

A Review on Primary and Sustainable Energy Scenario in Bangladesh

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Abstract A comprehensive overview of present primary energy production and its scenario in Bangladesh has been presented in this paper. The total primary energy consumption in Bangladesh is measured about 32.4 Mtoe in 2016 with a growth rate 3.2% which is significantly high from previous years. This high energy consumption is still met by the nonrenewable sources like natural gas, coal and crude oil. As a result, this high dependency and depletion of those fossil fuels reserve as well as the growing demand of energy supply frequently arise the issue of energy sustainability. That's why, this study is also focused on the discussion on prospect of primary energy in future as well as on exploration of the alternative energies like biomass, solar, nuclear and hydro energy to meet the growing demand of energy supply. Besides a short details on various ongoing and upcoming projects are mentioned which are undertaken by the Bangladesh government to promote renewable energy use as well as to create energy policy and regulations to attain the security and reliability of energy supply in this country.

Keywords: primary energy, sustainability, renewable energy, Bangladesh

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1. Introduction

The development and economic growth of modern civilization is entirely dependent on energy. David stern (2011) shows that when energy is scarce it imposes a strong constraint on the growth of the economy; however, when energy is abundant, its effect on economic growth is much reduced. The industrial revolution released the constraints on economic growth by the development of new methods of using coal and the discovery of new fossil fuel resources [36]. Therefore the researcher and technologies have given the importance on the research on sustainable energy development to find out a proper way to meet up the increasing demand of energy. The fuel consumption was growing from 6630 million tons of oil equivalents (Mtoe) in 1980 to almost double reaching 13,276 Mtoe in

2016 as shown in Table 1. The energy consumptions is mainly based on fossil fuels which account for 85.52%. The contribution of hydro power and nuclear are very small with only 7.08% and 4.6% respectively [5]. Furthermore, the energy generates from the combustion of fossil fuels has simultaneously created several environmental concerns which can threaten the sustainability of our ecosystem. One of the primary concerns will be the emissions of greenhouse gases and other types of air pollutants such as hydrocarbons, nitrogen oxide and volatile organic compounds [9]. Huge accumulation of those greenhouse gases and air pollutants in our atmosphere will eventually lead to drastic climate changes, acid rain and smog. For this remedy, the new and renewable energies are the only hope as well as will become one of the main energy sources in future for the world. Presently renewable energy contributes only 3.16% to global primary energy consumption which is shown in Table 1.

Table 1. Global Primary Energy Consumption [5]

Source	1980		2016	
	Mtoe	Share (%)	Mtoe	Share (%)
Petroleum	2979.8	44.9	4418.2	33.28
Coal	1807.9	27.3	3732.0	28.11
Natural Gas	1296.8	19.6	3204.1	24.13
Nuclear	161	2.4	592.1	4.6
Hydro power	384.3	5.8	910.3	6.86
Total	6629.80	100	13276.3	100

At current production and growth rates, Bangladesh proven reserves for coal and natural gas are estimated to last for 60 years and 126 years respectively [5]. Due to rapid depletion in natural gas, the crucial challenge facing the energy sector in Bangladesh currently is the issue of sustainability. That's why this sector has been given importance to ensure the security as well as reliability of energy supply and the diversification of the various energy resources. Therefore, this paper presents an overview of the current energy scenario in term of primary energy demand, supply and reserves in Bangladesh. The security and sustainability of future energy in various renewable energy options like biomass, wind, solar and hydro power has also been explored. Besides, the most recent alternative energy scenario and implementation in Bangladesh has covered in this study.

2. Bangladesh Energy Scenario

Bangladesh is the world's 8th most populated country with a population of 158 million [2]. Geologically, Bangladesh occupies a greater part of the Bengal basin with an area about 147570 km² and the country is covered by tertiary folded sedimentary rocks (12%) in the north, north eastern and eastern parts; uplifted pleistocene residuum (8%) in the north western, mid northern and eastern parts; and holocene deposits (80%) consisting of unconsolidated sand, silt and clay [6]. Agriculture used to be the main source of income for the people of this country. However the growth rate of Gross Domestic Product (GDP) in Bangladesh was 7.05% with GDP per capita about of 1,358.78 USD in 2016 [3]. Bangladesh Bank forecasts that on 2017 the economic growth will be more than 7% [4]. It is known that the economic growth for any developing country is a main tool for rapid urbanization as well as poverty eradication. And this economic growth has proportionality relation with total primary energy consumption in Bangladesh. The total primary energy consumption was measured about 32.4 Mtoe in 2016 with annual growth rate 3.2% and the average growth rate from 2005 to 2015 is around 6.3% which is considered high among other countries in Asia

and the Pacific region [1]. Even though the world's primary energy consumption is quite high about 13276.3 Mtoe, the contribution of Bangladesh in it is only 0.2% in 2016 [5]. However, it is expected to continue to increase in the future and most of the energies are consumed by residential, agriculture, transport and industrial sector. With the rapid advancement of urbanization in Bangladesh, the energy consumption in the residential sector is always dominant over 13 years which is shown Figure 1.

