BANGLADESH

(UPDATED 2012)

1. GENERAL INFORMATION

1.1. COUNTRY OVERVIEW

1.1.1. GOVERNMENTAL SYSTEM

Bangladesh is governed by a Parliament form of Government. The President is the head of the state while the Prime Minister is the head of the Government. The Prime-Minister is assisted by a council of ministers in discharging his/her duties. For the convenience of administration, the country is divided into six administrative divisions, each placed under a Divisional Commissioner. Each division is further sub-divided into Zilas (Districts). After the administrative re-organization carried out in 1984, the country has been divided into 64 Zilas. Each Zila is headed by a Deputy Commissioner who is assisted by other officials. Each Zila is further divided into a number of Upazilas (Sub-district) headed by Upazila Nirbahi Officer.

The constitution provides a Parliament for Bangladesh (to be known as the House of the nation) in which legislative power of the Republic is vested. It consists of 300 members directly elected by adult franchise. The members of house of the nation elect another 45 female members.

1.1.2. GEOGRAPHY AND CLIMATE

The People's Republic of Bangladesh is located in South-east Asia between latitudes 20°34' and 26°38' north and longitude 88°01' and 92°41' east. The country is bordered by India on the east, west, and north and by the Bay of Bengal on the south. There is also a small strip of frontier with Myanmar. The land is a deltaic plain with a network of numerous rivers and canals. The delta landmass comprises mainly of three mighty rivers the-Ganges, the Brahmaputra and the Meghna, with a network of numerous rivers and canals. The total area of the country is 147.57 thousand sq km in which about 17% is forested. There are a few hilly areas in the southeast and the north east of the country. Except the hilly regions in the northeast, some areas with high lands in the north and northwestern part, the country consists of low, flat and fertile land. The alluvial soil is thus continuously being enriched during the rainy season by heavy silts deposited by rivers. The country has about 2835 km of railroad, 21269 km of paved road and roughly 6000 km of perennial and seasonal waterways as in the year 2010. The limits of territorial water of Bangladesh are 12 nautical miles and the area of the high seas extending to 200 nautical miles measured from the base line constitutes the economic zone of the country.

Bangladesh enjoys generally a sub-tropical monsoon climate while there are six seasons in a year, three namely winter, summer and monsoon are prominent. Winter which is quite pleasant begins in November and ends in February. In winter, there is not much fluctuation in temperature which ranges from minimum of 7°-13°C (45°F- 55°F) to maximum 24°C-31°C (75°F-85°F). The maximum temperature recorded in summer months is 37°C (98°F) although in some places this occasionally rises up to 41°C (105°F or more). Monsoon starts in July and stays up to October. This period accounts for 80% of the total rainfall. The average annual rainfall varies from 1429 to 4338 millimeter. The maximum rainfall is recorded in the coastal areas of Chittagong and northern part of Sylhet district, while the minimum is observed in the western and northern part of the country.

FIG. 1. MAP OF BANGLADESH

1.1.3. POPULATION

As per preliminary report, the population of the country stood at 146 million in the end of 2010. The male population was 73.05 million and female 72.95 million. The intercensal growth rate of population 2011 census was 1.3 per annum. The density of population was 843 per square kilometre in 1999 which increased to 964 per square kilometre in 2011. The sex ratio of the population is 100.3 males to 100 females. There were 32.1 million households in the country distributed over 59,229 mauzas (revenue villages). the total civilian labour force of the country has been estimated at 57.1 million as per preliminary report of labour force survey 2010 of which 40.2 million are male and 16.9 million are

female. In the year of 2010, the literacy rate is 64.67 percent and the life expectancy is about 67.22 years.

TABLE 1. POPULATION INFORMATION

	1990	2000	1st July 2006	1st July 2007	1st July 2008	2010	Average annual growth rate(%) 2000 to 2010
Population (millions)	104	128.9	140.6	142.6	144.5	146	1.5
Population density (inhabitants/km^2)	799.3	990.4	953	966	979	964	-0.03
Urban population (% of total)	19.8	23.2	34.6	35.7	36.7	28.34	2.53
Area(1000 km^2)	147.57						

Source: Statistical Year Book of Bangladesh 2010.

World Development Indicators database, World Bank, Year 2010.

Annual Report 2009-10, BPDB.

1.1.4. ECONOMIC DATA

According to the final estimates of Bangladesh Bureau of Statistics, the country has achieved GDP growth of 5.74 percent in the financial year of 2008-09 amid unprecedented global financial crisis. Bangladesh Bureau of Statistics revised the provisional estimate of GDP growth at 5.83 percent for the fiscal year 2009-10. However, based on updated trend of macroeconomic indicators, the Medium Team Macroeconomic Framework (MTMF) projected 6.0 percent GDP growth for the same period. The MTMF considered positive trend in export earning, increased production of Aman and Boro, growth of agriculture and industrial credit and the growth of imports of capital machinery and industrial raw materials for the production of GDP growth. Moreover, the MTMF envisaged that the growth of GDP for the fiscal year 2010-11 will be 6.7 percent which will gradually increase to 7.2 percent and 7.6 percent in the fiscal year 2011-12 and 2012-13 respectively. As per vision 2021, the government will try to achieve 8 percent growth of GDP in 2013 and 10 percent 2017.

As estimated, the growth rate of broad agriculture sector in the financial year 2009-10 would increase by 0.55 percentage points. Moreover, it was predicted that while other sub-sectors of industrial sector would grow, overall growth in this broad sector would decline due to decreasing growth of manufacturing sector. However, the growth rate of broad service sector will increase slightly.

In the financial year 2009-10, the per capita national income and GDP were US$ 751 and US$ 685 respectively. During the period, the per capita GNI exceeded US$ 750 for the first time in our history. During the financial year 2009-10, the per capita GNI at current price was estimated to be Taka 51,945 which would be 11.7 percent higher than per capita GNI of Taka 46,504 during the financial year 2008-09. Besides, per capita GDP at market price during the financial year 2009-10 was estimated to reach Taka 47,405 as it would increase by 11.21 percent from the per capita GDP of Taka 42,628 during the financial year 2008-09. The GDP pattern of Bangladesh from 1970 to 2010 is shown in Table 2.

TABLE 2: GROSS DOMESTIC PRODUCT

							Average annual growth rate (%)
	1970	1980	1990	2000	2008	2010	2000 to 2010
GDP (millions of current US$)	8 992.7	18 114.7	30 128.8	47 096.8	79554	105560	10.61
GDP (millions of constant 2000 US$)	18 866.3	20 448.9	29 472.4	47 096.8	73900	83734	7.46
GDP per capita (PPP* US$/capita)		323	540	860	1450	1600	8.07
GDP per capita (current US$/capita)	138.5	220.4	289.6	365.3	520	675	7.98

Source: Statistical Year Book of Bangladesh 2010.

World Development Indicators database, World Bank, Year 2010.

World Economic Outlook, IMF

1.2. Energy Information

1.2.1. Estimated available energy

Bangladesh's per capita energy consumption is very low, the lowest within the Indian subcontinent. The 2008 energy consumption value stands at about 250 kgOE which is quite low compared to 550 kgOE for India, 515 kgOE for Pakistan, 430 kgOE for Sri Lanka, 475 kgOE (average) for South Asia and far below the world average of 1680 kgOE. Total primary energy consumption in 2008 was 33.50 MTOE and the energy consumption mix was

estimated as: indigenous biomass 62%, indigenous natural gas 25%, imported oil 12% and imported coal and hydro combined about 1%. Two-thirds of the country's total population livel in rural areas, meeting most of their energy needs (domestic, commercial and industrial) from traditional biomass fuels. Various marketing companies under the Bangladesh Petroleum Corporation (BPC) distribute kerosene and diesel throughout the country at a uniform tariff rate set by the government. Around 32% have access to electricity, while in rural areas the availability of electricity is only 22%.

But the quality of service in rural areas is very poor: frequent outages, voltage fluctuations and unreliable and erratic supply. Only 34% of the households have natural gas connection for cooking purposes. Only about 23% households use kerosene for cooking and the rest (over 90%) depend on biomass. Contribution of biomass in total primary energy consumption of Bangladesh is around 60%. The major sources of traditional biomass are agricultural residues (45%), wood and wood wastes (35%) and animal dung (20%). Industrial and commercial use of biomass accounts for 14% of total energy consumption. 63% of energy required in the industrial sector comes from biomass fuel.

Primarily biomass and kerosene are used by a majority of households. Natural gas, liquefied petroleum gas (LPG), electricity, kerosene and biomass fuels are mainly used for cooking. In areas without natural gas and electricity, biomass is used to meet household cooking needs. A good amount of bio energy is used for parboiling and space heating. A recent urban household survey estimated that consumption of biomass fuel is 319 kg per capita per year. Natural gas is currently the only indigenous non-renewable energy resource of the country and this has been continuously produced and consumed in significant quantities since 1970. Gas, the main source of commercial energy, plays a vital role in the economic growth of Bangladesh. The major consumers of gas are the power and fertiliser (using gas as feedstock) sectors, which account for 46.65% and 21.71% respectively. The cumulative efforts for exploration of oil and gas resources in Bangladesh have resulted in the discovery of 22 gas fields of various sizes. According to the 2008 BP Statistical Energy Survey, Bangladesh had, in 2007, proven natural gas reserves of 0.39 trillion cubic meters (0.21% of the world total) with production for the year totalling 16.27 billion cubic meters (0.55% of the world total). Although the remaining recoverable gas reserve is enough for the time being, it is understood that there is significant field growth potential, as most of the state-owned gas fields have not yet been fully appraised. Therefore, among the various renewable energy options, biomass energy might be the best choice for the electrification of rural Bangladesh.

