

The Importance of Nuclear Energy Utilization for Electricity Generation in Bangladesh

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Abstract: This paper presents current energy scenario in Bangladesh and indicates importance of nuclear energy in electricity generation in this country. Bangladesh is one of the densely populated countries in the world, over 160 million. Per capita electricity consumption is 212 kWh. Against the peak demand of 7500 MW, the average power shortage is recently 1500 MW. By 2015, demand will grow by 69.52%, 185% by 2020, and 315% by the year 2025. Natural gas accounts for 88% of the total electricity generation. Estimated reserve of 11.52 trillion cubic feet will deplete by 2020. Coal and hydropower share only 6% in present power production. Bangladesh is a net importer of petroleum products. In 2010, cost of imported petroleum products was US\$ 4.29-5 billion. Mono fuel dependency on natural gas is increasing at an alarming pace. Fuel diversification has become an essential policy issue for long term power sector development. Nuclear energy could be a viable alternative energy source to meet future energy demand. Planning for nuclear power plant started since 1961. By 2020, nuclear energy will share 10% of the total power generation.

Keywords: Nuclear, Bangladesh, Sustainability, Electricity, Renewable energy

I. INTRODUCTION

Sustainable economic development comes with the efficient and effective utilization of energy. Growth of gross domestic product (GDP) and per capita energy consumption have a positive correlation towards achieving such development [1]. Power production, especially, electricity, is now being considered as a major constraint to achieve greater economic growth, for a developing country like Bangladesh. It is the lowest energy consuming nation with per capita energy consumption 227 kilogram oil equivalent (KgOE) [2], and per capita electricity consumption of 212 kWh [3]. Expected power demand will rise up to 185% by the year 2020 [4]. For overall socio-economic development, constant power supply is the pre-requisite. Entrepreneurship and development researches showed small and medium enterprises, and other industrial sectors passing their promising time without adequate electricity supply. Years of mismanagement and poor infrastructural development left the power sector under-developed.

At present, power generation in the country has an average shortage of 1500 megawatt (MW)[5]. Natural gas as a primary energy source accounts for 88% of the electricity generation that reflects mono fuel dependency in Bangladesh [1]. Coal is another natural resource responsible for electricity generation which is relatively under-developed. Thus, installed and generation capacity of coal fired power plant is very limited, around 3.53% of the total installed electricity generation capacity. The only large scale hydropower station has a present generation capacity of 218 MW [2]. Figure 1 shows the contribution of different energy sources for power production in Bangladesh.

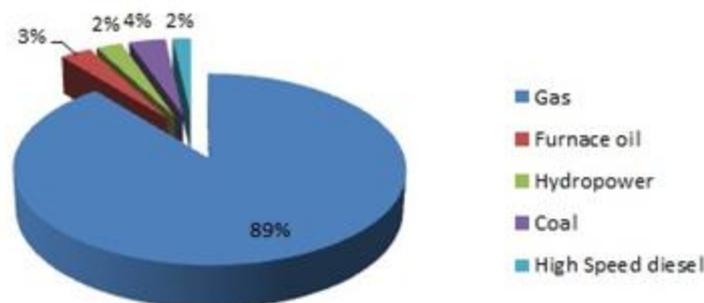


Fig 1. Power generation in Bangladesh (by fuel type)

Electricity generation system in Bangladesh is mono fuel based which has negative impact on national energy security. In order to tackle present and future energy demand, fuel diversification has become an essential part of the energy policy. Renewable energy sources, such as solar, wind, biomass and small scale hydro power found promising alternatives. However, large scale investment and technology disseminations are yet to be implemented to get end positive result. According to Ministry of power energy and mineral resources (MPEMR), Bangladesh; renewable energy is now contributing only 0.5% of the total electricity generation [6]. In 2009, total electricity generation was 38 billion kWh coming from 6.1 gigawatt (GW) installed capacity of power plants. Government tends to prepare 7 GW installed capacity by 2014, taking into account, peak demand of electricity 7.5 GW that occurred in 2009. However, only 30% of the population have direct electricity connection and 76% of the population residing in the rural areas are deprived from electricity supply [7].

Natural gas is the predominant energy source for power generation, and currently there is no other alternative energy found constructive. Electricity generation from diesel and furnace oil raised the tariff rate higher, posing an economic burden for the country. In this regard, nuclear energy could be a promising solution to long standing power production. Global nuclear energy share is currently 17%, and by 2030, it will be 19% [8]. At present, 31 countries have 439 commercial power reactors with total installed capacity of 360,000 MW. More 30 reactors are under construction, and 35 are under firm planned [9]. France and Belgium are the two countries that depend entirely on nuclear power for electricity generation.

