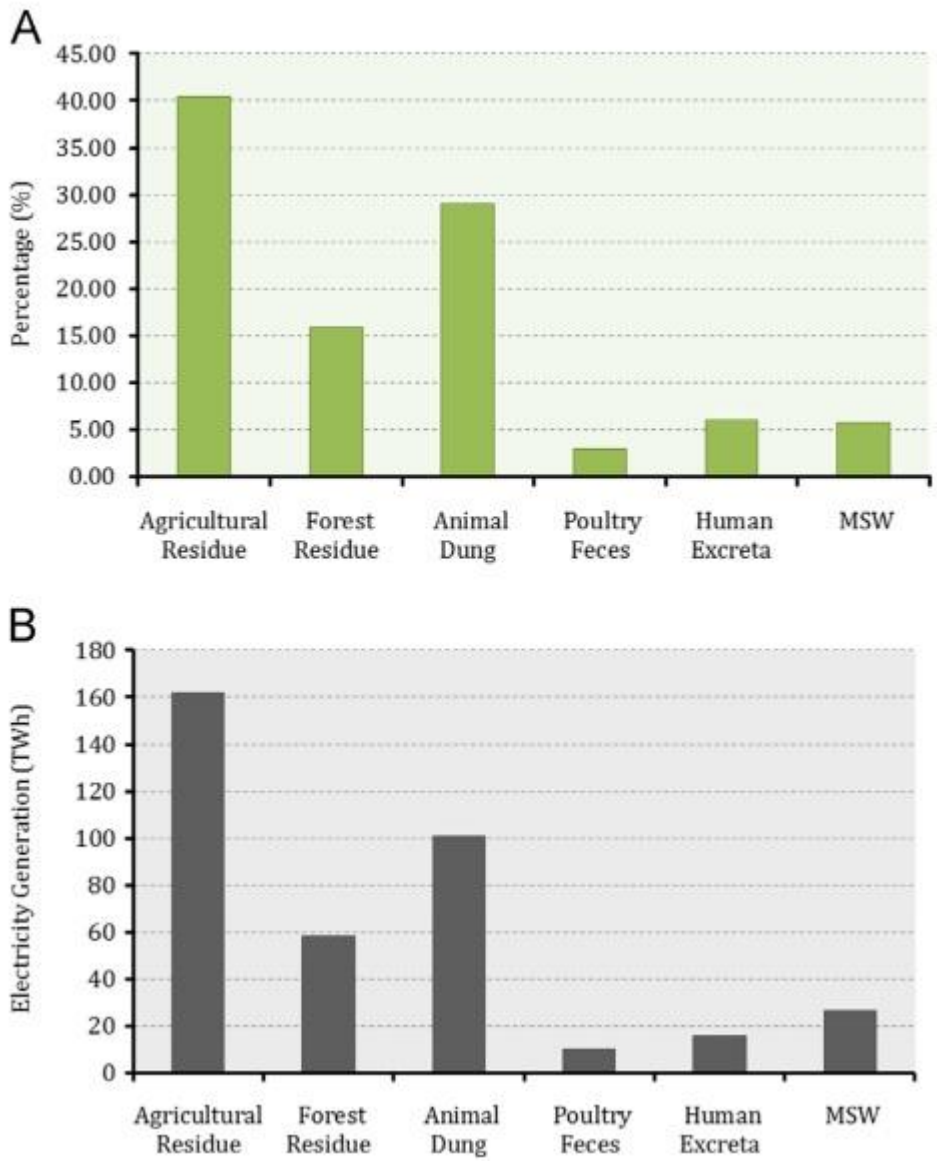

Figure 22: Contribution of various biomass sources in Bangladesh.

Some forms of bio mass energy sources are discussed below:

Agricultural residues

The potential of agricultural residues depends on the amount of crops and agricultural land. Measuring the availability of waste area and treatment area crops is very difficult due to the unavailability of real data of waste production. So, the amount of waste is estimated from waste production ratio (RPR). For each crop, a residual factor determines the crop residue and report product performance or culture. The amount of waste recovered It has been estimated taking into account the valuation of wet waste based factor as shown in Table 5. Accordingly, 2012-2013 it is estimated that the total annual repayment agricultural residue

(wet) in Bangladesh was about 42.92 million tonnes, of which 64.2% are waste field and process 35.8% residues [55].

Forest residues

Forests play a vital role in maintaining the balance of ecosystems. In addition, the large amount of energy consumption in rural areas Bangladesh is satisfied by forests and wood waste. Bangladesh has a small amount of forest land account intimidates 2.6 million (18%) the total area of 14.8 million henchmen [56]. However, forest land It is declining due to deforestation due to urbanization and Culture. Table 7 shows the distribution pattern of forest Bangladesh [57]. forest biomass fuel includes wood, tree waste (twigs, leaves, bark and roots) and wood processing resides (saw dust, dust plywood, veneer log dust, etc.). The wood Well, he thought as practical and renewable fuel and humans first used fire for cooking and heating.

Manure and human waste

Bangladesh has a massive number of potential breeding. There breeding study includes cattle, buffalo, sheep, goats, etc. animal i.e. dung manure cow, sheep and goats traditionally used waste cooking fuel and fertilizer in rural areas of Bangladesh. In addition, most poultry in the country are used as fertilizer. During the 2004-2005 fiscal year, there were 44,410,000 Animals raised to 53.02 million in 2012-2013 where cattle and goat was dominant, as shown in Table 11 [58]. Has been He reported in cattle work 92% is used for the culture and 0.19% is for transportation. [59] In addition, the total number of Poultry estimated in 2012-2013 in the country was 293,235 contains 246.60 million chickens and ducks 46635000 [58]. In addition, 163,655,000 human beings in countries produce a large amount of excrement. Therefore, the total livestock is estimated around 510,011,000.