Natural Gas

Bangladesh gas sector started its journey in the 60s, but its rapid expansion and integration started to accelerate in the early 70s spurred by the rising oil prices. Till now, 23 gas fields have been discovered. The gas initially in place (GIIP) has been estimated as 28.8567 Trillion Cubic Feet (TCF) out of which estimated proven recoverable reserve (P1) is 15.037 TCF.

Up to June 2010 as much as 8.548 TCF gas has been produced, leaving only 6.489 TCF of recoverable gas. Moreover, 23 gas fields have reserves of 5.471 TCF under 'Probable' (P2) and 7.691 TCF under "Possible' (P3) categories. Currently, 17 gas fields are in production and out of 100 wells located in 17 gas fields, 79 are on stream. A total of 562.13 Billion Cubic Feet (BCF) gas was produced in the financial year 2006-2007, 600.86 BCF in the financial year 2007-2008, 653.57 BCF in the financial year 2008-2009 and it reached 703.00 BCF in the financial year 2009-2010. During these years, production growth rate of gas rose from 6.8% to 8.7%. Until a big discovery is made, a plan must be placed for all our future activities on the basis of remaining volume of proven recoverable reserve of gas. However, to replenish the depleted resource and increase it to safe level to meet the future demand, massive exploration & drilling activities have been launched on. It may be noted with great concern that during the preceding 7 years, exploration activities were almost stagnant and other than the large discovery in Bibiyana, no significant discovery was made during this period.

Currently, demand for gas reaches at about 2500 mmcf per day whereas the supply of gas is nearly 2000 mmcf per day. As a result, there is shortage of about 500 mmcf of gas per day. Against this backdrop, Petrobangla has drawn time-bound programs to boost up gas production in the coming days and with this end in view, short-term (up to 2010), mid-term (up to 2013), long-term (up to 2015) projects have been taken up for enhancing gas production to an additional amount 1580 mmcfd within the year 2015 as envisaged in the road map. Meanwhile, a volume of about 284 mmcfd of gas is added to the national grid. It is expected that with the implementation of projects undertaken to alleviate gas deficit, a balance may be attained between demand and supply of gas within the year 2012. Considering the prevailing shortage of gas particularly in the Chittagong region, steps have been taken to add about 500 mmcfd gas through LNG import to ease the situation.

At present gas is being produced from 17 fields and operated by three national and four international companies under PSC & JVA. The cumulative production of natural gas in Bangladesh for last 49 years is 8.4 Tcf. The volume of gas production has been increasing substantially from 2000 and onwards.

Coal

It is well known that the bituminous coal, the so-called "Gondwana coal," of the Paleozoic to the Mesozoic Era occur as well as sub bituminous coal to lignite of the Tertiary Era in Bangladesh. According to the present development data, the coal fields in Bangladeshi are divided into five coal fields, all of which occur in the northwestern area that is sandwiched between the Jamuna River and the Padoma River in northwestern Bangladesh. The measured and probable coal reserves total 3.3 billion tons. According to the Draft Coal Policy (June 2007), the measured coal reserve that can be mined for the time being is estimated to be 1,168 million tons, except in Jamalgonj where coal seams are located relatively deep underground. As developments continue, probable coal reserves are likely to increase.

Coal in Bangladesh is generally characterized as having low ash content and low sulfur content that are in favor of the environment. It is bituminous coal with properties similar to the coal being used by power stations in Japan. Another grade of coal, which is classified into semi-coke (for iron production) whose commodity value is very high in the market, is also available.

Meanwhile, the problem with Bangladesh lies in its mining method. For underground coal mines, the thick coal seams (30 to 40m) pose a problem for the mining method and miming rate. For open-cast coal mines, the mining method which includes dewatering technology to prevent inundation and protect the environment has become an issue, because coal deposits accumulate in the relatively deep underground (170 to 450m) and such a coal mine tends to have an aquifer, called "UDT (Upper Dupi Tila)," over the coal seams. Fig. 4-3 shows a typical conceptual model of the conditions of a coal-bearing formation and the upper aquifer in Bangladesh. In particular, rice fields and houses are scattered on the surface above the coal seams. Thus, to relocate local people without trouble will become important. In particular, the suspension of the Phulbari open-cast coal mine development plan has brought about a significant negative impact.

Table 3 lists details of six coal fields that were explored and the progress in their development. The Barapukuria Coal Mine is the only operating coal mine in Bangladesh and is undergoing completely mechanized underground mining, the details of which will be described later. An open-cast coal mine development in Phulbari came to a deadlock due to the oppositions by the local people, which will give directions to the coal mine development in Bangladesh. In other words, coal mine development in Bangladesh will depend on whether the Government of Bangladesh can successfully win, as a national policy, consent from people for an open-cast mining method, which is superior to underground mining in terms of stable coal production. The comparison between open-cast mining and underground mining in Bangladesh will be described later.

Meanwhile, Bangladesh needs to continue coal exploration to obtain more information on coal fields with better mining conditions. At present, foreign companies, including Indian and South Korean companies, are aggressively engaged in coal development in the country. In particular, since Godwin coal is a kind coke of good quality with limited global availability, it has drawn much attention from concerned parties in many parts of the world.

TABLE 3: CURRENT COAL RESERVE AND EXTRACTABLE QUANTITY

Coal Field Name	Development Year	Exploring company (Number of borings)	Depth (m)	Number of coal seams	Thickness of coal seams (m)	Measured coal reserve (100 million Tons)	Measured plus probable coal reserve (100 million Tons)

Barapukuria (Dinajpur)	1985-87	GSB (31)	118-506	6	51	3.03 (Minable Coal Reserve: 64 million Tons)	3.9
Phulbari (Dinajpur)	1997	BHP (108)	150-240	2	15-70	5.72	5.72
Khalaspir (Rangpur)	1989-90	GSB (14)	257-483	8	42.3	1.43	6.85
Dighipara (Dinajpur)	1994-95	GSB (5)	328-407	5	62	1.5	6.0
Jamalgonji (Bogra)	1962	GSB (10)	640-1158	7	64	10.53	10.53
Kuchma (Bogra)	1959	SOVC	2380-2876	5	51.8	-------	--------

Source: JICA Study team, 2010.

Peat Deposits

Large deposit of peat was discovered in the marshy areas of the north-eastern, middle and south western parts in Bangladesh in 1953 at Baghia and Chanda beel in Madaripur and Gopalgonj. In 1960, further discovery of peat was made in Kola-Barasat area of Khulna. Apart from the above, smaller peat deposits were also found in Moulvibazar, Sunamganj and Brahmanbaria districts totaling reserve of more than 170 million ton peat deposits. Calorific value of peat ranges from 6000 to 7000 BTU/lb. Peat can be used as fuel for domestic purposes, brick manufacturing, boilers etc and as a substitute of coal. However, their exploitation has not yet been started. Details of the peat deposit is given in table 4.

TABLE 4: PEAT DEPOSITS

Deposits	Depth (m)	Thickness (m)	Area (Sq. km)	Reserve (m ton)
Baglachanda	0-4	0.6-3.3	500	150
Kolamouza	0.04-2.5	0.2-4	25	8
Maulvi Bazar	0-1.3	1.6	9.6	3
Chalan Beel	0.6-4.75	3.35-7.65	-	6.2
Charkai	0-0.8	0.13-2.6	11	3
Pagla	-	-	-	13.2

Source: Asia Mining Year Book (Seventh Edition), 2001

RENEWABLES

The economy of Bangladesh depends principally on agriculture. The main crops produced are rice, sugar cane, vegetables, wheat, jute, pulses, coconuts, maize, millet, cotton and groundnuts. Agricultural crops generate large quantities of residues. Such residues represent an important source of energy both for domestic and industrial use. Other sources of biomass are farm-animal wastes and poultry droppings, fire-wood, tree residues and saw dust from the forestry industry. The 138.1 million citizens of Bangladesh produce huge amounts of human waste and municipal solid waste (MSW) annually.

One of the great promises of renewable energy technologies is the potential to provide electricity in areas not served by national power grids. The Renewable Energy Policy of Bangladesh, published in 2008, stated that renewable energy could play a vital role for off-grid electrification in the country. The main renewable energy resources in Bangladesh are biomass, solar, wind and hydropower. The hydropower potential of Bangladesh is limited due to the relatively flat topography of the country. Most of the potential sites for wind power utilisation are situated in the coastal regions. Wind power generation in Bangladesh has certain limitations due to the lack of reliable wind speed data and the remarkable seasonal variation of wind speed. Another potential source is solar energy (utilising solar photovoltaic (PV) systems) but the high capital investment cost of solar PV is a big barrier. Biomass is the major energy source in Bangladesh and biomass utilisation systems represent a proven option for small to medium- scale decentralised electricity generation.

Table 5 shows the status of renewable energy currently developed in Bangladesh, according to "Bangladesh Power Sector Data Book" issued in June 2006 by Power Cell. As the table indicates, development of renewable energy is not progressing very much in Bangladesh. As to solar power generation, local electrification via Solar Home System (SHS) is ongoing; the capacity has reached 12 MW as of June 2008.

TABLE 5: Capacity of Energy Developed (as of June 2006)

Solar	4.0 MW
Wind	2.0 MW
Biomass	1.0 MW
Total Renewable	Around 7.0 MW

Source: Power Cell

The renewable could reach electricity to the rural people and help in poverty reduction. However, it cannot meet the ever growing demand for more power by the industries, service sectors, and the growing urban population economically.