The total consumption of this sector is around 12200 Mtoe in 2013 and followed closely by industrial sector which consume 700 Mtoe [1]. The energy consumption in transport and agriculture are increased rapidly. With future energy demand expected, average annual growth rate of total final energy consumption will be 6.3% between 2014 and 2041 [1]. Therefore the energy security is becoming a serious issue as fossil fuels are non-renewable energy and will deplete eventually in near future. With rapid change of global as well as domestic situation some energy policies are undertaken by National Energy Policy (NEP) of Bangladesh, which was formulated in 1996 to proper exploration, production, transmission, distribution and rational use of energy sources to meet the growing demand on a sustainable basis. The policies are: (i) To provide energy for sustainable economic growth so that the economic development activities of different sectors are not constrained due to shortage of energy. (ii) To ensure optimum development of all the indigenous energy sources. (iii) To meet the energy needs of different zones of the country and socioeconomic groups. (iv) To ensure sustainable operation of the energy utilities (v) to ensure rational use of total energy sources. (vi) To ensure environmentally sound sustainable energy development programmes, with due importance to renewable energy, causing minimum damage to environment. (vii) To encourage public and private sector participation in the development and management of the energy sector. (viii) To integrate energy with rural development to boost rural economy. (ix) To bring entire country under electrification by the year 2020. (x) To ensure reliable supply of energy to the people at reasonable and affordable price. (xi) To develop a regional energy market for rational exchange of commercial energy to ensure energy security [7].



Figure 1. Geological map of Bangladesh

3. Energy Mix in Bangladesh

3.1. Natural Gas

Natural gas is the most important indigenous source of energy that has been continuously produced and consumed in significant quantities since 1970. In Bangladesh, natural gas is the main contributor of primary energy consumption with 76.54% in 2016 and has the significant proven gas reserve compared to other commodities [8]. Natural gas from Bangladesh is very pure, with about 95% to 99% methane and almost no sulphur. The average compositions are 97.33% methane, 1.72% ethane, 0.35% propane and 0.19% higher hydrocarbons. Gas in most of the fields is dry, but in a few fields it is wet, with considerable amounts of condensate, e.g. at Beanibazar (16 bbl/mmcf), Jalalabad (15 bbl/mmcf), and Kailashtila (13 bbl/mmcf). The total condensate reserve in the country is estimated at about 65 million barrels [10]. Gas is largely available in the eastern part of the country extending from greater Sylhet down to greater Comilla, Noakhali and Chittagong. It has also been discovered offshore gas fields in the Bay of Bengal. In 2003, a total of 22 gas fields were discovered and the total initial gas reserve was estimated at 20.51 TCF and a remaining reserve of 15.4 TCF. In 2014, the number of gas fields grew to 26 with an estimated initial gas reserve of 26.84

TCF and a remaining reserve of 16.74 TCF [12].

The production of natural gas has risen steadily in recent years and reaching around 27000 MMCM with 2600.14 MMCFD in 2016 which is an increase of 32.21% since year 2012 which is shown in Figure 4. Three national companies; Bangladesh Gas Fields Company Limited (BGFCL), Bangladesh Petroleum

Exploration & Production Company Limited (BAPEX), Sylhet Gas Fields Limited (SGFL) and four international oil companies; Chevron, Cairn, Tullow and Niko are in charge of exploration and production of gas in Bangladesh. Three national companies are operating with a production capacity of 1139 MMCFD while the international oil companies are operating with a production capacity of 1615 MMCFD which is shown in Table 2.

The total gas produced are used to meet the demand of the following sectors: power generation, urea fertilizer production, industrial process heating, captive power generation, and household cooking inside the country. It is also being used as the fuel vehicles in the form of compressed natural gas (CNG) since 2005. In 2015-16 financial year, Bangladesh produced 27380.58 MMCM of natural gas. The country consumes 15733.4 MMCM of natural gas mainly for electricity and industries, while 8560.51 MMCM of natural gas for captive power generation and domestic uses. The country's natural gas consumption by sector is shown in Figure 5 and Figure 6.

Table 2. Natural Gas Reserves in Bangladesh [8]

Company	Gas fields	Number of Well	Production Capacity (MMCFD)	Remaining Reserved
BGFCL	Titas	26	542	2990
	Bakhrabad	7	225	343.9
	Habiganj	6	43	1940
	Narshigdi	2	30	54.5
	Meghna	1	11	83.8
	subtotal	42	851	5412.2
SGFCL	Sylhet	2	8	289.1
	Kailastilia (1)	2	13	2210
	Kailastilia (2)	3	55	
	Rashidpur	5	60	935.1
	Beanibazar	2	15	8.9
	subtotal	14	151	3443.1
BAPEX	salda	1	10	105
	Fenchuganj	3	26	213.4
	Shabazpur	3	50	117.45
	Semutang	2	3	23.94
	Sundalpur	0	0	35
	Srikail	3	40	275
	Begumganj	0	0	32.7
	Roopganj	1	8	50
	subtotal	13	137	852.7
IOCs (CHEVRON And TULLOW)	Sangu	0	0	164.2
	Jalalabad	7	272	267.8
	Maulavibazar	5	42	198.3
	Bibiyana	26	1200	4760
	Feni	0	0	67.2
	Bangora	5	103	191.4
	subtotal	43	1615	5648.9
	Kutubdia	0	0	45.5
	Grand total	112	2754	15402.4

Source: Bangladesh Oil, Gas and Mineral Corporation (PteroBangla), 2017.