Livestock waste and recovery of potential energy

Generation of manure varies from one region to another. In addition, waste production is influenced by body size, the type of Food and nutritional status of the animals. [60] Yield was manure estimated in 8-12 kg / animal / day for Buffalo, 5-10 kg / animal / day for cattle, 0.25-0.50 kg / animal / day for sheep and goats. [61] the rate of production of faces for chickens and ducks been 0.1 kg / animal / day. The generation of human waste was taken as 0.09 kg / person / day based on dry matter. [62] However, the annual waste production has been estimated by the average yield of high and low manure. Consequently, wet Total Livestock waste in 2012-2013 was estimated at 88.89 million tons. The recovery rate poultry droppings and animal waste were taken into account 50% and 60%, respectively [62,63]. However, 100% recovery the rate was considered by human waste. Recital the moisture content of poultry manure and animal waste 40% and 50%, respectively [60], the recovery of total dry residues 2012-2013 estimated at 34.26 million

tons as equivalent to 456.41 PJ. However, the recovery of waste under 2003 was 25.156 million tons equivalent to 337.67 PJ.

Municipal and industrial solid waste

Municipal solid waste (MSW) is a major threat to environment and a social problem facing the country. At present, the country has 522 urban centers, including 311 municipalities and nine companies in the city. Recently, a huge volume of solid waste is generated every day in municipal areas in the country due to the rapid urbanization and population growth. The main sources of waste these are houses, commercial areas, industries and hospitals. The Solid wastes include organic material, paper, plastic, textile and wood, leather and rubber, metal, glass, etc. However, in most City businesses and municipalities there is no separate solid Waste Management department because it is not well organized so far management of solid waste and tact is compounded daily day. The discharge is the most common practice in Bangladesh for waste arrangement having a negative impact on the environment. The country has few resources recovery plants [64], although there It is an excellent opportunity to generate energy such as gas and electricity. Most developed countries in the world produce electricity from solid waste by incineration or gasification or thanks to capture landfill methane development and focused on solutions to energy (WTE). [65] In addition, thermal Treatment can reduce waste volume by up to 90%; it could simultaneously address two problems: the elimination of solid waste and electricity production. [66] At present, some initiatives have been born to use this huge amount of waste generated in the Country. Effective uses (use of energy or power generation) of this huge amount of RSU reduce side effects on the environment and respond to electricity increasingly the country's demand.

Geothermal energy

The high temperature geothermal energy is thermal energy generated and stored in the ground. Thermal energy is the energy which determines the temperature of the material. Geothermal energy of the earth is from the original formation of the planet and the radioactive decay of minerals (uncertainty [67], but now proportions roughly equal, perhaps, [68]). The geothermal gradient, which is the temperature difference between the core and the surface of the planet, drives a continuous conduction of thermal energy as heat from the core to the surface. The word geothermal comes from the Greek roots geo, meaning earth, and thermos, meaning heat.

The heat used for geothermal energy may be the depths of the Earth, all the way to the core of the Earth - 4000 miles (6400 km) down. In the center, temperatures can reach over 9000 ° C (5000 ° C). It conducts heat from the core to the surrounding rock. High temperature and pressure extremely cause a rock to melt, which is commonly known as magma name. Magma convection comes up because it is lighter than solid rock. This magma rock and then the water in the paste is heated, sometimes up to 700 ° F (371 ° C). [69]

The hot springs, geothermal energy has been used for bathing since Pal-eolithic times and for space heating since Roman times, but is now better known for generating electricity [citation needed].

Low geothermal energy the temperature refers to the use of outer crust of the Earth, a thermal battery to facilitate renewable thermal energy for heating and cooling buildings and other refrigeration and industrial uses. In this form of geothermal ground source heat pump and heat exchanger in Canadian heat sinks are used together to advance the thermal energy on the earth (for cooling) and earth (for heating) on a seasonal basis variables. Geothermal low temperature (generally known as "BPH") is a renewable technology increasingly important, both to reduce the total annual energy costs associated with heating and cooling, and the demand curve flattens as eliminate electrical power requirements of high extreme summer and winter. Therefore low temperature geothermal / GHP is a growing national priority to support multiple tax credit [53] and focus as part of the move towards net zero energy. [70] City [71] New York, even adopted a law only [56] to require at any time GHP proves to be economical with socialized funding 20 years, including the cost of carbon. [72] [73]