Hydroelectricity

Bangladesh has a hydroelectric plant with 230 MWe generation capacity which is located at Kaptai in the south east region of the country. On average annually 833 GWh electricity is generated from this plant by 5 units. This plant has a potentiality of extending capacity by one hundred MW by utilizing spill water. In addition, the country has two potential sites for constructing two medium size new hydro plants across the rivers Matamuhuri and Sangu at the same region. The feasibility study shows that on average 500 GWh of electrical energy could be produced from the proposed two plants. The terrain of the country being flat, there is no realistic prospect for building additional hydro units.

Micro-hydro, generally between 5-300 kW ranges, converts hydropower primarily to mechanical power. In many cases they do not generate electricity. They are used for grinding cereals in mills and often driven directly from the turbine shaft. LGED's initiative with its Sustainable Rural Energy (SRE) project at Bamerchara micro-hydro power unit located at Banshkhali Upazila of Chittagong District suffered a setback where its installed capacity was 10kW but due to inadequate water head; about 4kW power is being generated. Given these realities, hydropower is not a suitable option for Bangladesh.

Biomass

The total annual generation and recoverable amounts of biomass in Bangladesh are about 165 and 9 MT/year respectively. Agricultural residues represent 48% of the total recoverable biomass followed by 23.9% from animal wastes and poultry droppings. In 2006, the biomass consumption for energy in Bangladesh was about 350 pico-Joules (PJ). At an average annual growth rate of 1.3%, the consumption in 2010 will be about 370 PJ. The total recoverable biomass energy of the country in 2006 was about 1250 PJ from which about 820 PJ of biomass energy was available for electricity generation. On the other hand, the total biomass energy consumption in 2006 was about 473 PJ. Assuming the same average annual growth rate of 1.3%, the biomass consumption in 2010 will be about 286 PJ. Therefore, the amount of biomass energy available in 2006 was 777 PJ, which is equivalent to 216 terawatt-hours (TWh). According to these two estimates and considering that the consumption of biomass for non-energy purposes is negligible, the annual available biomass energy potential for electricity generation in Bangladesh is in the range of 216- 250 TWh.

Data regarding availability of biomass resources in individual districts is needed for planning off-grid decentralised sustainable biomass electricity generation in Bangladesh. In many developing countries, the efficiency of utilisation of biomass in traditional systems is very low. A large amount of biomass can be saved annually in Bangladesh by employing improved (i.e. more efficient) cooking stoves, furnaces, boilers and other devices consuming biomass fuels. Overall efficiencies of the traditional mud cooking stoves used in Bangladesh vary from 5% to 10%. A number of improved stoves have been developed by the Bangladesh Council of Scientific and Industrial Research (BCSIR). These have been classified as:

- improved stoves without chimney which consume 50-55% less fuel than traditional stoves;
- stoves with chimney with fuel savings of 60-65%; and
- stoves with waste heat recovery system.

The Institute for Fuel Research and Development (IFRD) has been engaged in a pilot-scale dissemination of improved model biomass-fired stoves, capable of saving 50-70% of fuel compared with traditional stoves, all over the country. These improved stoves are gradually gaining popularity. Biomass briquettes have the advantages of easy transportation, better handling, cleaner and more efficient combustion and higher volumetric calorific value of the fuel. It also produces a fuel that is suitable for a variety of applications. Briquetting of sawdust and other agro residues has been practiced for many years in several countries. Briquettes can be produced with a density of 12001400 kg/m3 whereas the corresponding value for common wood is 500-700 kg/m3. Accordingly, savings of diesel fuel during the transportation of residues or wood are substantial: a 10 ton truck can transport 34 times more weight of briquette than loose biomass fuel. There are two types of machines used for briquetting the biomass: piston presses (also known as die and punch machines) and screw extruders. The screw extruder technology has proved successful in briquetting rice husk and saw dust in Europe, Japan, Malaysia, Taiwan and Thailand. The machines operating in Bangladesh are of heated-die type and there are currently 906 of these machines in operation.

There are two types of agricultural crop residues: field residues and processing residues. Studies in some neighbouring Asian countries produced useful residue-to-yield ratios for several agricultural crops. Crop residues can be collected, mostly by bailing, either at the same time or after the primary crop has been harvested. Not all field residues are recoverable. The percentage of field residues of a crop to be recycled onto the land depends upon the specific local climatic and soil conditions. No specific data is available concerning the common practices in Bangladesh or the neighbouring Asian countries. However, in developed countries, it has been established that only about 35% of field crop residues can be removed without adverse effects on future yields. Crop processing residues, on the other hand, have a 100% recovery factor. Accordingly, it is estimated that the total annual amount of recoverable agricultural-crop residues in Bangladesh is about 42 MT of which 63% are field residues and 37% are process residues.

Manure from cattle, goats, buffaloes and sheep are the common animal wastes in Bangladesh. The quantity of waste produced per animal per day varies depending on body size, type of feed and level of nutrition. The average amount of droppings (on air dry basis) produced by broilers and layers are 0.02 and 0.03 kg/bird/day respectively. The recovery/collection factors for animal waste and poultry droppings were reported in several studies to be 60% and 50% respectively. Accordingly, it is estimated that the total annual amount of recoverable animal wastes and poultry droppings in Bangladesh is 20.619 MT.

The total quantity of human waste generated in Bangladesh has been estimated as 4.537 MT of dry matter/year (corresponding to 0.09 kg/capita/day). The rate of generation of MSW in the urban areas of Bangladesh is 0.4 kg/capita/day whereas the rate varies between 0.4 to 0.5 in Indian cities. In rural areas of Bangladesh, the generation rate is only 0.15 kg/capita/day. Considering that human waste and MSW are 100% recoverable, the total annual amount of the biomass available from these two sources in Bangladesh is 14.793 MT.

Forests and wood-processing industry: Forest biomass includes tree components such as trunks, branches, foliage and roots. Tree trunks and main branches are the sources of fuel wood. Twigs, leaves, bark and roots are tree residues. Total fuel wood production in Bangladesh in 2003 was 6.932 MT. Both wood processing residues (e.g. sawmill off-cuts and sawdust) and recycled wood (derived from the demolition of buildings, pallets and packing crates) are important sources of energy. The annual availability of such recycled wood, on a sustainable basis, is, however, not known. It has been estimated that only about 20% of a tree, initially harvested for timber, is recoverable for use in furniture and fittings. The remaining 80% is discarded, in equal proportions, as forest residues and process residues (i.e. bark, slabs, sawdust, trimmings and planer shavings). Plywood mills produce about the same amount of residues as sawmills. In 2004, 0.123 MT of sawdust was available for energy purposes. Considering 100% recovery rate, the annual amount of recoverable biomass from forests and forestry industry in Bangladesh is 8.871 MT.

Solar Energy

Located at 20.30°to 26.38°north, Bangladesh receives 4.0 to 6.5 kW/m^2 of average solar

radiation. The solar radiation volume reaches its peak in March and April and its bottom in December and January. Bangladesh is a region suitable for photovoltaic power generation. However, the present cost for photovoltaic power generation is extremely expensive at 30 cents/kWh or higher and is uncompetitive with other power sources in terms of grid connection. The country is blessed with a solar power source, but the cost of power generation is basically high and has little chance to compete with other power sources in the case of connecting to power distribution systems. Due to this, it is necessary to receive subsidies to introduce solar power generation in the country. Actually, GEF, UNDP, WB, GTZ and KfW provide financial support for rural areas minus a grid connection.

Wind

Nationwide surveys are conducted to explore wind conditions. According to existing surveys, the average wind velocity at an altitude of around 25m above ground is low i.e. approx. 3.0 m/s to 4.5 m/s even during the monsoon period. Bangladesh has little places where wind condition is good for power generation. A separate survey, however, found several places along the coastal side that has a wind velocity of 6 m/s or above, which is suitable for wind power generation. Thus, although the past surveys are inaccurate, there seem to be potential sites with an average wind speed of 6 m/s or more which is a generally accepted as an economically viable point for wind-power generation. BPDB installed an experimental test plant to Muhuri Dam (Feni), one of such sites in September

2005. The plant consists of four 225 kW power generators, the total output power of 900 kW. GoB plans to invite a bid of 400 MW wind power generation plant but due to the low purchasing price (approx. 6 cents/kWh) it is estimated that only a small number of organizations would submit their bidding documents.

TABLE 6. ESTIMATED ENERGY RESERVES (2010)

	Petroleum (in billion barrels)	Natural Gas (in BCF)	Coal (in million tons)	Hydro (in TWh per year)	Uranium
Total amount	0.028	12506.678*	2700	1100	-------

* Net Remaining Reserve

Source: Energy Information Administration, Official Energy Statistics from the US Government, Web site of Energy and Mineral Resource Division.

Annual Report 2010, PetroBangla, Bangladesh Oil, Gas and Mineral Corporation.

1.2.2. ENERGY STATISTICS

TABLE 7: ENERGY STATISTICS (All energy values are in Exa-Joule)

							Average annual growth rate (%)
	1980	1990	2000	2006	2008	2010	2000 to 2010*
Energy consumption**							
- Total	0.17	0.33	0.5306	1.157	1.3724	1.5242	14.10
- Solids***	0.007	0.017	0.015	0.016	0.168	0.171	
- Liquids	0.07	0.08	0.173	0.1971	0.212	0.2186	
- Gases	0.05	0.15	0.35	0.587	0.633	0.762	
- Nuclear	0.00	0.00	0.00	0.00	0.00	0.00	
- Hydro+Wind	0.003	0.003	0.003	.0033	0.0034	0.0026	
- Other	0.00	0.00	0.00	0.353	0.356	0.370	

Renewables							
Energy production							
- Total	0.10	0.23	0.369	0.943	1.0338	1.17414	15.57
- Solids***	0.00	0.00	0.00	0.00	0.0144	0.03954	
- Liquids	0.00	0.00	0.00	0.00	0.00	0.00	
- Gases	0.05	0.15	0.35	0.587	0.651	0.762	
- Nuclear	0.00	0.00	0.00	0.00	0.00	0.00	
- Hydro	0.01	0.01	0.003	.0033	0.0034	0.0026	
- Other Renewables	0.00	0.00	0.00	0.353	0.356	0.370	
Net import (Import – Export)							
- Total	0.07	0.10	0.161	0.194	0.1978	0.2431	5.28

* Year 2010

** Energy consumption = Primary energy consumption + Net import (Import - Export) of secondary energy.

*** Solid fuels include coal, lignite

Source: Energy Information Administration, Official Energy Statistics from the US Government, FORUM: A monthly publication of "The Daily Star", Volume 3, Issue 1, January 2010, Official web site of Bangladesh Petroleum Corporation.