With current GDP growth, energy demand in Bangladesh will increase by 33% according to the recent estimation [10]. Moreover, the projected power generation in the country will be 20,000 MW against the demand of 18,838 MW. However, it is expected that 2000 MW power will come from nuclear power by the year 2020. According to power system master plan (PSMP) 2010, total 4000 MW power production is envisioned from the nuclear by 2030. Power demand met by nuclear energy would be the next generation endeavour for Bangladesh. Successful nuclear power plant project will generate an enhanced level of employment, developed livelihood standard and overall socio-economic development. The objective of this paper is to show nuclear energy as a sustainable solution to meet up the electric power generation need partially in Bangladesh. This study illustrates prospect of nuclear energy for electricity generation in Bangladesh within the scenario of present electricity generation and future energy security.

II. CURRENT ENERGY SCENARIO AND ELECTRICITY GENERATION IN BANGLADESH

Global consumption of fossil fuels (i.e. natural gas, coal, oil) is increasing at a significant momentum. From year 2000 to 2012, global primary energy consumption has been increased by 31.20%. Bangladesh is a developing country in the South-East Asia with a population over 160 million. The total land size of the country is 147,570 km². Due to rapid urbanization and industrial growth, energy demand has increased dramatically. Total primary energy consumption was 12.7 million tonnes of oil equivalent (Mtoe) in 2000 and reached 24.3 Mtoe in 2011 [11]. Table I shows the present energy scenario of the country, as of 2011.

TABLE I
PRESENT ENERGY SCENARIO IN BANGLADESH

| Sector | Status |
|----------------------------------|---|
| Electricity growth | 10% in fiscal year (FY) 2010 (average 7% since 1990) |
| Total consumer | 12 Million |
| Per capita generation | 236 kWh |
| Present generation capacity | 5936 MW |
| Present demand | 6000 MW |
| Present available generation | 4000 - 4600 MW |
| Maximum load shedding in FY 2010 | 1500 MW (Hot Summer) |
| Future demand FY 2015 | 15000 MW |
| Future demand crisis FY 2015 | 11500 MW |

Present demand for natural gas by all sectors, is 1061.5 billion cubic feet (BCF), and will reach 1306 BCF by 2015. According to Ministry of Finance (MoF), power sector is the top consumer of natural gas [12]. Present probable natural gas reserve is around 15.32 trillion cubic feet (TCF). However, estimated gas reserve will diminish by 2020 [13]. In year 2011, 151 BCF was supplied to several power plants in the country. Figure 2 shows energy production, energy use and per capita electricity consumption in Bangladesh. In this figure, it is

found that from 1996 to 2011, natural gas consumption increased by 41% [12]. According to world development indicators (WDI) by World Bank, per capita energy and electricity consumption have been increased by 73% and 473%, respectively from year 1990 to 2010 [14]. Transportation sector also depends on natural gas in the country since 1998. Present demand for natural gas in the form of compressed natural gas (CNG) at the refuelling stations in the country is 38.54 BCF, and expected to reach 120.9 BCF by the year 2015 [12]. In the upcoming years, number of CNG driven vehicles is supposed to increase due to cost effective price and performance.

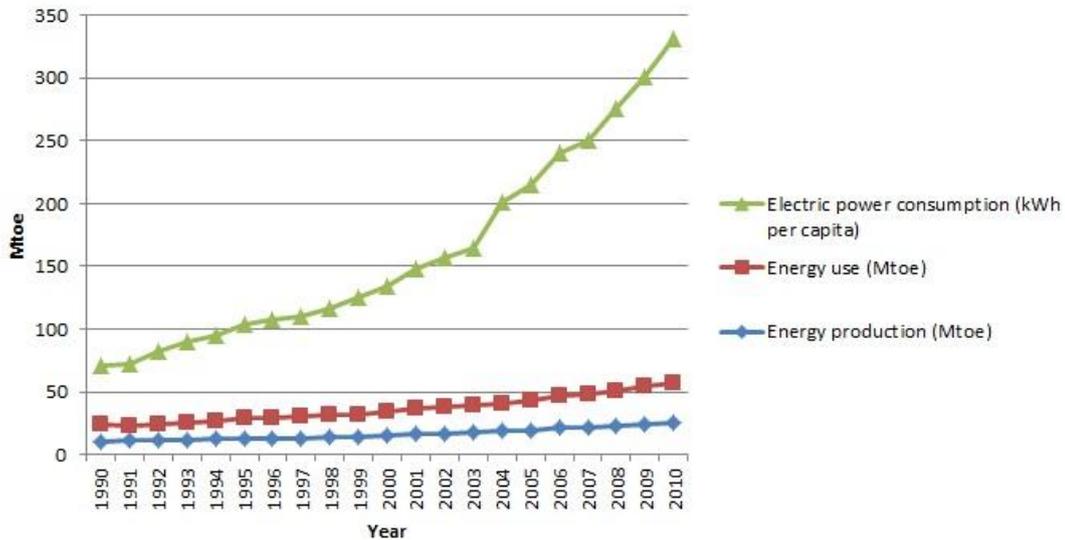


Fig 2. Energy production, energy use and per capita electricity consumption in Bangladesh[14]