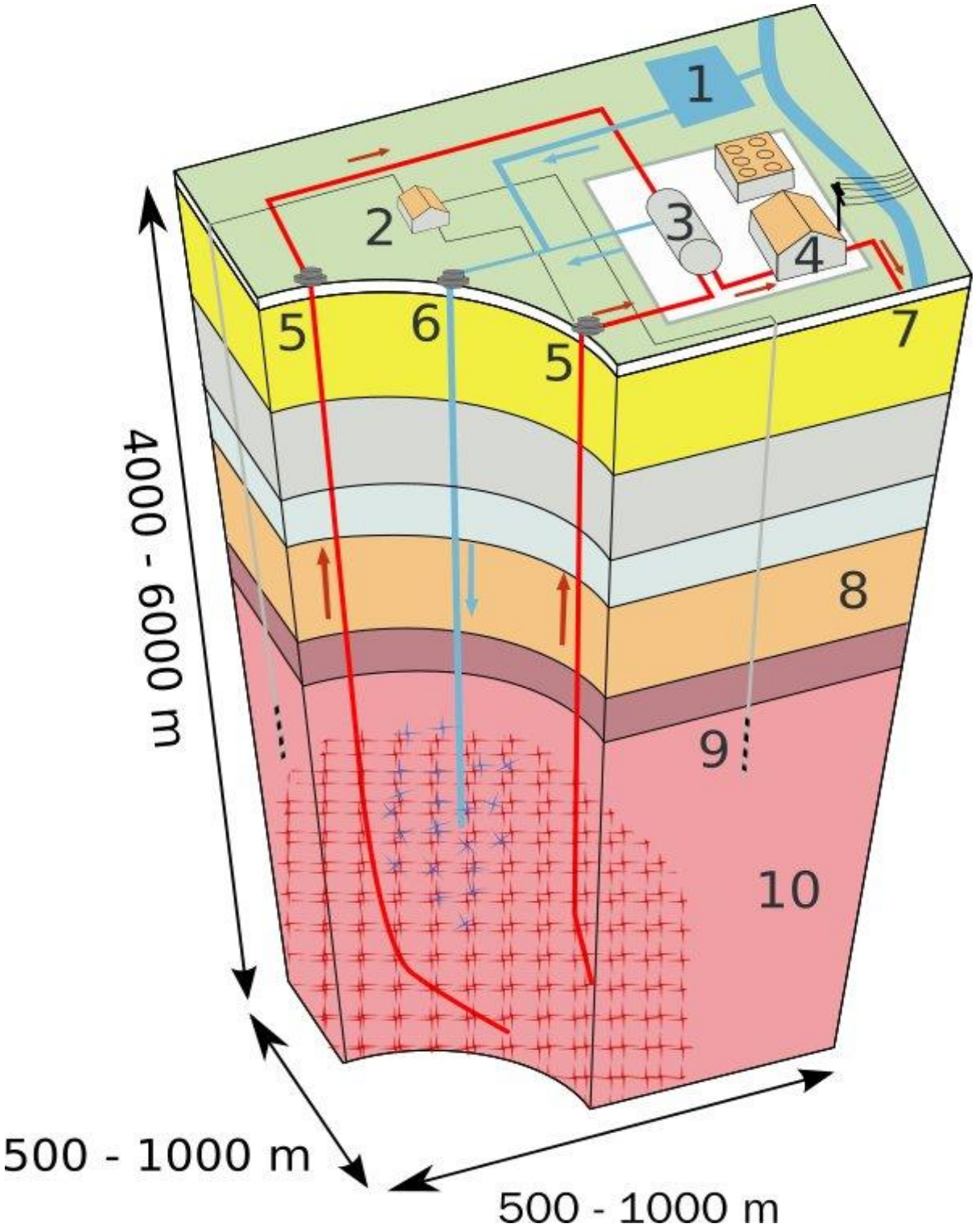

Figure 23: Geo-thermal energy diagram.

Scenario in Bangladesh

Geographically Bangladesh does not have any potentiality of geothermal energy resources.

Major stakeholders and institution

Governmental Body:

- Institute of energy, university of Dhaka.
- SREDA (Sustainable and Renewable Energy Development Authority)
- Ministry of power energy mineral resources Bangladesh
- BPDB
- LGRD
- BERC
- BCSIR
- IDCOL(Infrastructure Development Company Limited)

Figure 24: Institute of energy, university of Dhaka

Non-governmental organization

- Grameen Shakti
- BRAC
- WB
- ADB
- JICA
- German Development Cooperation (GIZ**)**
- **Rahimafrooz** Renewable Energy Ltd. (RREL) [74]

Renewable Energy policy

In order to achieve maximum output a policy must be established. A policy is like constitutional path that provides a way on how to achieve the goal or targets, RET is also not different from that. Public policy and political leadership helps to "level the playing field" and drive the wider acceptance of renewable energy technologies.[51][76] Countries such as Germany, Denmark, and Spain have led the way in implementing innovative policies which has driven most of the growth over the past decade. As of 2014, Germany has a commitment to the "Energiewende" transition to a sustainable energy economy, and Denmark has a commitment to 100% renewable energy by 2050 [75]. There are now 144 countries with renewable energy policy targets. After the Fukushima incident of earth quake and tsunami public opinion went against nuclear energy and now the public opinion is very favorable to RET.

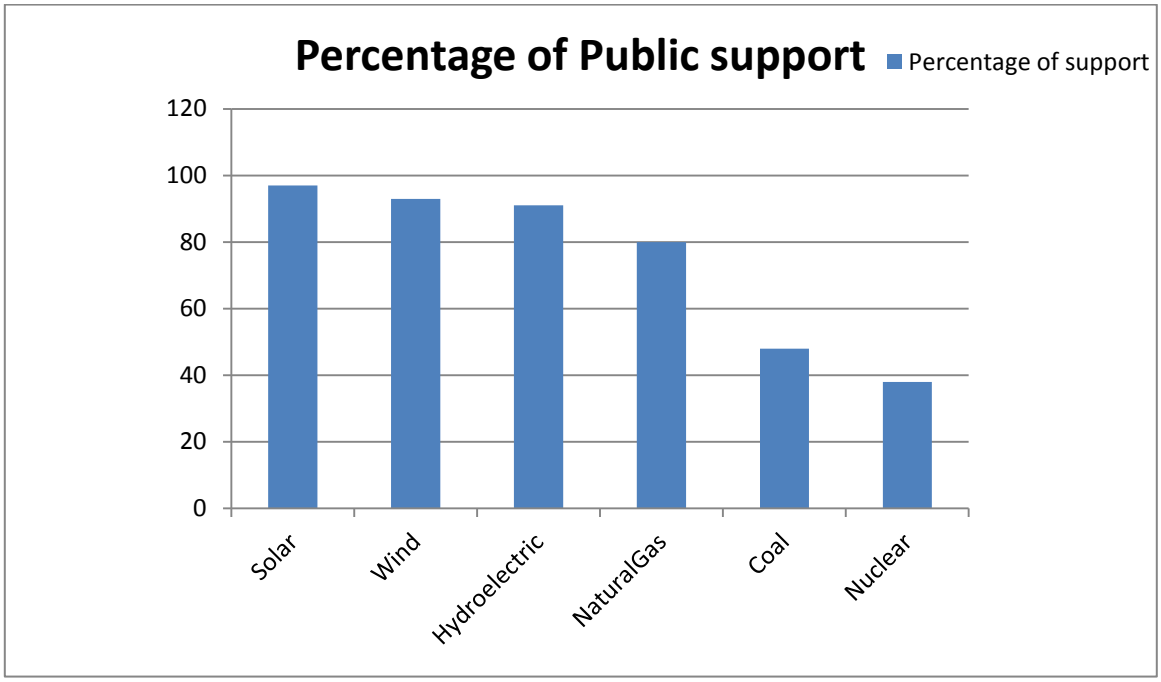

Figure 25: Global public support for energy sources, based on a poll by Ipsos Global @dvisor. This survey was conducted in 24 countries.