1.2.3. ENERGY POLICY

Presently, primary commercial energy resources include natural gas, oil, condensates, coal, peat and renewable energy resources. Biomass still plays an important role in the country's energy consumption in the rural area. Government is actively considering use of nuclear energy for electricity generation.

The appreciable commercial energy resources of the country are well-developed natural gas sector and undeveloped coal sector. Prevailing constraints in the indigenous commercial energy sources limit the scope of widening the range of possible long-term national energy supplies.

A long-term strategic plan is required for carrying out systematic exploration and proper appraisal of discoveries. Hydrocarbon resource assessment studies indicate good prospects for finding new hydrocarbon resources especially in the offshore and deep sea areas.

In 2005-06 energy consumption was about 35 MTOE with biomass contributing 35% of the total energy. During 1999 – 2006, average annual increase of energy consumption was about 5%. In 2005-06 major commercial energy consumers were transport and household followed by agriculture, industry and commercial entities. During 1999 – 2006 share of biomass in total energy consumption was decreasing although its quantity was increasing at an average rate of about 2% per annum. Consumption of LPG in households and coal in brickfields will be encouraged to reduce the use of biomass and thereby reducing deforestation.

Bangladesh is facing twin energy crises – an urban energy crisis characterized by power shortages and skyrocketing gas consumption and a rural energy crisis reflected in the increasing inability of the rural poor to have access even to low-valued traditional biomass. To overcome these crises, sector reforms and additional investments are urgently needed for accelerated development and thus improving basic livelihoods of urban and rural population.

Areas having prospects of finding uranium and thorium deposits are to be appraised and techno-economic feasibilities conducted at prospective sites.

An earlier energy planning effort led to the formulation of first National Energy Policy (NEP), 1996 which brought Government attention to the urgency of ensuring proper exploration, production, distribution and rational use of energy sources to meet the growing energy demand of the country. With the rapid changes in global as well as domestic conditions Energy & Mineral Resources Division (EMRD) has undertaken a comprehensive programme for updating the National Energy Policy. The proposed updated policy will describe the role that the energy sector must play in order to meet its obligations for sustainable development of the country. This policy will also focus on implementation mechanisms and procedures for tracking results to ensure that the policies are reflected in practice.

Priority will be given on diversification of available indigenous commercial energy resources with coal assuming a much expanded role in providing the country's future energy needs.

The recoverable reserves of 4 (four) coalfields could range from 250 million to 900 million tons depending on the mining methods applied.

Due attention will be given for implementation of Nuclear Power Plant to cater to the future energy needs of the country. At the same time opportunity for regional energy trade will be explored to enhance energy security of the country.

The major issues causing slow development of the energy sector have been identified by Govt. and other agencies. Following remedial measures need to be taken to address those issues:

- More emphasis needs to be given on hydrocarbon exploration and development by national companies as well as IOCs to meet the future demand of gas.
- Dependence on natural gas is to be reduced by developing alternative sources of commercial energy.
- Gas and electricity consumption practices are to be improved by efficient management.

- Transparent transaction of subsidies needs to be ensured through oversight regulatory body.
- Massive investment is required to meet the growing energy demand.
- Power supply shortages are to be addressed by establishing new power plants, and proper maintenance and rehabilitation of existing power plants.
- Public-private partnership and/or joint ventures and private sector participation are to be further encouraged.
- Institutional capacity is to be built through necessary legal and administrative reforms and intensive investment programmes.
- Nuclear energy is to be introduced within the shortest possible time.

Strategic Goals

The overall goals of the energy sector are to:

- Provide adequate and secure energy resources for all.
- Support socio-economic development.
- Reduce poverty and ensure social equity.
- Provide sustainable energy mix.
- Promote rational use of energy.
- Improve sector management and performance.
- Increase private sector investment.
- Ensure balanced growth of east and west zone of the country.
- Promote regional energy markets.

Source: NEP 2008

1.3. THE ELECTRICITY SYSTEM

1.3.1. ELECTRICITY POLICY AND DECISION MAKING PROCESS

The Bangladesh Power Development Board (BPDB) was created in 1972, a public sector organisation. The Rural Electrification Board (REB) was established in 1977, as the semi-autonomous government agency.

As Dhaka grew in population and became a metropolitan city, the need for its own electricity grid, led to the creation of the Dhaka Electric Supply Authority (DESA) in 1991. It was implemented to operate and develop the distribution system and bring improvements in customer service, revenue collection and lessen the administrative burden of BPDB. The Dhaka Power Distribution Company Ltd. (DPDCL) took over DESA activities in 2008 as part of an overall power sector reform, to unite the energy system, and produce a more competitive, reliable and efficient system. The Power Grid Company of Bangladesh (PGCB) was created in 1996 to own, operate and expand the national power grid. In 2003, PGCB completed the takeover and began the operation all the transmission assets of BPDB and DESA. The PGCB is a public limited company, and is 76.25 % owned by BPDB, the remaining 23.75% is owned by the general public.

The creation of the Dhaka Electric Supply Company (DESCO) was also part of the reforms. It

is a public sector company, and a subsidiary of DESA. However, in the future, its shares will be offered to other power sector entities and the general public.

The REB has 70 operating rural electric cooperatives called Palli Bidyuit Samity (PBS). These cover more than 90% of the area for rural electrification. These cooperatives bring service to approximately 7,200,000 new connections, and are constructing more than 14,000 km of new transmission and distribution lines each year.

The oil and natural gas market is primarily operated by the Bangladesh Oil, Gas and Mineral Corporation, which holds the shares of all state-owned companies involved in oil and gas production and exploration, and the Bangladesh Petroleum Corporation (BPC), responsible for the refining, distribution and import of crude oil and petroleum products.

The electricity sector of Bangladesh has undergone reform since the mid-1990s, including unbundling of the state-owned energy supplier, the BPDB, into separate companies responsible for power generation, transmission and distribution. At present BPDB is functioning as a single buyer, except for some direct power purchase from small IPPs. Multi buyer/competitive pools may be adopted when the market becomes mature and stable.

Since 1996, responsibility for the operation and expansion of the entire electricity transmission grid has lain with the PGCB, a subsidiary of the BPDP. Since the start of the power reform process in 1996, the DPDCL (formally the DESA) has shared electricity distribution operations in the capital with the DESCO, a state-run joint-stock company. In addition, a further power distribution company, the West Zone Power Distribution Company (WZPDC), was established in 2003 as a BPDB subsidiary, and is responsible for the country's south-west.

Although generation, transmission and distribution have been opened to foreign and private sector involvement, these sectors remain dominated by state-owned entities. BPDB accounts for over 70% of the electricity generated in Bangladesh. This share also includes the first BPDB-founded subsidiaries, such as the Ashuganj Power Company (APS), which originated with the transformation in 2002 of the state-owned Ashuganj Power Station into a joint stock company. IPPs have been allowed to enter the market since 1996. Between 1998 and 2005, seven power plants belonging to IPPs started operation, providing an installed capacity of more than 1,290 MW, mainly fired by natural gas. These plants represent a 26% share in the country's total electrical generating capacity. Actual planning envisages the construction of further power plants by non-state-run producers, or joint state and private providers, for a total output exceeding 1.590 MW. Self-generators account for 1.1 GW of installed capacity in Bangladesh.

Moreover, the government declared its vision "Twenty-Twenty" that means that the government would ensure electricity for all by the year 2020.

Source: Retrieved from the website http://www.reegle.info/policy-and-regulatory-overviews/BD, dated 23rd April, 2012.

PROJECTED DEMAND FOR ELECTRICITY

In Bangladesh, the power supply has constantly remained strained in peak hours. Potential demands have not been met, and rotational outage has frequently occurred. The actual recorded maximum power has not included these potential demands. To estimate the maximum power that includes potential demands, PSMP 2006 adopts a method for calculating the generated power energy with which a compound daily load curve is produced by adding the evening peak demand for lighting, calculated from a daily load curve with no rotational outage on weekends and holidays in winter, to a daily load curve suppressed by rotational outage on weekdays in summer. By regressively analyzing the relation between the generated power energy calculated this way and the economic level indicated by the actual GDP and setting the load factor from a load curve that includes potential demands, PSMP 2006 estimates the maximum power energy. The following table shows the result of the forecast of power demands indicated in PSMP 2006.