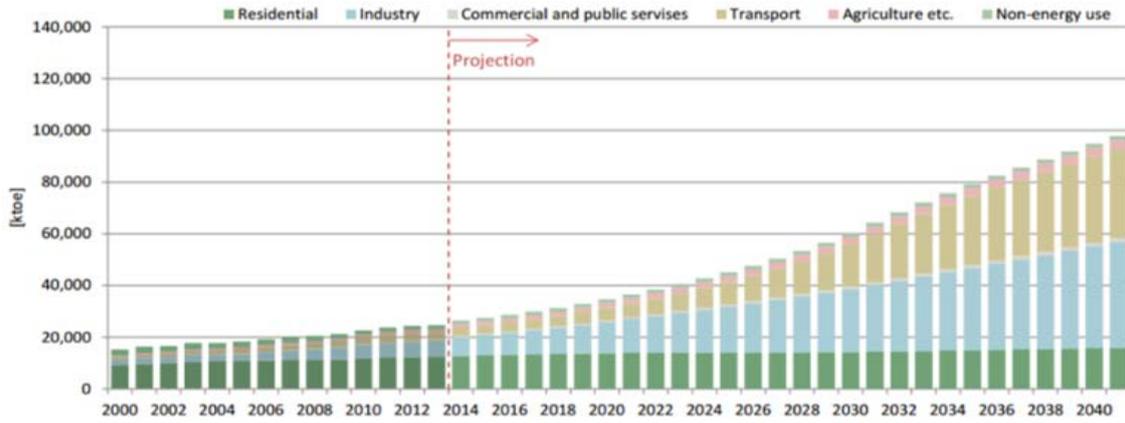


Figure 2. Projection of sector wise primary energy consumption in Bangladesh (JICA survey Team) [1]

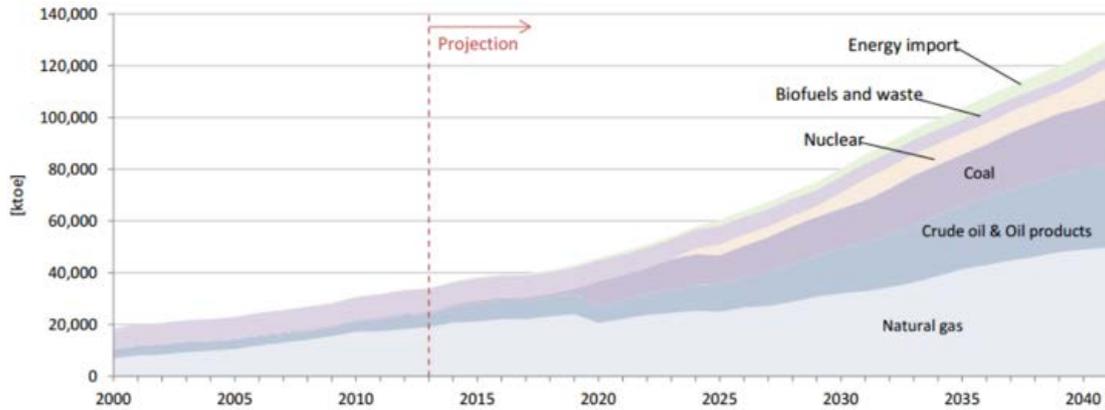


Figure 3. Projection of primary energy supply by fuel type in Bangladesh (JICA survey Team) [1]

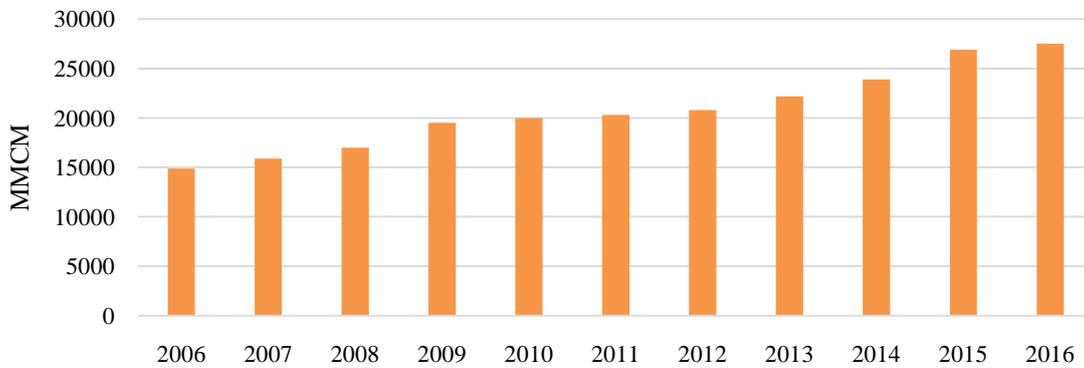


Figure 4. Yearly natural gas production in Bangladesh [8]

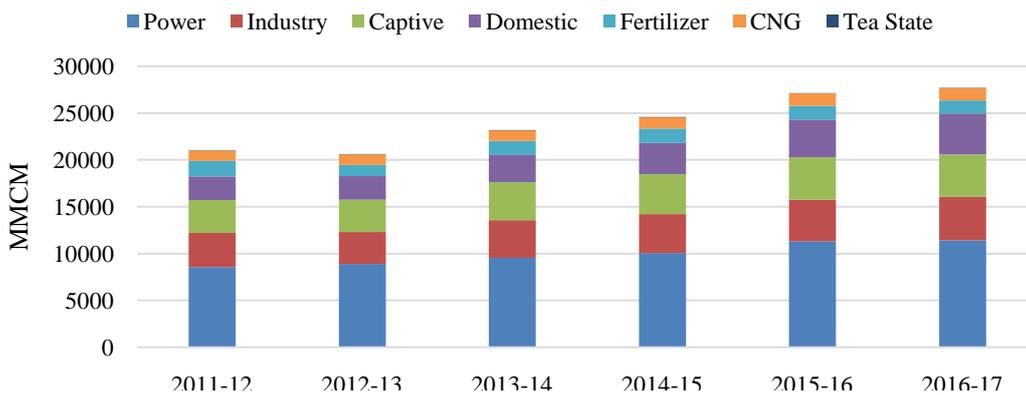


Figure 5. Sector wise natural gas consumption in Bangladesh [8]