Renewable Energy policy of Bangladesh, 2008

GOB has issued its Vision and Policy Statement in February 2000, to bring the entire country under electricity service by the year 2020 in phases, in line with the direction of the Article 16 of 'The Constitution of the People's Republic of Bangladesh,' to remove the disparity in the standards of living between the urban and rural areas through rural electrification and development [78]. Aside from that Bangladesh is also suffering from huge energy crisis. There is also an outcry for the climate change. Therefore GOB has announced a much waited renewable energy policy for Bangladesh in the hope it will secure Bangladesh's energy security. Major aspects of the policy are discussed below

- Renewable Energy policy of Bangladesh2008 recognizes solar, wind, hydro, biomass, biogas as the major potential source of renewable energy source.
- Objective of the policy is to harness the potential of renewable energy resources, encourage the use and investment of RET in private and public sector, develop sustainable energy supply that can substitute indigenous non-renewable energy supplies, Train; facilitate the use of renewable energy at every level of energy usage, promote CDM project, achieve the target of 5% from RET of the total energy requirement etc.
- An institution, Sustainable Energy Development Agency (SEDA), shall be established under the Companies Act, 1994, as a focal point for sustainable energy development and promotion, 'sustainable energy' comprising renewable energy and energy efficiency. SEDA Board will comprise of representatives of stakeholders including business community, academics and/or representative from Bangladesh Solar Energy Society, NGOs, and financial institutions and implementing agencies.
- RET policy states a direction how other related government organization and interested government organization act with SREDA and with each other in case renewable energy related aspects.
- The policy also briefly discussed in which manner the commercialization of the RET will be occur.
- Policy shows a direction how the RET projects will sale electricity. In order to sale electricity any RET project which has a capacity more 5MW it has to get a license from BERC. BERC will also approve tariff by negotiating with SREDA and Power division for green energy or RET.[79]

Drawbacks and opportunities

After reviewing the Renewable energy policy of Bangladesh in contrast with Renewable energy policy of other country like India, Pakistan here some of the Drawbacks and opportunities are discussed below

- In order to achieve goal of 5% of total electricity supply from RET there is no specific policy or direction how they can be achieved.
- Renewable Energy policy of Bangladesh should have include new forms of device or policy like RPS, Heat obligation, net metering which are playing significant role to implement RET in various countries around the world.
- By revising the scheme of Jawaharlal Nehru National Solar Mission of India [] it can be seen that the policy they implemented is (i) long term policy; (ii) large scale deployment goals; (iii) aggressive R&D; and (iv) domestic production of critical raw materials, components and products, as a result to achieve grid tariff parity by 2022. But in policy of Bangladesh it is not the case.[80]
- Renewable energy policy of Bangladesh does not give any direction of domestic production of RE technologies.
- Renewable energy project investors both in public and private sectors has been exempted from corporate income tax for a period of 5 years, which is a great measure to encourage the RET in Bangladesh.
- All renewable energy equipment has been exempted from 15% VAT which also a great step for the encouragement of RET [79].
- The policy is giving emphasis on CDM projects which is a good option for investor.
- The main positive aspect of Renewable energy policy of Bangladesh, 2008 is that it has paved the way for establishment of the sustainable and renewable energy development authority or SREDA [79].

Feed in tariff policy (FIT)

Feed-In Tariffs are payments to ordinary energy users for the renewable electricity they generate. Feed-In Tariffs (also known as FITs) are the electricity part of what some people call Clean Energy Cash back, a scheme that pays people for creating their own "green electricity". Feed in tariff Responsible for approximately 50% of global wind power development and over 75% of global solar PV [81]. Countries like Germany, China and Japan integrating the policy of feed in tariff to make their energy policy more sustainable. In 2008, a detailed analysis by the European Commission concluded that "well-adapted feed-in tariff regimes are generally the most efficient and effective support schemes for promoting renewable electricity" [83]. This conclusion was supported by other analyses, including by the International Energy Agency, the European Federation for Renewable Energy, as well as by Deutsche Bank [84].

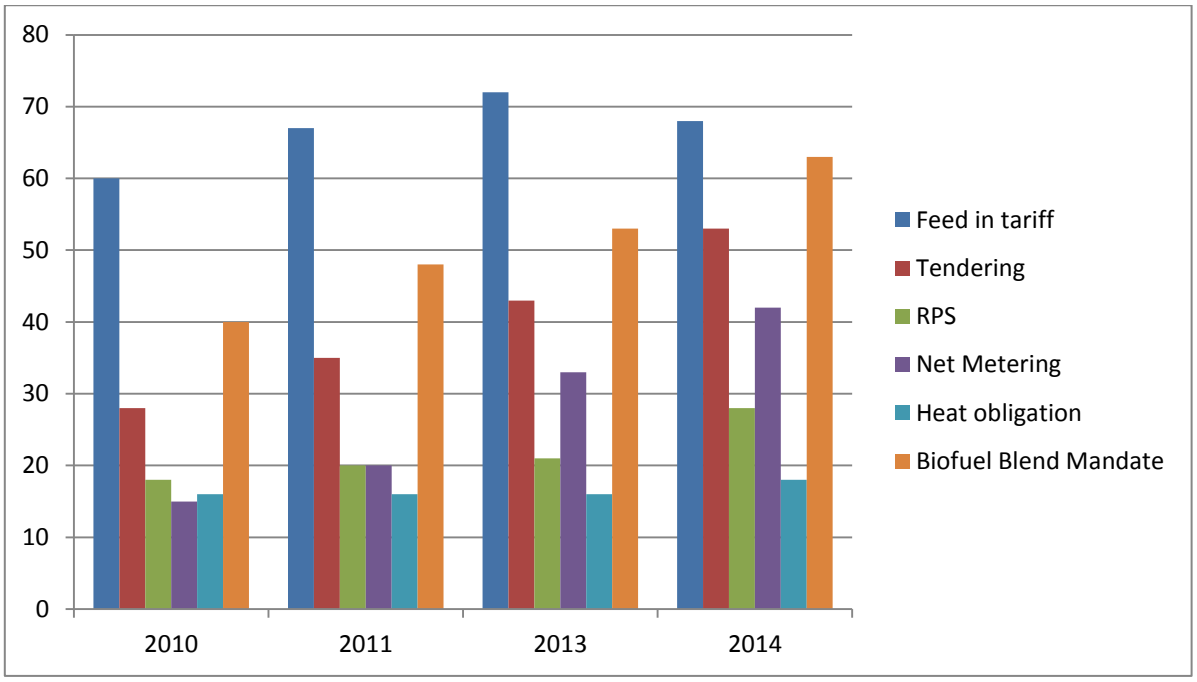

Figure 26: Number of countries and renewable energy policy method.