Lately, immediate power shortage was minimized by introducing rental and quick rental power plants. The plants have been established with imported diesel and furnace oil and that gave rise to per unit price of electricity. Bangladesh is a net importer of petroleum products. In 2010, Bangladesh imported oil of US\$ 4.29-5 billion, and in 2011, US\$ 0.56 billion was subsidized for imported petroleum products which are mainly for rental and quick rental power plants [1]. Per unit price of the electricity (kWh) has been increased from Bangladesh taka (BDT) 2.62 to BDT 4.15 [15]. Increased electricity prices will have a long term effect on socio-economic pattern. Public money should be spent according to appropriate tariff plan and considering purchasing power parity in the context of Bangladesh.

Coal is relatively economic for power generation. There are total 6 coal deposits so far discovered but due to under-developed policy planning this sector is relatively marginalized compared to natural gas. Current coal reserve is 2.7 billion tons; however, extraction and utilization process in the sector is not efficient for power generation. Barapukuria coal mine is the largest coal deposit in the country with an annual production target of 1 million tons. At present, 2500-3000 metric tons/day of coal is being extracted. Thermal power plant of generation capacity of 250 MW at Barapukuria consumes 65% of the coal. Total power generation capacity from coal was 800 MW in 2012 based on domestic coal, and by 2020 generation will be 1900 MW and 3800 MW in 2025. Imported coal from India will also contribute to the cumulative power generation capacity of 2100 MW by the year 2025. On the other hand, adverse use of coal might trigger CO₂ emission level and would have negative impact on the environment and surrounding eco-system. Uncontrolled CO₂ emission level causes climate change phenomenon too [16].

Bangladesh has only one large scale hydroelectric power plant at river Karnaphuli in Chittagong district with a generation capacity of 218 MW. Last November 2012, the hydro power plant has generated 3.63% of the total electricity generation of the country. Power generation growth at present is around 316 MW per year. However, demand is expected to reach 10,283 MW by 2015, and 25,199 MW by 2025 [17]. Table II shows power generation capacity by different energy sources.

TABLE II
INSTALLED AND GENERATION CAPACITY OF POWER PLANTS IN BANGLADESH (BY FUEL TYPE) [3]

| Energy sources | Installed capacity | | Power generation | |
|----------------|--------------------|-------|------------------|-------|
| | MW | % | GWh | % |
| Hydro | 230 | 3.46 | 872 | 2.96 |
| Natural gas | 4863 | 73.25 | 23879 | 80.99 |
| Furnace oil | 671 | 10.11 | 1780 | 6.04 |
| Diesel | 655 | 9.87 | 2174 | 7.37 |
| Coal | 220 | 3.31 | 780 | 2.64 |
| Total | 6639 | 100 | 29485 | 100 |

In 2012, total 35,118 million kilowatt hour (mkWh) electricity has been generated from the energy sources. The electricity generation has been increased by 447% from year 1990 to 2010, where consumption increased by 707%. Figure 3 shows the net electricity production from various energy sources currently significant in Bangladesh, and net consumption. Mono fuel dependency on natural gas and under-developed policy for coal has triggered the continual depletion of energy sources in the country. Bangladesh government has envisioned providing seamless electricity supply to all its citizens by the year 2021. Power generation will be increased up to 15,000 MW by the year 2016, under medium and long term energy planning. According to PSMP 2010, power demand will be 20,000 MW by 2020 and 34,000 MW in 2030. At present, the total generation capacity is 8100 MW. To achieve such rigorous target, nuclear energy is considered as viable option as alternative energy source concerning future energy demand in the country for electricity generation. It is expected that starting from 2020, nuclear power will contribute 10% of the total electricity generation.