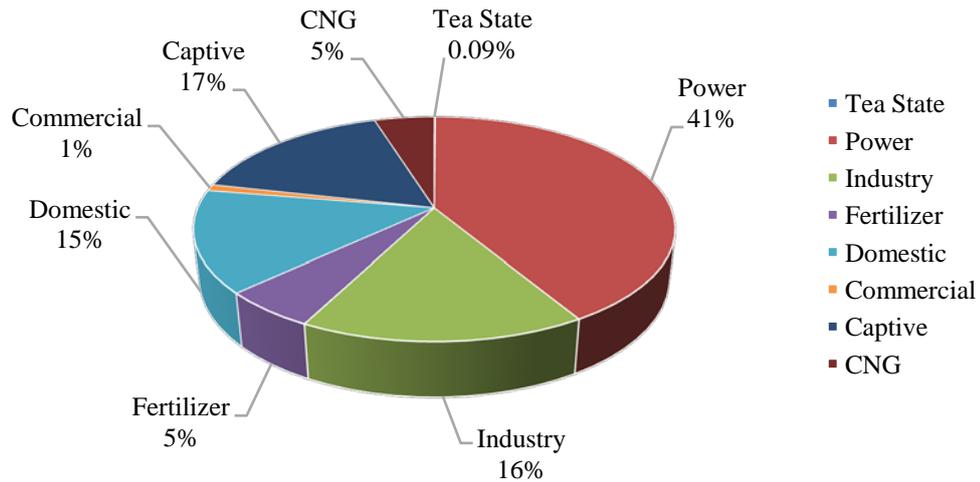


Figure 6. Percentage gas consumption in Bangladesh at different sector in Bangladesh [8]

According to JICA 2016 final report, Gas Production from the current domestic gas fields in 2015 was 2,500 mmscf and will reach a peak production of 2,700 mmscf in 2017, then start to decline. However, Gas demand in Bangladesh forecasts a significant increase in future. The demand and supply gap must be filled by gas (LNG) imports. The first LNG will be introduced in 2019 at the rate of 500 mmscf, which corresponds to 17% of gas demand. This percentage is forecast to increase to 40% in 2023, 50% in 2028, and 70% in 2041. Currently, introduction of LNG via FSRU, initiated by Petrobangla, is underway, and concurrently, construction of a land LNG terminal by Power Cell is also under discussion [1].

3.2. Crude Oil

The share of crude oil in world primary energy consumption in 2016 is 33.28% in where Bangladesh has a negligible contribution of 0.05% [5]. Because Bangladesh is not an oil producing country and the total oil energy demand is met by imported crude oil from other countries like Saudi Arabia, Abu Dhabi and so on. Bangladesh has no significant reserve oil field except the small quantity of oil in Haripur gas field, located in northeastern part of the country. It was discovered in 1986 and estimated probable and recoverable reserves of which were 27 and 6 million

barrels, respectively (Petro Bangla 1992). Oil was extracted from a single hole in that field from 1987 to 1993, and then production ceased. During 1990, 118449 barrels of oil were extracted, which at that time was economically viable for Bangladesh (Akhtar & Hasan 1994). Though Bangladesh has no potential reserve for production of crude oil, a significant amount of condensate around 12327.1 bbl/day is recovered from natural gas fields (Banglapedia). Bangladesh current annual demand of oil is around 37.76 million barrels (PSMP2016) and major consumer of this energy is transport sector followed by agriculture, industry and commercial sector which is mostly met by imported liquid fuel. Bangladesh has only one refinery plant named Eastern Refinery Limited (ERL), a subsidiary company of Bangladesh Petroleum Corporation (BPC) and the storage capacity of that plan is 27.45 million barrels. Imported crude oil is refined at that refinery in Chittagong to produce secondary fuels such as liquid propane gas, naphtha, gasoline, furnace oil, bitumen and other oil products. At present total refinery capacity is 43 thousand barrels per day [5]. The crude oil consumption in Bangladesh in yearly basis is shown Table 3 in where the consumption in 2016 is estimated 131 thousand barrel per day with an annual growth rate 5.65%. This rate would be higher in future which is forecasted by JICA survey team as shown in Figure 7.

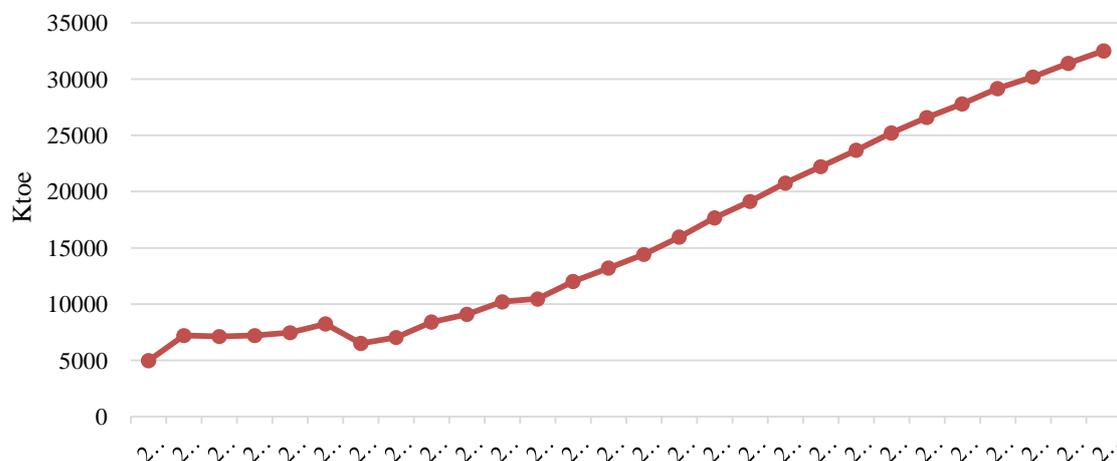


Figure 7. Forecasting of oil demand (JICA survey team) [1]