Scenario in Bangladesh

Figure 27: Regulators, academics and government officials in a seminar on feed-in tariff organized by Institute of Energy of Dhaka University in collaboration with the Asia Foundation.

Currently a FIT is going through its building process for the promotion of RET in Bangladesh. The section 5A of the Draft Electricity (Amendment) Act 2012 provides for specific provisions in relation to introduction of FIT framework for promotion of renewable energy in Bangladesh [89]. It is prepared by Idam infrastructure advisory private limited under the guidance and support of institute of energy – Dhaka University and the Asia foundation for reference and use by Bangladesh Energy Regulatory Commission. Its draft copy is open for discussion. Name of the Regulations is Bangladesh Energy Regulatory Commission (Feed in Tariff for Wind and Solar Electricity) Regulations, 2015 [85]. Some aspect of the regulation discussed below

- Bangladesh Energy Regulatory Commission (Feed in Tariff for Wind and Solar Electricity) Regulations, 2015 provides FIT for wind energy power project, Utility scale Solar PV and Solar rooftop PV systems and other small solar power.
- The technological eligibility of FIT will be approved by SREDA as per the Bangladesh Energy Regulatory Commission (Feed in Tariff for Wind and Solar Electricity) Regulations, 2015[85].

- Useful life is 25 years for each technology which means total amount of twenty five years that wind energy power, Utility scale Solar PV and Solar rooftop PV systems and other small solar power will serve the grid.

- The capital cost for wind energy projects shall include Wind turbine generator including its auxiliaries, land cost, site development charges and other civil works, transportation charges, evacuation cost up to inter-connection point, financing charges and Interest during Construction (IDC). The Capital Cost for Utility scale Solar PV power projects shall include Solar PV modules, power conditioning units, mechanical works, cabling & instrumentation, civil & structural works, land cost, site development costs, transportation costs, power evacuation cost up to inter-connection point, financing charges and Interest during Construction (IDC).

- Normative Capacity Utilization Factor (CUF) for wind energy project is 20% and for Utility scale Solar PV power project is 19% in Bangladesh [85].

- The tariff for renewable energy technologies shall be single-part tariff consisting of the following fixed cost components:

a) Return on equity;
b) Interest on loan capital;
c) Depreciation;
d) Interest on working capital;
e) Operation and maintenance expenses;

- Tariff determined under these Regulations shall be exclusive of taxes and duties on generation and sale of electricity from renewable energy project as may be levied by the Government, provided that the taxes and duties levied by the Government on generation and sale of electricity from renewable energy project shall be allowed as pass through on actual incurred basis.

- All risks, costs and efforts associated with the availing of carbon credits shall be borne by the generating company. Further, the entire proceeds of carbon credit from approved CDM project, if any, shall be retained by the generating company.

- Normative O&M expenses allowed at the commencement of the Control Period under these Regulations shall be escalated at the rate of 5% per annum over the tariff period for the purpose of determination of tariff.

Table 4: Three types of technology and their Tariff period, Capital cost norm and O&M cost norm from schedule 1, 2.

Types of the technology And description	Reference BERC RE regulation	Tariff period (Year)	Unit	Capital Cost Norm	O&M Cost Norm
Wind Power Project	25.2, 27.1	15	Million Taka / MW	100	2.00
Utility Scale Solar Power Project	30.2, 32.1	15	Million Taka / MW	112	1.54
Rooftop PV and other small solar power projects with installed capacity	35.2, 37.1	25			
a) - Up to 10 kW			Taka / kW	130,000	1820
b) - More than 10 kW and up to 1000 kW			Taka / kW	120,000	1680

Table 5: FIT rate Comparison with China, India, Pakistan and Japan.

	China[86]	Japan[86]	India[86]	Pakistan[87]	Bangladesh*[85]
Solar	0.14–0.16	0.338–0.390	0.15	0.189, 0.20	.162
Wind power	0.08–0.10	0.232–0.580 (onshore) 0.380 (offshore)	0.09	N/A	.145
Hydro Power	0.03–0.12	0.148–0.359	0.07	N/A	N/A
Biomass	0.12	0.137–0.411	0.09	N/A	N/A

*1$=78.50 Taka, 2015-16 FY

Drawbacks and opportunities of FIT in Bangladesh

From the review of the final draft copy of "Bangladesh Energy Regulatory Commission (Feed in Tariff for Wind and Solar Electricity) Regulations, 2015" I have found some drawback which are given below

1) Only two types RET technology wind and solar are available for feed in tariff policy but from the table we can see that most of the country, who are doing well in renewable energy implementation, are offering technologies for hydro power and biomass also. Countries like Germany, UK are even offering FIT for new technologies like tidal energy, wave energy etc. Only two type of package will discourage many investors who are interested to invest in new technology which in turn also discourage the research and development in RET.

2) There are FIT for wind energy but it was not determined whether it is offshore or on shore. Offshore technology is new and away from the locality which reduces many demands like land requirement, public agitation etc.

3) Bio mass has great potentiality in Bangladesh. We are traditionally using it for a long period of time. There are some ongoing projects which are producing electricity from rice husk. So if biomass is introduced in the FIT policy it will encourage more investment in the biomass sector.

4) From the highest retail price for peak hour offered by the BPDB is almost equal to the FIT. This extra cost may be little burdensome for the users [13].

Other policies of Bangladesh related to RET

Power System Master Plan (PSMP)

From the PSMP of 2010 we can see very little hope for the RET. Bangladesh Renewable Energy Policy "issued in November 2008, according to the Ministry of Energy, Bangladesh's target of 5% of total electricity demand in 2015 and 10% renewable energy by 2020 will be met government estimates that output settings will require almost within reach 10,283 MW in 2015, almost mean 510 MW to cover 5% of the demand will come from renewable energy sources. Likewise, it is estimated that electricity demand in 2020 will reach around 17600 MW and 1760 MW of energy from renewable sources 10% cap should be generated. Renewable energy policy defined input assuming demand is equal to the actual performance of renewable energy power production equipment, more than twice the output level should be developed to cover the share of renewable energy is less than approximately 30% for renewable energy, ranking countries in terms of population), which is a priority electrification (currently 48.5% increase in the share SHS (Solar home System) promotes the introduction of solar panels using currently.