	Base Case		High Case		Low Case		Projected Load Factor
Fiscal Year	Net Generation (GWh)	Net Peak Load (MW)	Net Generation (GWh)	Net Peak Load (MW)	Net Generation (GWh)	Net Peak Load (MW)	
2005	21,964	4,308	22,336	4,381	21,964	4,308	58.2%
2006	23,945	4,693	24,692	4,839	23,611	4,627	58.2%
2007	26,106	5,112	27,297	5,345	25,382	4,970	58.3%
2008	28,461	5,569	30,177	5,904	27,286	5,339	58.3%
2009	31,028	6,066	33,592	6,567	29,333	5,734	58.4%
2010	33,828	6,608	37,652	7,355	31,533	6,160	58.4%
2011	36,622	7,148	42,202	8,237	33,659	6,569	58.5%
2012	39,647	7,732	47,627	9,288	35,928	7,007	58.5%
2013	42,922	8,364	53,749	10,473	38,351	7,473	58.6%
2014	46,467	9,047	60,659	11,810	40,937	7,970	58.6%
2015	50,306	9,786	68,924	13,408	43,697	8,501	58.7%
2016	54,079	10,512	78,316	15,223	46,643	9,066	58.7%
2017	58,135	11,291	88,384	17,166	49,788	9,670	58.8%
2018	62,496	12,128	99,746	19,357	53,145	10,313	58.8%
2019	67,183	13,027	112,568	21,827	56,728	11,000	58.9%
2020	72,222	13,993	126,172	24,445	60,553	11,732	58.9%
2021	77,092	14,924	141,419	27,377	64,178	12,424	59.0%
2022	82,290	15,917	158,510	30,661	68,020	13,157	59.0%
2023	87,839	16,977	176,448	34,103	72,092	13,934	59.1%
2024	93,761	18,107	196,415	37,931	76,408	14,756	59.1%
2025	100,083	19,312	217,137	41,899	80,982	15,626	59.2%

Table8: PSMP 2006 demand forecast scenarios

Source: PSMP 2006, Bangladesh

In the first step of PSMP 2010, the power demand will be forecast using a similar method as that used in PSMP 2006.

Since its independence in 1971, Bangladesh has striven to improve its socioeconomic conditions and grow its economy with support from domestic and international society. The average annual growth rate in the 14-year period from 1995 to 2008 was 5.6%. In the past three years, a high growth rate has been maintained since the stable and high growth of the mining and industrial sectors and the service sector has covered the low growth rate of the agricultural sector. The midterm macroeconomic framework of the Poverty Reduction Strategy Paper (PRSP), which the government has formulated, set a goal of achieving a GDP growth rate of 6.8% in fiscal 2007 and 7.0% in fiscal 2008 and 2009. However, due to negative factors such as increased pressure for inflation, soaring international prices of crude oil, disasters caused by floods and cyclones, and serious power shortages, the real GDP growth rate in fiscal 2008 was only 6.2%. The World Bank has drawn up a mid- to long-term growth scenario that by judging from circumstances, including the following facts: the country has assets required for growth, its economic fundamentals have improved and it has succeeded in first-stage reforms, its workforce is young, and corporate spirit and cultures have been established, the country will break away from its present status of being the poorest country and advance to become a medium-income country in approximately 10 years1.

Scenario	Mid-term forecast	Long-term forecast
	2010-2015	2016-2030
Base case	7% growth rate, a goal set by the Bangladeshi government in the Poverty Reduction Strategy Paper (PRSP), continues.	It is assumed that although the economic growth will continue, the growth rate will decrease by 0.5% every 5 years due to maturity of economic activities.
High growth case	Case in which the economy grows at 8.0%, which is 1.0% higher than the growth rate set by the government.	
Low growth case	Case in which the economy grows at 5.5%, which is 1.5% lower than the growth rate set by the government. It is equivalent to the average growth rate in the past 14 years.	

Source: JICA Study Team

Table 9: Economic Growth Scenarios

The adoption scenarios of the power demand forecast in this MP are as shown in the figure 2 below. The figure indicates three scenarios; (i) GDP 7% scenario and (ii) GDP 6% scenario, based on energy intensity method, and (iii) government policy scenario.

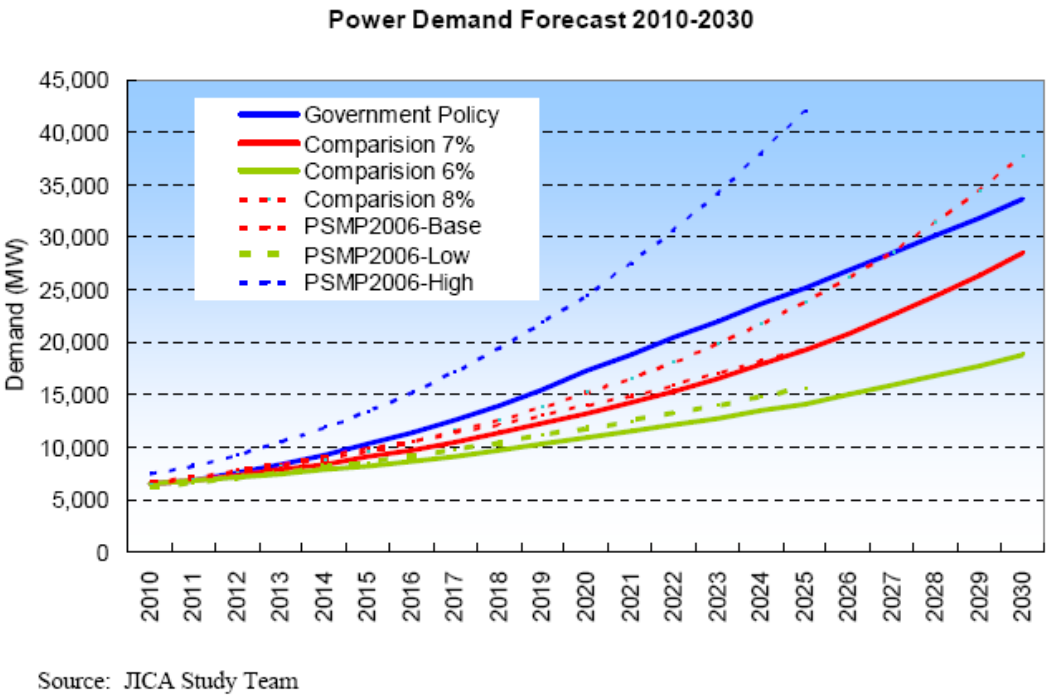


Figure 2: Three scenarios for power demand forecast

Perspective Energy Plan of Present Government

The Perspective Plan of the Planning Commission of the government of Bangladesh for the period 2010 – 2021 has recommended an energy mix to achieve the generation of 20,000 MW by 2021. Targets of electricity production by 2013 and 2015 are 7,000 MW and 8000 MW, respectively. According to the Perspective Plan, the energy mix for power generation is as follows.

Table 10: Energy mix of the Perspective Plan 2010 – 2025 for power generation

Energy Sources	Target Period		
	Current	2021	2030
Gas	88%	30%	28%
Coal	3.7%	53%	38%
Oil	6%	3%	5%
Hydro	2.7%	1%	4%
Nuclear	0%	10%	19%
Renewable	0%	3%	6%

Source: The Perspective Plan for Bangladesh 2010-2021.

ROLE OF INDIGENOUS FUEL IN POWER GENERATION

State of Natural Gas

The total gas shortfall was about 800 mmcdf, in which about 500 mmcfd was unmet demand, i.e. the amount was not delivered to the existing gas customer, and about 300 mmcfd was potential demand, i.e. the amount was wanted from the potential customer who had already applied for a gas contract but it was not executed yet. This gas shortfall arose continuously from around 2005. In order to project the gas demand forecast, the shortfall amount as of June 2010 was incorporated into the forecast as unmet/potential demand, then extrapolated to 2005. The gas shortfall will be alleviated due to the Gas Evacuation Plan (2010-2015) including the introduction of LNG, and the Government incentive plan for switching from gas to other fuels to gas potential customers. Via these measures, the gas shortfall is expected to be dissolved by 2016.

Since the development of Chattak gas field, 23 gas fields have been discovered until now and currently (June 2009), 17 gas field are producing the gas. The gas fields are operated by three National companies and four IOC companies. The gas fields of Titas, Bakhrabad, Habiganj, Narsingdi, and Meghna are possessed by BGFCL, the gas fields of Sylhet, Kailasitila, Rashidpur, and Beanibazar are possessed by SGFL Company, and the gas fields of Salda, Fenchuganj, and Shahbazpur are possessed by BAPEX. The gas fields of Jalalabad, Moulavizar, Bibiyana (Chevron), Sangu (Cairn), Bangura (Tullow) and Feni (Niko) are operated by IOCs with PSC. The average gas production volume is 1,791 mmcfd (2008/09) in all, and the production volume of IOC makes up 50%.

State of coal

According to the 2010 BP Statistical Energy Survey, Bangladesh had 2009 coal consumption of 0.35 million tonnes oil equivalent.

Substantial reserves of coal, estimated at 1,000 Mt, are known to exist in the Jamalganj and Rajshahi areas, but they lie at a depth in excess of 900 m, making exploitation both difficult and expensive. As a result, the country has to import about 60,000 t of coal from China, India and Indonesia. Coal was first discovered at Phulbari in north-west Bangladesh during surveying and drilling between 1994 -1997 by the Australian mining company BHP, which entered into licensing and investment agreements with the Government of Bangladesh. These agreements were acquired by Asia Energy Corporation Bangladesh Pty Ltd in 1998 and were in turn taken over by Asia Energy PLC in 2003.

BHP established the presence of a coal deposit of between 14 and 45 metres thickness at a depth of 150 metres to 250 metres with inferred resources of 387 million. Subsequent drilling by Asia Energy increased the estimated in situ resource to 426 million tonnes. The coal resource (JORC code indicated and inferred) is 370 million tonnes.