Table 3. Crude oil consumption in Bangladesh [5]

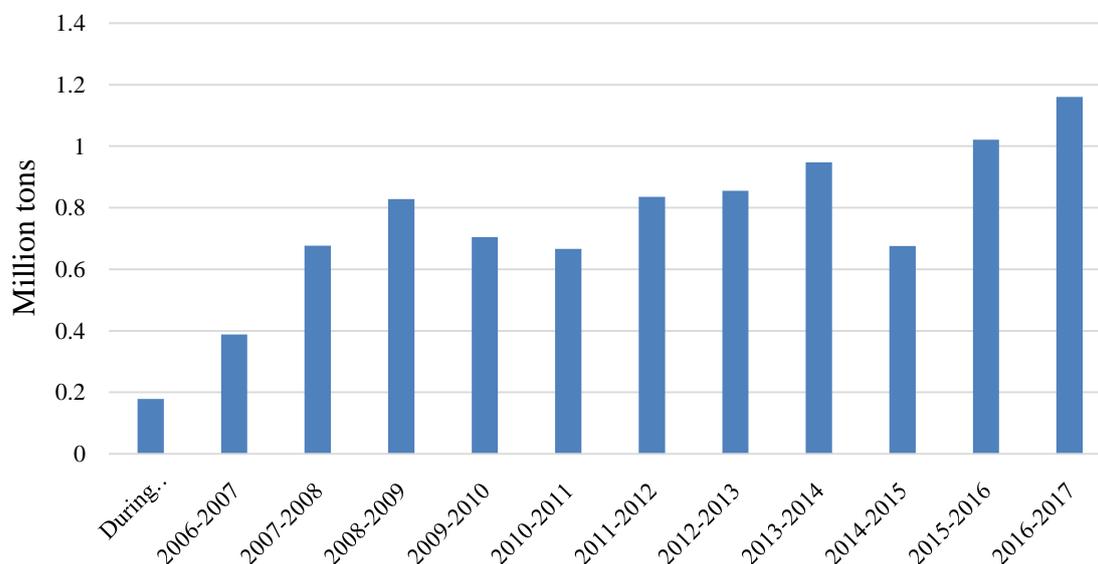
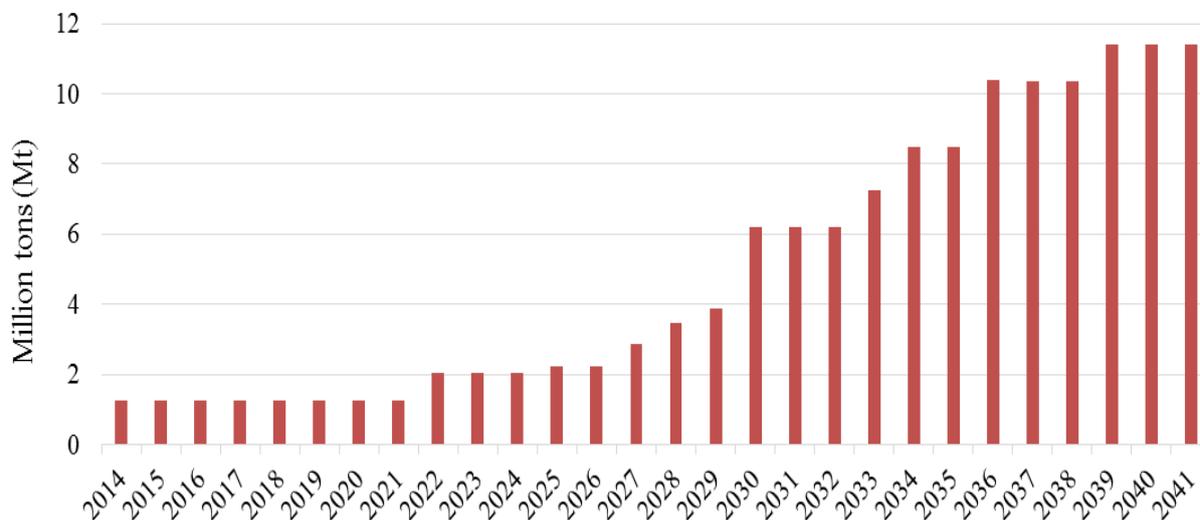
Year	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Thousand barrels per day	81	76	77	72	80	104	110	107	116	124	131
Growth rate per annum (%)	-----	-6.17	1.32	-6.49	11.11	30	5.77	-2.73	8.41	6.90	5.65

Source: BP Statistical Review of World Energy 2017.