Energy from renewable sources such as photovoltaic, solar thermal and wind energy will be included in the power supply, then their generation costs reasonably technical and / or economic reasons for the success is canceled. Renewable energy becomes possible, such as oil and other imported coal supply LNG imports will be reduced accordingly. Renewable energy sources, especially technical problems connecting to the distribution system is important for isolated rural areas. However, the promotion of renewable energy through other programs than the zoning plan must be implemented [88].

Electricity Act (Draft) 2012

The Government of Bangladesh notified Draft Electricity (Amendment) Act 2012 on October 1, 2012 as a change to its existing Electricity Act, 1910. The Act provides for increased use of renewable energy (solar, wind, hydro, biomass, geothermal, wave, as well as fossil fuel and renewable hybrid electrical generation systems)

5A. Encouraging Power Generation utilizing renewable and non-conventional energy– (1) The Government shall, after consultation with the Commission, prepare and notify a national policy, for promotion of generation of electricity based on renewable and other non-conventional sources of energy [89].

(2) Such policy shall include, inter alia, provisions for such subsidies, feed-in tariff, facilities and incentives, fiscal as well as others, as may be provided by the Government from time to time, to the producers of electricity using renewable sources of energy and the operators of any renewable energy system (Emphasis Added) [89].

500 MW solar power program around Bangladesh

The government has initiated a program to generate 500 MW of solar based electricity for the national grid. In this program, the private sector has been identified as an essential partner. The main components of this program include:

1) Replacement of Diesel Irrigation Pumps with Solar Power
2) Solar Mini Grid Power System at Remote villages
3) Solar Parks
4) Roof-top Solar Power Solution for Commercial including government owned buildings, Industrial and Residential buildings
5) Electrification of health centers, educational Institutions, E Centers at Union levels, religious establishments and railway stations

Small off-grid solar projects: for all these projects are funded mostly Infrastructure Development Company Limited (IDCOL), a government-owned financial Institution under the Ministry of Finance. Some of the NGOs, private organizations are selected as a partner organization to implement the program works on the basis of management capabilities, financial strength and experience in microfinance. These are the conditions responsible for choosing the location and potential consumers. They are in a position to perform Site Survey detail to carry out a technical feasibility study and then install the plant. They are also responsible to supply the products to the consumers and thereafter collect the bills [90].

Table 6: 500MW PV project of SREDA.

Serial No	**Type of projects**		**Capacity addition in MW**
1	Solar Irrigation		150
2	Solar Mini Grid		25
3	Solar Park		135
4	Solar Roof-top	a) Residential and Commercial Building	10
		b) Industrial Building	20

Comparison of electricity cost per unit on different types sources in Bangladesh

Table 7: Comparison of prices (TK/kWh) on different types of electricity sources in Bangladesh.

	Average electricity cost	Coal based electricity cost	Nuclear electricity cost	Petroleum Based electricity cost	Natural gas based electricity cost	Cost on RET sources
Cost/kWh	5.86	4-7	7-9.40	5-8	2-3	11-14
CO2 Emission Kg/kWh	N/A	.909	.006	.821	.465	.080-.0

Source: BPDB annual report 2014-15

From the table it is visible that energy sector of our country is heavily subsidized. Where average cost per unit is 5.86 TK but GOB is buying or producing energy at price of 4 to 9.40 for conventional electricity sources. This is one of the reasons that the RETs in Bangladesh is lagging behind. Aside from that we can see that proposed nuclear based electricity will cost 7 to 9.40 Tk. Per unit but it can pose a harmful effect on environment. In that case we can remember the Fukushima Doichi horrendous incident of nuclear reactor meltdown. Coal based electricity is cheap but detrimental for environment as well as for human being. In the energy mix of Bangladesh major source is natural gas which cheap because Bangladesh is blessed with some natural gas mine but for the over use this abundance is declining day by day. Recently a feed in tariff (FIT) plan for solar and wind energy has been proposed where price is set on an average 13 to 14 TK per unit. GOB and Beximco has also entered in an agreement to produce electricity at a price of 13.69 TK. Those prices may seem high as compared to the conventional sources but considering the environment and energy security it can be termed as a future investment, because the price will decrease with the technology advancement.

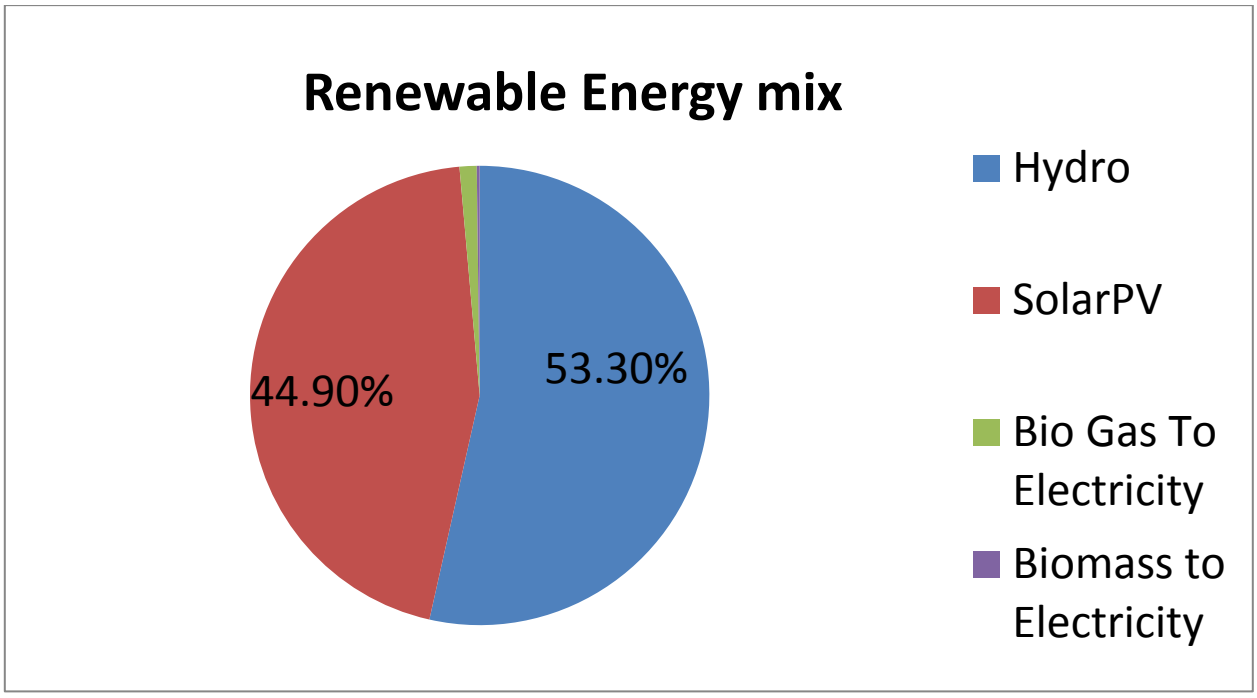

Figure 28: Renewable energy situation in Bangladesh.