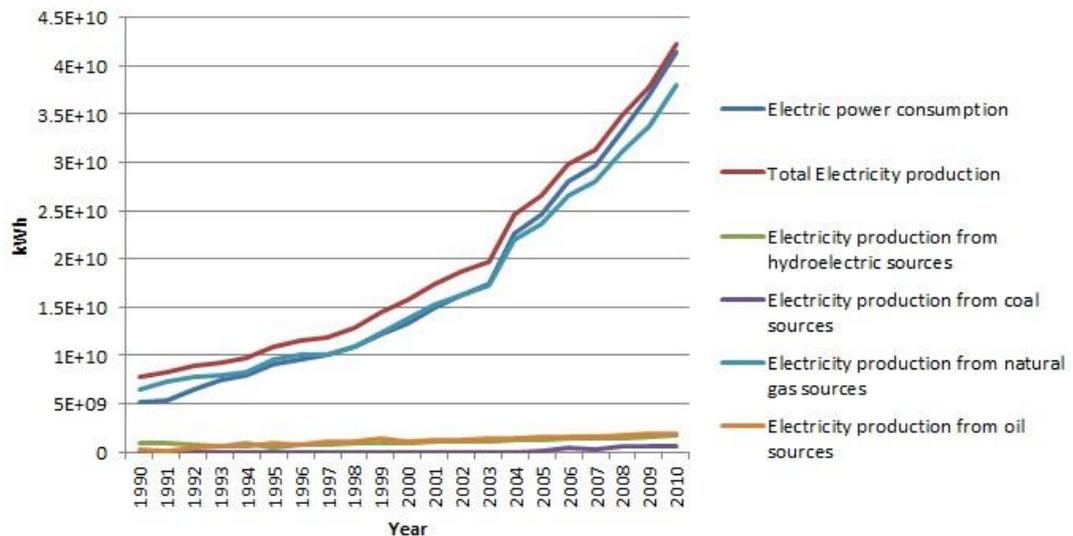


Fig 3. Electricity production and consumption in Bangladesh [14]

III. NUCLEAR ENERGY IN THE WORLD

Nuclear energy accounts for 17% of world's power generation. Total energy demand in the world has been increased almost 3 times, from 1970 to 2010 [11]. Since 1954, commercial electricity supply from nuclear power has been operationalized. The share of nuclear energy for electricity generation has been increased over 7% from 1990. At present, nuclear power plants have been established in 32 countries with total installed capacity of 375 GW from 439 commercial reactors [9]. More 30 reactors are under construction, and 35 are under concrete plan targeting with a total generation capacity of 58.6 GW. In 2009, 2558 billion kWh of electricity has been produced from nuclear power. The United States is also producing significant amount of electricity from nuclear power about 805 TWh that accounts for 20% of the electricity production [18].

IV. HISTORICAL DEVELOPMENT AND IMPORTANCE OF NUCLEAR POWER IN BANGLADESH

Electricity generation from nuclear energy has been planned in Bangladesh since 1961, before the independence of the country, and until 2009, there were no significant achievements. As per PSMP 2010 concern, by the year 2020, two nuclear power plants at Rooppur will generate 2000 MW which will supply 11.55% of the total power demand. By 2030, power demand will grow up to 33,708 MW and nuclear energy share 4,000 MW. The initial cost of establishment will be financed by the Russian government for 2000 MW project.

The site works of the nuclear power plant are due to build starting from January 2014, and the first plant is expected to start its construction from 2015. Power generation will start soon after 2020. At present, Bangladesh has a 3 MW TRIGA research reactor for training and collection of medical isotopes. Table 3 shows key activities of the nuclear power plant project in Bangladesh [19].

TABLE III
KEY ACTIVITIES FOR NUCLEAR POWER PLANT IN BANGLADESH [19].