Table 4. Coal Reserves in Bangladesh [8]

Coal field (district)	Depths of coal seam (in meter)	Estimated Reserve (million ton)	Coal Compositions (%)				Calorific value	Status
			FC	VM	Ash	S		
Jamalganj (Joypurhat)	640-1158	1053	47	38	22	0.62	11000	Mining not feasible economically
Barapukuria (Dinajpur)	118-506	303	45.5 -54.7	2.28 -3.60	11.79- 23.71	0.43 -1.33	10547-12529	Underground mine started production
Khalashpir (Rangpur)	257-451	147	32.0 -80.8	32.0-80.8	2.93-30.47	7.6-50.51	0.24-3.15	Undeveloped
Dighipara (Dinajpur)	250	200	51.3 -65.6	25.3-38.23	2.64-20.05	0.51-1.02	10200-1477	Undeveloped
Phulbari (Dinajpur)	152-246	572	-----	-----	-----	-----	-----	Open pit mine feasibility study undertaken in 2004

Source: Bangladesh Oil, Gas and Mineral Corporation (PteroBangla); 2017.

**Figure 8. Yearly coal production in Bangladesh [13]****Figure 9. Forecast of Domestic coal production (JICA survey team) [1]**

3.3. Coal

As an available fossil fuels, coal still has a dominating role in world primary energy consumption with a share of 28.11%. Countries like CHINA, INDIA, USA, RUSSIA, SOUTH AFRICA, JERMANEY etc. are the main consumers of coal. On the other hand coal in Bangladesh contributes only 4% to the energy mix in 2016 [5]. The total production of coal has accumulated 1.16 million tons during FY 2016-2017 with a growth rate of 13.6% which is shown Figure 8 and the whole production comes from the mines of Barapukuria in Dinajpur [Petrobangla]. Till now five major fields in Bangladesh have been discovered which are located between two big rivers Padma and Jamuna at the north western portion of the country. The total estimated coal reserves are 2083 million tons with fixed carbon content ranging from 32% to 81% as shown in Table 4 [Petrobangla & Banglapedia]. Commercial coal production at Barapukuria Coal Mine started in April 2003 with the expectation to produce 1 million short tons of coal per year. Current production rate is about 1500 tons per day (Banglapedia). The plan to establish an open pit mine in nearby Phulbari was aborted due to the wake of mass protest by the local people. Coal mine in Khalashpir and Dighipara are under at development process. Coal in the Jamalganj area is too deep to mine. The facts that make coal mining difficult in Bangladesh is the greater depths of coal seams and more importantly because of the occurrence of a 100-200 meter thick loose water bearing sandy layer covering the coal deposits. Extraction of coal bed methane from this field is under consideration (Banglapedia). Total peat reserves in Bangladesh are estimated at about 600 million tons (UNDP). In some rural areas, locally extracted peat is used for domestic cooking and in small industries. With the depletion of natural gas, coal has significant importance for the future generation capacity addition plans of Bangladesh. The government has given priority on coal assuming a much expanded role in providing the country's future energy needs. Therefore, it is necessary to carry out required preparation to meet the upcoming energy needs. Fortunately after one decade the production of Barapukuria coal mines in 2016 was more than 1.0 million tons and crossed the value that was expected in 2003, but it is assumed that the total production will be 1.1 million by 2020, 5.7 million by 2030 and 11.2 million tons by 2041 as shown in Figure 9, considering that Khalashpir and Dighipara coal field have high development possibility with Phulbari coalfield. The recoverable reserves of remaining four coalfields could range from 250 million to 900 million tons, depending on the mining methods applied (IAEA Bangladesh). However a major portion of coal production is used for power generation at Barapukuria coal power plant with a generation capacity of 250 MW. It consumes 80% of total coal production leaving only 20% for other purposes such as railway transportation, fuel for cooking, various industrial uses for producing heat and raising steam, for brick fields to produce heat and for carbonization to produce coke, tar, and so on. According to Power Sector Master Plan (PSMP2016), around 16.5 gigawatt (GW) of imported coal based power plants are being planned and are

currently under various stages of development in Bangladesh. Bangladesh's being adjacent to sea on one side is in strategically advantageous position in terms of coal imports. Australia, Indonesia, and South Africa are considered as preferable location for sourcing of imported coal [11].

4. Renewable Energy

Due to depletion of fossil fuel reserves most countries have given importance on the use of renewable energy sources. Renewable energy offers a degree of advantage over the fossil fuel as they are regenerative, hardly have any effect on the environment and can be produced at a large amount with the help of proper technology. Although the contribution of renewable energy is still negligible in global energy picture, it has a growth rate of 3.26% in 2016 [5]. Apart from fossil fuels Bangladesh has a great possibility in harvesting energy from different sources. The widely known renewable energies like solar, wind, biomass, and micro/mini hydro power have potential in Bangladesh [11]. Bangladesh Power Development Board (BPDB) has taken systematic steps for developing Renewable Energy projects as well as implement and promote Energy Efficiency Measures for the last few years to achieve the target of the Renewable Energy Policy [11].

4.1. Hydropower

Hydropower generation is an eco-friendly clean power generation method. In Bangladesh, the scope of hydropower generation is actually very limited as most of the country has plain terrains except some hilly region in the northeast and southeast parts of the country. At present only 230MW of hydropower is utilized in Karnafuli hydro station through 5 units of Kaplan turbine, which the only hydroelectric power plant operated by BPDB [11]. Besides two ongoing projects on hydropower are conducted in Chittagong and Rangamati district.

4.2. Solar

The geographic location of Bangladesh is in between 20.30° N and 26.38° N latitude and 88.04° E and 92.44° E longitude. This is an ideal location having a total area of 1.49×10^{11} m² for solar energy generation [15]. Renewable Energy Research Centre (RERC) at Dhaka University, Bangladesh Meteorological Department and the Department of Mechanical Engineering, Bangladesh University of Engineering and Technology have got time series data of solar insolation of Dhaka and other major cities [16]. Based on these data, the average solar radiation is measured about 5 kWh/m that descend over the land for approximately 300 days per annum. Maximum solar radiation occurs during the months March to April and the minimum radiation occurs during the months December to January [16].