Analyses and Criticism

Bangladesh is a developing country. Thriving economy of Bangladesh requires a lots off energy with cheap price also in an environment friendly way. Therefore Bangladesh's policy makers started to take into consideration of the renewable energy sources. Recently Bangladesh has published some of the policy related to the RET which are discussed in this paper. There some flaws in those policies which are discussed below:

- Bangladesh had fixed an aggressive target of 5% total energy production from renewable energy without proper directions and polices in 2010 for 2015. One of the leading RET implementing country is Germany they have policies like German Renewable Energy Sources Act, Electricity Feed-in Act (1991), Renewable Energy Sources Act (2000), PV Interim Act (2003), Renewable Energy Sources Act (2004), Renewable Energy Sources Act (2009), PV Act (2010), PV Interim Act (2011), Renewable Energy Sources Act (2012), PV Act (2013), Sustainable energy act, climate change mitigation act etc. [91] Those police helped Germany to achieve goal of their renewable energy.
- Bangladesh is now going to adopt the Feed in Tariff policy in order to buy electricity RET source. This is a good step to increase the usage of RET in Bangladesh. However Bangladesh Energy Regulatory Commission (Feed in Tariff for Wind and Solar Electricity) Regulations, 2015 article 4.1, 4.2, 4.3 has offers only two types technology capable of availing the opportunities to sale electricity from ret source. This will leave the FIT policy incomplete. Around world the countries that are providing FIT is giving offers on new RET source also.
- From the "Bangladesh Energy Regulatory Commission (Feed in Tariff for Wind and Solar Electricity) Regulations, 2015" there is no mention of off shore and on shore wind energy. The integration of off shore and on shore types of wind energy will make the policy robust and up-to-date.
- "Bangladesh Energy Regulatory Commission (Feed in Tariff for Wind and Solar Electricity) Regulations, 2015" schedule 1 provides the pricing rates of technologies. Price is slightly higher [88] than the price GOB buy electricity from the private sector. This may trigger an agitation in both consumer and producer company.
- In "Renewable Energy Policy of Bangladesh 2008" there is no mention off the production of the technology related to RET.
- From PSMP 2010 in article 6.2.2 we can see that there is an aggressive plan to achieve 5% from the RET in 2015 but there was no direction how this goal can be achieved.
- Once SREDA has established a project that will ultimately produce 500MW from RET source Photo voltaic production but there is no assessment report of that project.

Recommendation

On the basis of this long discussion some recommendations for better dissemination of RET in Bangladesh are given below

Policy Integration: In order to accelerate process GOB can adopt some new device policy like FIT which are also effective for proper dissemination of RET some of them are discussed her briefly

a) **Net metering*:*** Net metering allows residential and commercial customers who generate their own electricity from solar and wind power to feed electricity they do not use back into the grid. Many counties have passed net metering laws. Net metering is a billing mechanism that credits solar energy system owners for the electricity they add to the grid. For example, if a residential customer has a PV system on the home's rooftop, it may generate more electricity than the home uses during daylight hours. If the home is net-metered, the electricity meter will run backwards to provide a credit against what electricity is consumed at night or other periods where the home's electricity use exceeds the system's output. Customers are only billed for their "net" energy use. On average, only 20-40% of a solar energy system's output ever goes into the grid. Exported solar electricity serves nearby customers' loads [92]. It requires only one meter on the other hand FIT requires two meter.

b) **Renewable portfolio standard** (RPS): BERC can adopt policy like RPS. RPS is also one of the mechanism which is accelerating RET in different countries. RPS is a regulation that requires the increased production of energy from renewable energy sources, such as wind, solar, biomass, and geothermal. Other common names for the same concept include Renewable Electricity Standard (RES) at the United States federal level and Renewables Obligation in the UK [94]. An RES establishes incremental targets which increase over time; for example, a state could require utilities to increase their renewable generation by 2% each year for the next ten years, resulting in 20% renewable power in that state. The targets, compliance mechanisms, and qualifying resources of RES policies can vary widely from state to state. Some states include more specific requirements (called carve-outs), which further incentivize the deployment of particular market segments or energy technologies [93].More than half of all U.S. states have some type of renewable energy standard or goal in place. National RES policies have been considered by Congress but have yet to be signed into law.

c) **Renewable Heat Incentive (RHI) or Heat obligation:** The Renewable Heat Incentive (the **RHI**) is a payment system for the generation of heat from renewable energy sources introduced in the United Kingdom on 28 November 2011. The RHI operates in a similar manner to the Feed-in Tariff system [95].

d) **Sustainable tourism:** Now a day's tourism is thriving in our country. However sometimes tourism creates environmental hazards in natural tourist spots. Bangladesh Tourism Corporation can adopt the Idea sustainable tourism which is though a very new idea for sustainable growth. Sustainable tourism defined as the concept of visiting a place as a tourist and trying to make only a positive impact on the environment, society and economy [96].

e) **Environmental tariff:** An Environmental tariff, also known as a green tariff or eco-tariff, is an import or export tax placed on products being imported from, or also being sent to countries with substandard environmental pollution controls. They can be used as controls on global pollution and can also be considered as corrective measures against "environmental races to the bottom" and "eco-dumping"[97].

f) **Eco tax**: An Eco tax (short for ecological taxation) is a tax levied on activities which are considered to be harmful to the environment and is intended to promote environmentally friendly activities via economic incentives. Such a policy can complement or avert the need for regulatory (command and control) approaches. Often, an Eco tax policy proposal may attempt to maintain overall tax revenue by proportionately reducing other taxes (e.g. taxes on human labor and renewable resources); such proposals are known as a green tax shift towards ecological taxation. Eco taxes address the failure of free markets to consider environmental impacts. Eco taxes are examples of Pigouvian taxes, which are taxes that attempt to make the private parties involved, feel the social burden of their actions [98]. NBR (National Board of Revenue) under the provision and direction of BERC (Bangladesh Energy Regulatory Commission) can put eco tax for the companies who are responsible eco hazards. Eco tax can make Bangladesh's sustainable and environment friendly development easier.