In September 2004 studies by Asia Energy indicated the Phulbari Coal Project's outstanding economic potential for an open cast mine. Based on a 15 million tonnes per year coal operation and a 30-year mine life, showed a Project Net Present Value of US$2.3 billion using a discount rate of 10%. Start-up capital to the second year of production was estimated at approximately US $530 million. The low sulphur coal type at Phulbari, varying between High Volatile A and High Volatile Bituminous, will be suitable for both a mine-mouth power station and for export to Asian seaborne markets. The projected mine offers a large number of benefits for the local, regional and national economies of Bangladesh.

The Bangladesh government will receive an estimated $245 million annually in taxes and royalties at an annual production of 15 million tonnes and based on a coal price of $50 per tonne. Production at Phulbari would significantly reduce Bangladesh's dependence on imported coal and help replace the country's dwindling reserves of natural gas as a power source. Power is in scarce supply in Bangladesh with fewer than one in four having regular supplies of electricity.

At present two major mines are being developed by Petrobangla to extract about 1 million tons of coal and 1.65 million tons of granite respectively from the Barapukuria Coal Mine and Madhyapara Hard Rock Mine. These deposits occur at depth range of 150 to 280 meters.

In addition, two more mining projects are being processed, to be implemented preferably by the public sector under BOO/ BOOT/ BOT mechanism. These two projects aim at the development of the Khalashpir coal deposit and the Jaipurhat integrated limestone mining and cement complex.

State of hydro-power

The lone hydropower plant of the country with an installed capacity of 230 MW is located at Kaptai of Chittagong Hill Tracts. Since Bangladesh is a flat land, there is not much potential sites for any other hydro-electricity plants or micro-hydro projects which might provide substantial contribution to the total generation of electricity.

State of renewable energy sources

Bio-mass, solar and wind energy are the prominent renewable energy sources in Bangladesh. Till now, only a total of 19 MW has been generated from these sources.

Energy Mix

Considering all the indigenous sources in Bangladesh, it can be concluded that the present primary energy sources cannot meet even the base case scenario (which is shown previously) let alone the high case scenario. Even considering high-case scenario, it is below those of the neighboring countries like India, Pakistan. In this context, the Government is formulating the "Five-Fuel strategy" in which the priorities are given below.

1. Undertake immediate exploration of hydrocarbon and identify additional reserves that can meet the growing demand of gas by all consuming sectors.

2. Develop alternative commercial energy supplies suitable for power generation, especially coal to ease the burden of fast-growing electricity demand on gas resources. Thus a two-fuel (gas and coal) strategy is required for both resource diversification and energy security.

3. Ensure efficient use of energy by using energy–saving appliances, plants and equipment in order to effectively increase the stock of available energy supplies. It can alleviate current capacity shortages, and create a more sustainable energy supply and demand balance. Mobilization of this "third fuel" will dampen unwanted demand growth, reduce the need to add new peak power capacity, and insulate consumers from future price increases.

4. The resource potential of renewable energy is significantly larger than its present consumption and is a promising source of clean, convenient energy supply, especially in rural areas. With available and evolving technologies, renewable energy can be converted into modern energy like photovoltaic, biogas, bio-fuels, wind energy etc. making significant contributions to the total energy supply. This "fourth fuel" can help in meeting the energy access throughout the country including the remote areas and thereby achieving poverty reduction goals.

5. Considering the limitation of fossil fuel supplies, nuclear fuel could be a potential energy option for the country, as it is a proven technology for economic, reliable and sustainable electricity generation. So, nuclear energy may be considered as the fifth fuel in the energy sector. Over the next decade, it could become a significant source of energy, thereby increasing diversity in the energy sector.

OPTIONS OF FUEL-MIX FOR POWER GENERATION

Fuels and Technologies

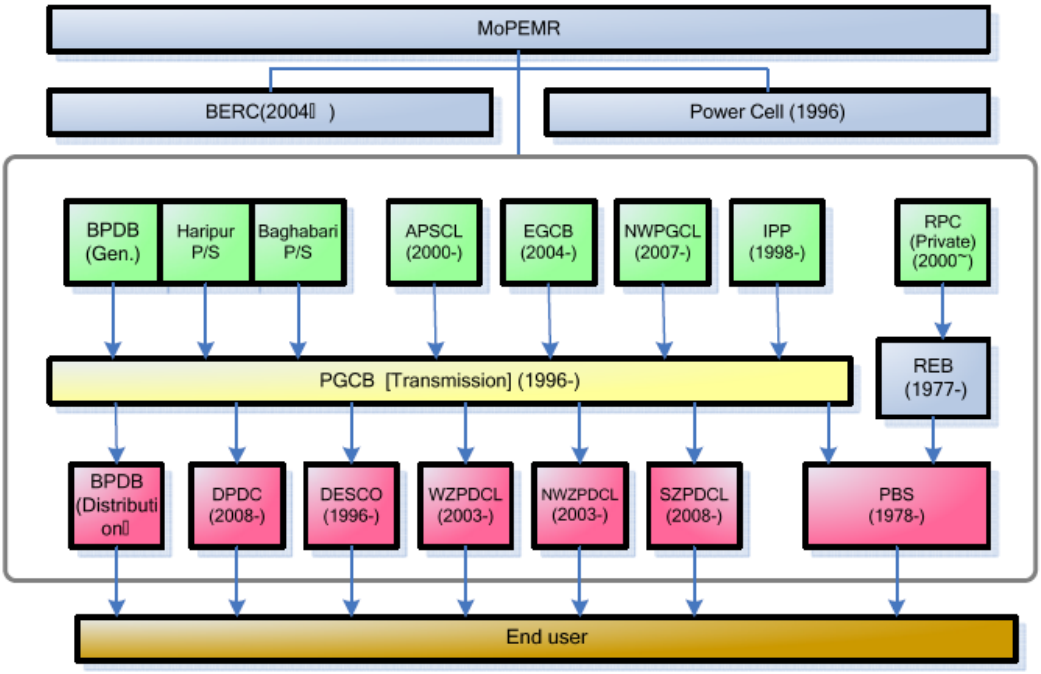
Considering the projected demand of power and the reserve bases of both gas and coal, it is high time to consider introduction of nuclear power as an alternative source of primary energy, and to explore the opportunity for regional energy trade. The option of the fuels and technologies for power generation is follows.

1. Considering the reserves and availability of resources, efforts are to be made to maximize the use of indigenous fuels, namely natural gas and coal.
2. A mix of fuel such as gas, coal and oil may be used for power generation and nuclear fuel should be considered to reduce reliance on any particular type of fuel.

3. Local coal will be used for coal-fired power plants and necessary infrastructure for handling and transporting imported coal for power generation is to be developed.
4. Criteria for selection of technologies will include its proven, reliability, efficiency, maintainability and environmental compatibility.
5. Priority will be given to combine cycle technology for base load power plants using gas.
6. Preference will be given to nuclear energy for power generation.
7. Efforts will be made to standardize systems, sub-systems and components of energy equipment so as to minimize cost, improve reliability of the system and facilitate operation and maintenance

1.3.2. STRUCTURE OF ELECTRIC POWER SECTOR

In the country Bangladesh MoPEMR Power Division manages the electricity business. Under its control, the power is generated by the BPDB, power plants which are departments and subsidiaries of BPDB, IPP, and private power generation companies. Power is supplied through PBCB's power transmission facilities to customers in local cities by BPDB, in the metropolitan area by DPDC and DESCO, and in rural areas by PBS. Note that distribution departments in local cities are being separated one by one. Fig. 3 shows the structure of the electric power sector in the country Bangladesh.



Note: ⟶ Power flow、

Abbreviation	List
MoPEMR	Ministry of Power, Energy & Mineral Resource
BERC	Bangladesh Energy Regulatory Commission
BPDB	Bangladesh Power Development Board
APSCL	Ashuganj Power Station Company Ltd.
EGCB	Electricity Generation Company of Bangladesh
NWPGCL	North-West Power Generation Company Ltd.
IPP	Independent Power Producer
RPC	Rural Power Company Ltd.
PGCB	Power Grid Company of Bangladesh
DPDC	Dhaka Power Distribution Company Ltd.
DESCO	Dhaka Electric supply Company Ltd.
WZPDCL	West Zone Power Distribution Company Ltd.
NWZPDCL	North-West Zone Power Generation Company Ltd.
SZPDCL	South Done Power Distribution Company Ltd.
REB	Rural Electrification Board
PBS	Palli Biddyut Samities

Source: "Electric Energy Situations in Foreign Countries" Vol.2 (2010) JEPIC BPDP Annual Report