Under the Hill Tracts Electrification Project BPDB has already implemented three solar projects in Juraichori Upazilla, Barkal Upazilla and Thanchi Upazilla of Rangamati District. Under 1st, 2nd and 3rd Phases, 1200

sets Solar Home Systems of 120 W each, 30 sets Solar PV Street Light Systems of 75 W each, 3 sets Solar PV Submersible Water Pumps of 1800 W each, 6 sets Solar PV Vaccine Refrigerators for the Health Care Centers of 360 W each and 2 sets 10 kW capacity Centralized Solar System for market electrification has been installed [18]. So, a total of 173.81 kW Solar PV Systems have been installed in Juraichori, Barkal and Thanchi upazilla of Rangamati District under the Hill Tracts Electrification Project. In the fiscal year 2008-09, BPDB implemented another two solar electrification projects in Angoorpota and Dohogram Chit Mohol. Under this program, BPDB implemented 2 sets Solar Home System of 50W each, 2 sets Solar Home System of 80W each and 8 sets Solar Home System of 100W each. A total of 206.3 kW Solar PV Systems have been installed throughout the country from 2009 to 2013. At same time some ongoing and upcoming projects are conducted by BPDB which are shown in Table 5. Up to May 2017, about 4.12 million SHSs have been installed by IDCOL under the program in the remote areas where electrification through grid expansion is challenging and costly. Besides they have

taken numerous solar mini grid projects and solar irrigation program to provide grid quality electricity in rural households as well as to provide irrigation facilities in off grid areas [28]. Although solar has small share in present energy mix, Bangladesh host the fastest growing Solar Home System program in the world with about 5 million SHS at a rate of about 50,000 SHS unit installations per month in the recent past [35].

4.3. Wind

The wind is an important source of renewable energy. From global wind report of Global Wind Energy Council (GWEC), it was found that more than 54 GW of clean renewable wind power was installed across the global market in 2016, which now comprises more than 90 countries, including 9 with more than 10,000 MW installed, and 29 which have now passed the 1,000 MW mark. Cumulative capacity grew by 12.6% to reach a total of 486.8 GW [33]. Wind power generating capacity grew by 12% in 2016, with capacity increasing by 50 GW to reach 469 GW by the end of 2016 [34].

Table 5. Some ongoing and upcoming projects on renewable energy in Bangladesh

Item	Ongoing Project	Project Under Planning
Solar	<ul style="list-style-type: none"> 650 KW (400 KW load) Solar Mini Grid Power Plant at remote Haor area of Sullah upazila in Sunamgonj district under Climate Change Trust Fund (CCTF) on turnkey basis. 8 MW Grid Connected Solar PV Power Plant at Kaptai Hydro Power Station, at Rangamati on turnkey basis. 3 MW Grid Connected Solar PV Power Plant at Sharishabari, Jamalpur on IPP basis. 30 MW Solar Park Project adjacent to new Dhorola Bridge, Kurigram on IPP basis. Solar Street Lighting Projects in seven (7) City Corporations of the country. 	<ul style="list-style-type: none"> BPDB has planned to install Grid Connected Solar PV Power Plant on IPP basis such as- <ul style="list-style-type: none"> 1 MW Grid Connected Solar Power Plant at Regional Training Centre (RTC), Rajshahi. 500 KW Grid Tied Solar System at 33/11 KV substation's compound of former Hajigonj Electric Supply, Chandpur. BPDB has planned to install Solar Mini Grid Power Plant on turnkey basis under Climate Change Trust Fund (CCTF) at remote and inaccessible areas such as- <ul style="list-style-type: none"> 500 KW Solar Mini Grid Power Plant at Swandip Upazila of Chittagong district. 500 KW Solar Mini Grid Power Plant at Thanchi Upazila of Bandarban district. BPDB has planned to implement Solar Park Projects on IPP/PPP basis under the Roadmap of ADB's 500 MW Solar Power Mission such as- <ul style="list-style-type: none"> Rangunia 60 MW Solar Park Project on IPP basis at Karnafuli river side, Rangunia, Chittagong 40-45 MW Solar Park Project adjacent to Bangabandhu Bridge, Tangail and Sirajgonj area. 2-3 MW Solar Park Project adjacent to PGCB Grid Sub-station compound, Ishwardi. 1-2 MW Solar Park Project adjacent to PGCB Grid Sub-station compound, Jhenaidaha.
Wind	<ul style="list-style-type: none"> Repairing work of the existing 900 KW grid connected Wind Power Project at Muhuri Dam of Sonagazi in Feni is going on. Repair and operation & maintenance of the existing Kutubdia 1000 KW Wind Battery Hybrid Power Project is underway Steps have been taken to install 15 MW Wind Power Plant across the coastal regions of Bangladesh 	<ul style="list-style-type: none"> BPDB has planned to implement 50-200 MW Wind Power Project at Parky Beach area, Anawara in Chittagong on IPP basis. Power Division and BPDB have primarily identified 22 potential sites for Wind Resource Mapping in Bangladesh. Wind monitoring stations will be installed at these sites for comprehensive Wind Resource Assessment (WRA). BPDB has also plan to expand On-shore Wind Power Plants along the coastline of coastal regions of Bangladesh.
Hydro	<ul style="list-style-type: none"> 50-70 KW Mohamaya Irrigation-cum-Hydro Power Project at Mirrorsorai, Chittagong. Rehabilitation of 50 KW Micro-Hydro Power Plant at Barkal Upazila of Rangamati district. 	<ul style="list-style-type: none"> Micro-hydro power projects on the potential streams/charas/rivers of CHT regions will be implemented after detail Feasibility Study.
Hybrid	<ul style="list-style-type: none"> 7.5 MW off Grid Wind-Solar Hybrid System with HFO/Diesel Based Engine Driven Generator in Hatiya Island, Noakhali. 	<ul style="list-style-type: none"> BPDB has planned to install 1 MW off grid solar- diesel based hybrid power plant in kutubdia island.