| Year | Activities |
|------|---|
| 1961 | The first nuclear power plant was proposed. |
| 1963 | The site was selected at Rooppur, Pabna district; 200 km north of Dhaka. |
| 1980 | After the independence of Bangladesh, a 125 MW nuclear power plant was proposed. |
| 1999 | The government expressed its firm commitment to construct the Rooppur nuclear power plant |
| 2001 | The national power action plan was adopted |
| 2005 | Intergovernmental agreement with China for nuclear power plant was signed. |
| 2007 | Bangladesh atomic energy commission (BAEC) proposed for 1000 MW (2 X 500 MW) nuclear power plant at Rooppur, starting its operation by 2015. |
| 2008 | <ul style="list-style-type: none">• In April, the government of Bangladesh expressed its refined intention to build a nuclear power plant with the help of China, and China offered funding for the project.• In March, Russia made a formal proposal for building a nuclear power plant in Bangladesh. |
| 2009 | <ul style="list-style-type: none">• In April, Bangladesh approved the Russian proposal. The project will cost US\$ 2 billion. By this time, it appeared that 2 nuclear power plants of 1000 MW are possible for construction.• In May, intergovernmental agreement was signed between Bangladesh and Russia |
| 2010 | <ul style="list-style-type: none">• In May, Bangladesh signed intergovernmental agreement with Russia, in the areas of legal and technical aspect of nuclear power plants.• In February, Russian state nuclear corporation, Rosatom signed agreement to build 2000 MW nuclear power plants with the technical cooperation of BAEC. |
| 2011 | <ul style="list-style-type: none">• In November, an intergovernmental agreement was signed between joint stock companies Atomstroyexport and Nizhny Novgorod Atomenergoproekt, NIAEP.• In May, energy bill was introduced in the parliament. Bangladesh atomic energy regulatory authority was set up. The second phase of the nuclear power plant was proposed to build in the southern part of the country. |
| 2012 | <ul style="list-style-type: none">• In February, regulatory and safety related affairs were agreed between the Ministry of Science and Technology of Bangladesh and Rostechndzor of Russia, with provision of advisory support of the Bangladesh nuclear regulatory commission.• In August, a financial agreement was signed between Bangladesh and Russia. By virtue of this agreement, Bangladesh is allowed to take loan US\$ 500 million with 4.5% interest rate to construct the nuclear power plant. |
| 2013 | In January, US\$ 500 million provisional loan has been approved for site selection, project development and personnel training. Russia is providing 85% of the loan, estimated US\$ 1.5 billion for the first plant (1000 MW) at Rooppur. |

V. DISCUSSION

Bangladesh is a small country with a relatively large population. Rapid industrialization and urbanization has triggered energy consumption by all sectors. Existing demand for energy will raise pressure on natural gas, as it plays a pivotal role in power generation in the country. Mono dependency must be diversified for future energy security. Bangladesh is an agricultural economy, and constant supply of fertilizer is pre-requisite for agricultural growth. The CNG refuelling station is a growing sector that depends on constant natural gas supply. If high priced imported petroleum products could be substituted by CNG, then a large amount foreign currency could be saved.

Indigenous coal has economic value for power generation. However, due to underdeveloped policy and inappropriate technological implementation, coal sector has not seen any major accomplishment, besides, Barapukuria coal mine. Bangladesh government is importing coal from India for power generation which is somewhat unrealistic, where indigenous coal deposits in the country are left underdeveloped.

Bangladesh is also a net importer of petroleum products. However, the recent trend of power generation from diesel and furnace oil is not economically viable though demand shortage is minimized by opportunity cost. Energy deficit compensated by costly and depleting energy sources will hamper long term development.

Lately, 4000 metric tons of thorium deposit found in Sirajganj, at the meeting point of river Brahmaputra-Jumuna, by which, Bangladesh can generate 4,67,760 MW electricity annually, if it is utilized and harnessed properly [20]. Nuclear power, in that context could play a vital role in the power sector development and efficient solution to present power crisis.

VI. CONCLUSION

Bangladesh is a developing country with the lowest per capita energy consumption. To attain future GDP growth around 7%, per capita energy consumption must be 600 kWh. The natural gas dependency must be reduced in order to target long term growth and stability in the power sector. Though it was lately started, nuclear energy is expected to have a positive effect in the socioeconomic development of the country. Moreover, power generation from conventional fossil fuels, emits large quantity of greenhouse gases (GHGs) that is responsible for climate change. Nuclear power plants are considered to have less GHGs emission. Nuclear energy in this 21st century is a matured technology for power generation. Experience from other countries in technology, security, maintenance, and most importantly waste disposal should be managed. Implementing nuclear energy project has become a national call for Bangladesh to meet its challenge for future energy demand as well as ensuring national energy security.

VII. ABBREVIATION

| | |
|-----------------|--|
| BCF | Billion cubic feet |
| BDT | Bangladesh taka |
| BPDB | Bangladesh power development board |
| BP | British petroleum |
| BAEC | Bangladesh atomic energy commission |
| CNG | Compressed natural gas |
| FY | Fiscal year |
| GDP | Gross domestic product |
| GW | Giga watt |
| GWh | Giga watt hour |
| GHGs | Greenhouse gases |
| kgOE | Kilogram oil equivalent |
| kWh | Kilowatt hour |
| km ² | Kilometre square |
| MW | Megawatt |
| MPEMR | Ministry of power energy and mineral resources |
| Mtoe | Million tonnes of oil equivalent |
| MoF | Ministry of finance |
| MkWh | Million kilowatt hour |
| PSMP | Power system master plan |
| TCF | Trillion cubic feet |
| TWh | Tera watt hour |
| US\$ | United States dollar |
| WDI | World development indicator |
| WNN | World nuclear network |

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