Figure 3: Structure of Electric Power Sector of Bangladesh

GENERATION

During the year 2009-10, 16072 GWh of net energy was generated in the public sector power plants. In addition, about 11,398 GWh of electricity was purchased by BPDB as a single buyer from IPPs, SIPPs & rental power plants in the private sector. As a result, the net energy generated by public and private sector power plants stood at 27,470 GWh (excluding power purchase by REB and IPP) which was 7.21 percent higher than that of the

previous year's net generation of 25,622 GWh. Total electricity generation by types of fuel was as follows: hydro (728.56 GWh, 2.65%), natural gas (24316.49 GWh, 88.52%), furnace oil (876.51 GWh, 3.19%), diesel (517.36 GWh, 1.89%), coal (728.56 GWh, 3.75%). The overall thermal efficiency (net) of the generators in the public sector in the financial year 2010 was 32.12% compared to 31.99% in the previous year. The forecast of maximum demand for financial year 2010 was 6454 MW. Demand is increasing fast due to enhanced economic activities in the country with sustained GDP growth. At present, electricity demand growth is about 10 percent which is expected to be more in the coming years. Total installed capacity was 5823 MW including 1330 MW in IPP, 548 MW in SIPP/ rental power plant and 226 MW in REB, but generation capacity (derated) was 5271 MW. The actual maximum peak generation was 4606 MW which was 10.67% higher than that in the previous year. The reasons for lower actual peak generation were (1) some plants were out of operation for maintenance, rehabilitation and overhauling. (2) capacity of the plants was derated due to aging and (3) gas shortage. The installed capacity mix including IPPs by plant type in the financial year 2010 was as follows: Hydro (230 MW, 3.95%), Steam Turbine (2638 MW, 45.31%), Gas Turbine (1466 MW, 25.18%), Combine Cycle (1263 MW, 21.69%), Diesel (226 MW, 3.87%). Also, the installed capacity mix including IPPs by fuel type in the financial year 2010 was as follows: Gas (4822 MW, 82.81%), Furnace Oil (335 MW, 5.75%), Diesel (186 MW, 3.20%), Hydro (230 MW, 3.95%) and Coal (250 MW, 4.29%). In the east zone, electricity generated is mainly by indigenous gas based power plants. Hydro in south-east region contributes a small portion of total generation. In the west zone, imported liquid fuel, domestic coal and natural gas are used for generation of electricity. Low cost electricity generated in the east zone, is being transferred to the west zone through 230 KV East-West Interconnector (EWI). The energy transferred through EWI at the Ghorashal and Ashuganj end in the financial year 2010 was 3831 GWh, which is 50% increase over the previous year. The average fuel cost per unit generation of thermal power plants in the east and west zone under BPDB was Taka 0.88/KWh and Taka 3.76/KWh respectively.

TRANSMISSION AND DISTRIBUTION

Bangladesh Power Development Board (BPDB), Dhaka Electric Supply Authority (DESA), Rural Electrification Board (REB), Power Grid Company of Bangladesh (PGCB) are responsible for transmission and distribution of electricity. During the financial year 2009-10, Khulna(s) – Gallamari 4.2 Km double circuit 132 KV transmission line under ADP (Annual Development Programme) and Ashuganj-Shahjibazar 53 Km 132 KV single circuit, Naogaon-Niamatpur 46 Km 132 KV single circuit & Aminbazar-Savar 13 Km 132 KV double circuit transmission lines from PGCB's own fund were completed and energized. Construction of several 132 KV lines are under way. Some will be commissioned very soon. The length of 132 KV line of whole transmission network has been increased to 5754 circuit kilometre. Also, the length of 230 KV line of whole transmission network in the financial year 2010 is 2647.30 circuit kilometre and the length of route kilometre is 1324.40.

The total length of distribution lines of 33 KV was 3827 Km, 11 KV was 9659 Km and 0.4 KV was 16,103 Km i.e. total distribution line was about 29,589 Km in the end of the financial

year 2010. Distribution loss in BPDB's own distribution zones has decreased to 13.06% from 13.57% in 2010. In the financial year 2009-10, the total capacity of 230/132 KV grid sub-station was 6850 MVA and a total of 225 MVA of new capacity of transformer was added. In this fiscal year, Gallamari 132/33 KV, 2×25/41 MVA, Niamatpur 2×35/50 MVA & Savar 2×50/75 MVA sub-stations have been commissioned. Therefore, the total capacity of 132/33 KV sub-station was increased from 9529 to 9899 MVA. In this fiscal year, the total duration of grid failure was 32 hours 30 minuets which was about 57.44% lower than the interruption in the financial year 2009.

1.3.3. MAIN INDICATORS

TABLE 11: ELECTRICITY PRODUCTION AND INSTALLED CAPACITY

							Average annual growth rate (%)
	1980	1990	2001	2006	2008	2010	2001 to 2010
Capacity of electrical plants (GWe)							
- Thermal	0.91	2.29	3.48	5.039	4.972	5.593	
- Hydro	0.08	0.23	0.23	0.23	0.23	0.23	
- Nuclear	0.00	0.00	0.00	0.00	0.00	0.00	
- Wind						0.00	
- Geothermal	0.00	0.00	0.00	0.00	0.00	0.00	
- other renewable						0.00	
- Total	0.99	2.35	3.711	5.269	5.202	5.823	6.65
Electricity production (TW.h)							
- Thermal	2.07	7.17	14.48	22.802	23.361	26.742	
- Hydro	0.58	0.88	1.08	0.935	0.949	0.728	
- Nuclear	0.00	0.00	0.00	0.00	0.00	0.00	
- Wind						0.00	
- Geothermal	0.00	0.00	0.00	0.00	0.00	0.00	
- other renewable						0.00	
- Total (1)	2.65	7.73	15.56	23.737	24.311	27.475	8.46
Total Electricity consumption (TW.h)		4.704	14.002	20.954	22.622	26.627	9.62

(1) Electricity transmission losses are not deducted.

* Year 2010

Source: Annual Report 2009-2010, Bangladesh Power Development Board

CONSUMPTION

The per capita consumption of electricity is very low. The per capita consumption of electricity is increasing almost steady over the years. At present only 49% of the people have access to electricity. The consumption patterns in different end-user categories were as follows: Domestic (47.21%), Industry (36.56%), Commercial (9.49%), Agriculture (4.99%) and others (1.75%). In this financial year 2010, the utility wise bulk sales of electricity were as follows: REB/PBS (35.77%), BPDB (25.33%), DPDC (21.59%), DESCO (11.02%) and WZPDCO (6.28%).

TABLE 12: ENERGY RELATED RATIOS

	1980	1990	2001	2002	2003	2004	2006	2008	2010
Energy consumption per capita (GJ/capita)	2	3	3.8	4.1	4.64	4.83	6.61	10.5	10.44
Electricity per capita (kW·h/capita)	22.07	44.04	106.08	113.80	122.43	133.11	149.97	176.87	200
Electricity Production/Energy production (%)	9.55	12.11	14.21	12.73	14.7	15	8.64	8.68	8.42
Nuclear/Total electricity (%)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ratio of external dependency (%)[(1)]	44	29	25	25	28	27.97	16.76	14.41	15.94
Load factor of electricity plants									
- Total (%)	31	72	51	72	64.7	66.17	72.89	69.91	70.54
- Thermal									
- Hydro									
- Nuclear (Not Applicable)									

(1) Net import / Total energy consumption.

(2) Source: Annual Report 2009-2010, Bangladesh Power Development Board, Energy Information Administration, Official Energy Statistics from the US Government, FORUM: A monthly publication of "The Daily Star", Volume 3, Issue 1, January 2010.

SOME OTHER ISSUES

Low consumption pattern

The average annual growth in peak demand of the national grid was not up to the level of projected demand. The gap between projected demand and supply is increasing day by day. If present trend of consumption continues, the gap will increase sharply in future. As a consequence, the socioeconomic development will tremendously be hampered.

Regional Imbalance

In is seen in Bangladesh that the indigenous reserves of primary energy resources influenced the development of energy sector. In the country all most all-commercial energy resources are located in the Eastern Zone and it has more than 90% of total generating capacity of the country and consumes about 75% of total generation. The Western Zone depends on Eastern Zone for electricity for meeting not only the peak demand but also a part of the base load. As a result, electricity demand of the western zone is strongly suppressed due to lack of supply. The gap in energy use between the two zones is widening day by day that has been hampering proper industrialization and urbanization of the west zone. This should be realized by increasing the generating capacity in the western zone, which is adequate to meet its base load from the power plants located there.

Area Based Planning and Rural Energy

National economy is agriculture based and its development is dependent on expansion of modern agriculture. Area based planning on demand supply balancing should be encouraged. This would help equitable development reflecting needs, priorities, weaknesses and strength of each individual planning unit. Adequate measures have to be initiated to enhance the quality of rural life; fruitful basic needs and achieve equitable income distribution. Importantly supplying of electricity for irrigation purpose will help to attain self-sufficiency in food production and in production of basic materials.

Energy Pricing

As of the financial year 2009, the structure of the power source of BPDB, the single buyer of the power in the country, consists of; 41% from its own generation; 19% from public generation entities (government/BPDB owned); 34% from IPP purchases; and 5% from rental power producers. The costs of electricity for each of the sources are Tk 2.53/kWh for its own generation; Tk 1.21/kWh for the publicly owned generation entities; Tk 2.70/kWh for IPPs; and Tk 5.20/kWh for rental power producers. The overall acquisition cost of BPDB for all the power sources stands at Tk 3.07/kWh for the year. The average billing rate of BPDB, on the other hand, stands at Tk 2.56/kWh including its retail selling to certain designated consumers1. The acquisition and selling prices leave BPDB with a negative margin of Tk 0.51/kWh[2]. Of particular mention is the increase of rental power which expanded its shares among the total acquisition of BPDB from 0.2% in the financial year 2008 to 5.2% in the financial year 2009, is creating significant losses in the single buyer operation.

It is observed that tariff of energy is often fixed without considering the realities like the need for internal revenue generation and economic operation of the concerned utilities.

Often the pricing is such that the conversion facilities such as power plants of fertilizer factories can afford to install machinery with lower efficiency without sacrificing the profitability of the industry. The gas tariff of the energy sector may be mentioned here. According to tariff structure, the cost of gas per MCF was (Tk. 78.40) for the power sector, Tk. 68.15 for the fertilizer production, Tk. 243.67 for the commercial uses, Tk. 162.45 for the tea industry, Tk. 211.1817 for the brick manufacturing and Tk. 134.00 for the domestic burners. On the other hand, power and the fertilizer sector consume about 80% of total gas supplied annually and they have to pay about one third or less of the highest tariff. If willingness to pay is an indicator of economic price of gas, then the gas sector is being deprived of the desired revenue generation.