Source: Bangladesh Power Development Board (BPDB).

As Bangladesh is situated in the tropical region, the potential of wind energy is limited to coastal areas, off-shore islands, rivers sides and other inland open areas with strong wind regime [18]. An analysis was performed by CWET India which showed that wind energy resource of Bangladesh is not good enough for grid connected wind parks [19]. However, the average wind speed in July is measured above 5.1 m/s in the coastal region of the country [20]. The research in the field of wind energy in Bangladesh has not expanded well yet. Previous research shows that some places in the southern region of the country have the potential for harnessing wind energy [21]. Based on these studies, it can be said that small wind turbines can be put to use in the coastal and offshore islands to harness wind energy [22]. In order to generate electricity from Wind Energy, BPDB installed 4x225 KW = 900 KW capacity grid connected Wind Plant at Muhuri Dam area of Sonagazi in Feni. Another project of 1000 KW Wind Battery Hybrid Power Plant at Kutubdia Island was completed in 2008 which consists of 50 Wind Turbines of 20 KW capacity each.

4.4. Biomass

Bioenergy is energy from organic matter (biomass), i.e. all materials of biological origin that are not embedded in geological formations (fossilised). Biomass can be used in its original form as fuel, or be refined to different kinds of solid, gaseous or liquid biofuels [30]. The major use of biomass is in the form of heat in rural and developing countries. About 90% of all the bioenergy consumption is in the traditional use [30]. Globally the number of people that depends on traditional biomass as the major source of heating and cooking fuel is expected to rise from estimated 2.4 billion in 2002 to 2.6 billion in 2030 which shows an increment of 8 % [32]. In 2009, about 13 percent of biomass use was consumed for heat and power generation, while the industrial sector consumed 15 percent and transportation 4 percent. The global consumption of biofuels in transportation equaled 2 percent of the transport sector total [31].

In Bangladesh, the most promising renewable energy is biomass. Most of the households, especially the rural households in Bangladesh use biomass fuels [23]. However, there is a limitation of supply from biomass sources. The main reason is the scarcity of land. The main positive side of biomass energy is that it does not emit many harmful gasses compared to other conventional energy sources. It basically emits two gasses carbon dioxide and ethanol. The carbon dioxide which is emitted by the biomass energy is captured back for its own use whereas all the fossil fuels release it in the environment which is responsible for greenhouse effects and climate change [29]. Biomass is a universal form of renewable energy. The main reason is, different types of organic matter can produce various products [24]. Bio-gas consists of 40-70% methane, 30-60% carbon dioxide and 1-5% other gases [25]. The components of a biogas based electricity generation system are a generator, a biogas collection tank and a digester. There are also some piping and controls that are required for the operation of a biogas based electricity generation system. The biogas is produced in the anaerobic digester because of anaerobic

fermentation which is provided every day with livestock manure in the form of cattle dung [25]. Recently Government Non-government and private sectors have taken numerous projects to promote biogas plant. Infrastructure Development Company Limited (IDCOL) had a target of setting up 37,669 biogas plant within 2012 and also planned to set 25% of total biogas plant to be placed in the northern region which is yet to be brought under the national gas grid [26]. IDCOL has a plan to install 60,000 biogas plants in Bangladesh by 2018 and it has already financed construction of over 46,200 biogas plants all over the country through its 45 partner organizations [28]. A non-governmental organization named Grameen Shakti is working to promote biogas plant. They have completed 13,500 biogas plants throughout the country. Another non-governmental organization named Seed Bangla Foundation proposed to build a biogas power plant in Rajshahi of 25 kW capacity [25]. Some organizations are also working independently to promote biogas plants with their own funds. Such as Grameen Shakti has built 3664 biogas plants, BRAC built 3664 plants of their own [27]. A total of 18713 biogas plants have been set up by IDCOL and other organizations since May 2011 [25].

5. Conclusions

A details scenario of Bangladesh's primary energy has been presented using data and illustrations from different authentic sources. The fossil fuels use was started in the early nineteenth century [6] and are still being continued for developing different sectors of the country. Though statistics shows that there will be a significant increase of fossil fuel reserve in near future, due to high demand of energy consumptions it will be depleted soon. As a large portion of primary energy consumption is still met by the fossil fuels like coal, natural gas and oil, the rural population of Bangladesh is strongly dependent upon traditional renewable sources. There is a considerable opportunity for Bangladesh to meet its future power demand, ensure sustainable development and economic growth through renewable resources. The results show that solar and biomass based installations have significant potential in terms of feasibility and resource availability. Government, non-government agencies and the public should take a more proactive step to promote and use renewable energy in order to achieve the secure and environmentally sustainable energy resources. The Renewable Energy Programs taken by BPDB, IDCOL and Grameen Shakti have become highly appreciable among national and international policy makers. The other private organizations should come forward and join hands with government to solve the future crisis situation.

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