FIT policy for bio mass, bio gas and Hydroelectricity: As it is clear from the Bangladesh Energy Regulatory Commission (Feed in Tariff for Wind and Solar Electricity) Regulations, 2015, that it is not intended for bio mass and hydro power. FIT policy should extend to FIT for those types of energy. As from the study we can see that Bangladesh has ability to produce electricity from bio mass, bio gas as well as from mini hydro power. For better dissemination RET and for sustainable growth GOB need to implement bio mass, bio gas and Hydroelectricity for FIT also.

Investigation on failing targets: An investigation should be launch why GOB has failed to achieve the target of 5% from RET in 2015 by BERC, SREDA and BPDB. Because all we know that failure is the pillar of success. The investigation report will give us new insights on how we can establish a better RET plan and policy to implement renewable and sustainable energy in our power system.

A central database system dedicated for RET: SREDA together with IE, DU, BERC, and BPDB can establish a central database system dedicated for RET, because the data is scattered here and there. A standard should be put on the evaluation of data. Pure professionalism must be needed here.

Home production of RET related technologies: Currently GOB is not considering the production RE related technologies which is a drawback for the dissemination of RET in Bangladesh. A clause should be added to Renewable Energy policy of Bangladesh dedicated to the production of renewable energy technology production in the country.

Assessment of project publicly open: Assessment of projects should be publicly open. It will make everyone dedicated to their responsibility.

Conclusion

It is true that Bangladesh is blessed with numerous RET source of energy. However a proper utilization of those RET source requires proper policy planning and management from government. Without government regulation renewable energy wouldn't thrive. Lately Bangladesh has taken steps to adopt policies like Bangladesh Energy Regulatory Commission (Feed in Tariff for Wind and Solar Electricity) Regulations, 2015, "Renewable Energy Policy of Bangladesh 2008" which are fully dedicated to the implementation of renewable and sustainable energy source. This is a good sign for the dissemination of RET around the country. Almost 75% of RET dissemination in the world is currently accounted for the FIT (FEED in Tariff) policy. Therefore FIT policy will bring better dissemination of the RET in Bangladesh which will in turn can fulfill the target 5% of total energy production from RET source. Renewable Energy Policy of Bangladesh 2008 has paved the way for establishing the renewable and sustainable energy related government organization SREDA, SREDA came into being on 2012. Now SREDA is working as the main government organization to deal with matter of renewable and sustainable energy implementation and policy making. Renewable energy research Centre (RERC), Dhaka University, which was established in1981, has turned itself into Institute of Energy DU from Institute of Renewable Energy DU in 2013. This institute is pioneer in doing research and education in the field of Renewable Energy Technology in Bangladesh as well as collaborating with international organization. Relentless effort of the teacher and scholar of this institute is also accelerating the RET dissemination process in Bangladesh as well as around the world. Bangladesh also implemented 4.5 million of solar home system across the country which is the largest in number in the world. Therefore overall outlook of the RET sector of Bangladesh is holding an optimistic view from policy making perspective. However the field level implementation requires rigorous effort both from private and public sector. Some of the recommendations which are given in the recommendation section can also help to accelerate the current dissemination process of RET in Bangladesh. To conclude here we have found the following obstacles

- Absence of Feed in Tariff (FIT)
- Knowledge gap in the policy making level
- No consumer protection regulation in RE field.
- Absence of regulation related to waste to energy conversion.
- Absence of incentive for RE.
- Lack of financing from the financial institutions.
- Weak R&D funding for RE.
- Subsidized fossil fuel cost.

Nomenclature

BBS	Bangladesh Bureau of Statistics
BERC	Bangladesh Energy Regulatory Commission
BP	Bangladesh Plan
BPDB	Bangladesh Power Development Board
BPRE	Bangladesh Policy of Renewable Energy
BRAC	Bangladesh Rural Advancement Committee
IE	Institute of Energy, DU
CDM	Clean Development Mechanism
DC	Direct Current
GDP	Gross Domestic Product
GOB	Government of the People's Republic of Bangladesh
ICT	Information and Communication Technology
LGED	Local Government Engineering Department
MOF	Ministry of Finance
MDG	Millennium Development Goals
MPEMR	Ministry of Power, Energy and Mineral Resources
NEP	National Energy Policy
NGOs	Non-Government Organizations
PV	Photovoltaic
RE	Renewable Energy
REB	Rural Electrification Board
R&D	Research and Development
RETs	Renewable Energy Technologies
RSF	Research Support Facility
SRE	Sustainable Rural Energy
SREF	Small Renewable Energy Program
SHSs	Solar Home Systems
SREDA	Sustainable and Renewable Energy Development Agency
SNV	Netherlands Development Organization
DANIDA	Danish International Development Agency
BDT	Bangladesh Taka
USD	United States Dollar
WB	World Bank
NDBMP	National Domestic Biogas & Manure Programme
GOB	Government of Bangladesh
MoYS	Ministry of Youth and Sports
GTZ	German Technical Cooperation
HH	Household
IDCOL	Infrastructure Development Company Ltd
IFRD	Institute of Fuel Research and Development
LGED	Local Government Engineering Department

Subscript	
Ktons	kilotons
sq. km	square kilometer

%	percentage
M/s	meter per second
1C	degrees Celsius
1F	degrees Fahrenheit
Cft	Cubic feet
MJ/m^2	mega joule per meter square
GWh	giga watt hour
kWh/m^2	kilowatt hour per meter square
kWp	kilowatt peak
MWp	megawatt peak
KW	kilowatt
MW	megawatt
KWh/m2/yr	kilowatt hour per meter square per year
W/m^2	watt per meter square

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