Barapukuria coal mine is the first coal mine in Bangladesh. The company has gone into commercial operation on September 10, 2005. During the fiscal year 2009-10, the company has earned Tk. 444.09 crore by selling coal to BPDB & other buyers and Tk. 14.09 crore from other sources.

2. NUCLEAR POWER SITUATION

2.1. HISTORICAL DEVELOPMENT AND CURRENT ORGANIZATIONAL STRUCTURE

Peaceful uses of Nuclear Technology were initiated in Bangladesh in early 1960's under the framework of the then Pakistan Atomic Energy Commission (PAEC). After independence, Bangladesh became a Member State of the Agency in 1972. Bangladesh Atomic Energy Commission was formed in 1973 by the Presidential Order No. 15 with the goal of utilization of Nuclear Science & Technology for national development.. Nuclear establishment in the country however existed and concerned activities were carried on even before its independence from Pakistan. The Commission was entrusted with the following charter of duties: "Promotion of the peaceful uses of atomic energy in Bangladesh, the discharge of International obligations connected therewith, the undertaking of research, the execution of development projects involving nuclear power stations and matters incidental thereto." Since then, three decades have elapsed and the Commission pursued various research and development projects, established a number of research and service providing centres with necessary laboratory facilities and equipment, trained working scientists and developed supporting facilities that can be used to meet the fast changing trends of scientific and technological pursuits of the modern world.

BAEC's overall R&D programs are formulated in two distinct trains, namely (a) problems addressing the needs of national development and (b) basic R&D. Of these, the first group of projects is now being given higher priority. This will also be evident from the fact that vertical linkage of BAEC is provided through the Ministry and the Planning Commission, which ensures that national goals and development targets are featured in its programs and projects.

Over the years, the Agency has been a partner-in-development in most of the leading BAEC institutes. This has meant a continuing relationship with various institutes at Savar and at AECD. Broadly speaking, the program at Savar covers research reactor commissioning and its utilization for isotope production, 1.85 PBq Co-60 irradiator, neutron activation analysis, and neutron radiography. Nuclear analytical facilities, and laboratories for repair and maintenance of nuclear instruments, have been established both at Savar and at AEC, Dhaka. Utilization of Van de Graaff accelerator at AECD was also supported by the Agency. NDT program at AECD and isotope hydrology at Savar, and food preservation, pest control, radiation sterilization of pharmaceuticals, tissue banking and agrochemical residue analysis at the Institute of Food and Radiation Biology, have also been well supported.

The Law on Nuclear Safety and Radiation Control was enacted in 1993. Considering that BAEC is the only national institution that has expertise and trained human resources needed for the enforcement of the law, it was also given nuclear regulatory responsibility. In future, a separate regulatory organization will be set up in order to separate promotional responsibilities from the regulatory ones. When this is implemented, it will be possible to attain the required transparency in nuclear safety and radiation control especially in all stages for licensing and inspection of nuclear facilities and radiation sources.

In addition to making excellent use of opportunities under the country TC program, Bangladesh has been an active partner in the Regional Cooperation Agreement (RCA) program. According to a recent review of the Technology Transfer through RCA program, the country participated in different areas of RCA activities. Through the devotion, dedication and hard work of scientists, engineers and technicians, sustained support from the Government, and a judicious combination of IAEA country projects with the RCA program the country has attained a high level of technology transfer. This is a good achievement and reflects the growing maturity of Bangladesh's nuclear program.

Some of the key milestones of Bangladesh national Nuclear Power program:

1	1963:	Rooppur site selected
2	1971-78, 1987-88:	Feasibility Studies for site and first NPP conducted.
3	1996:	National Energy Policy identifies nuclear power as an option
4	2000:	BANPAP approved by the government
5	2010:	National Parliament approves first NPP project and new structure for NP program development (equivalent NEPIO) were formed (National Committees, Technical Committee, Working Group).
6	2011:	IGA with Russia signed for the first NPP with two VVER units,

each of 1000 MWe.

2.1.1 OVERVIEW

Bangladesh Atomic Energy Commission (BAEC) was established in February 1973 through the promulgation of the Presidential Order 15 of 1973. Since then BAEC has been keeping itself engaged in the planning and development of acquiring nuclear technology for possible peaceful applications in the fields of Food, Agriculture, Health, Industry and Environment ensuring nuclear safety and radiation protection. Accordingly, BAEC has undertaken a good number of R&D programs in its various research establishments and developed indigenous expertise to achieve the cherished goal of self-reliance through national efforts and international cooperation. The Vision and Mission of BAEC are stated below:

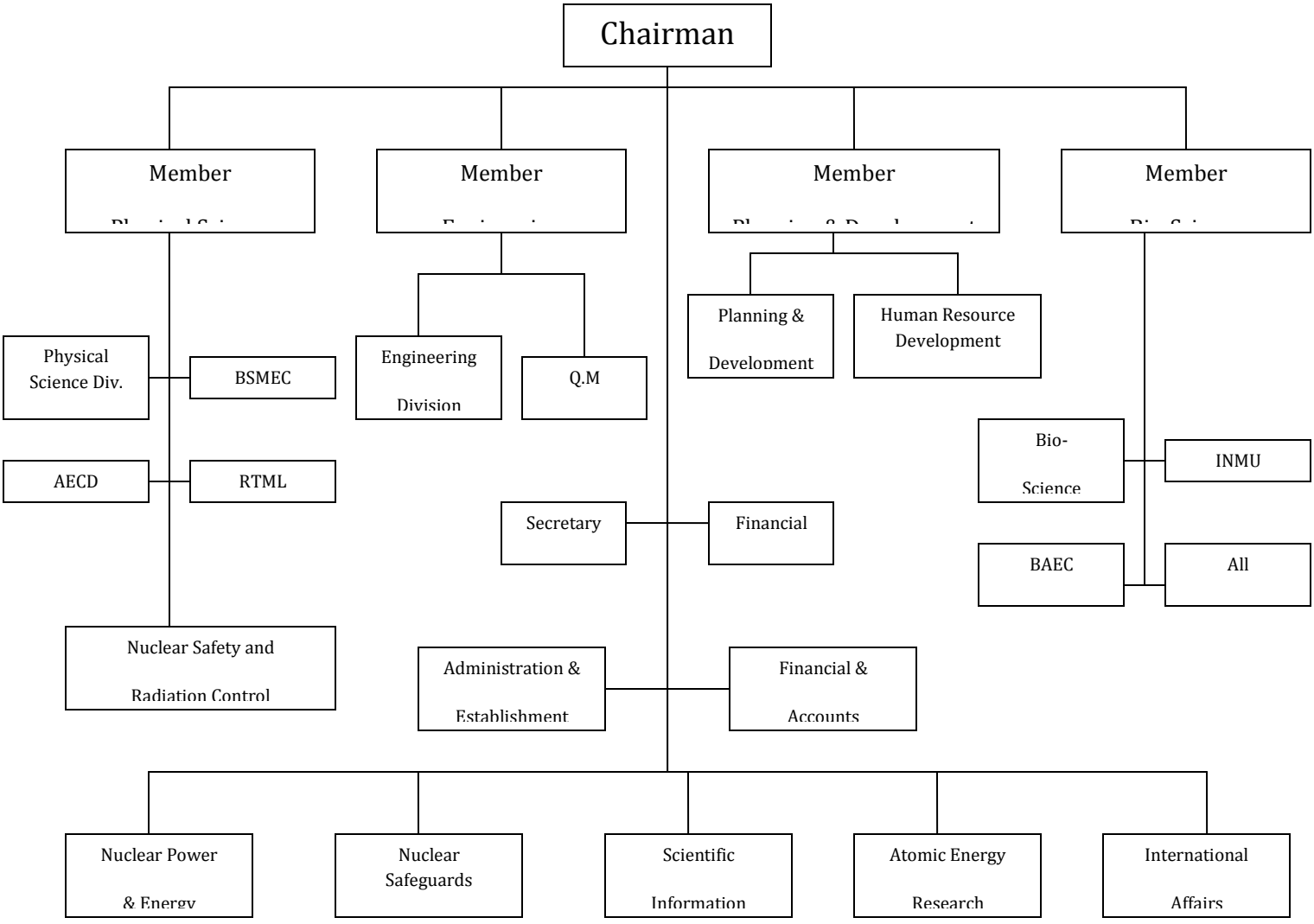
Vision

Promotion of nuclear science and technology for peaceful uses of atomic energy to achieve self-reliance for overall socio-economic development.

Mission

- Promotion of nuclear science and technology based fundamental and applied as well as advanced research programmes in various fields of physical, biological and engineering disciplines;
- Implementation of nuclear power programme;
- Transfer of nuclear technology based services to various stakeholders;
- Application of nuclear technology in agriculture, industry, health and environment;
- Development of human resources in the area of nuclear science and technology;
- Establishment of radiation safety culture;
- Application of nuclear technology in exploration and exploitation of mineral resources.

2.1.2 CURRENT ORGANIZATIONAL CHART(S)



BAEC: Bangladesh Atomic Energy Commission; AECD: Atomic Energy Center, Dhaka; RTML: Radiation Testing and Monitoring Laboratory; BSMEC: Beach Sand Minerals Exploration Center; Q.M: Quality Management; INMU: Institute of Nuclear Medicine and Ultrasound;

Figure 4: Current BAEC Organizational Structure

2.2. NUCLEAR POWER PLANTS: OVERVIEW

HISTORICAL DEVELOPMENT OF NUCLEAR POWER PROJECT IN BANGLADESH

The proposal for building a nuclear power plant in the western zone of the country was first mooted in 1961. Since then a number of feasibility reports had been prepared which established that the plant was technically and economically feasible. The Rooppur site was selected in 1963 and 292 acres (118.3 hectare) of land (105.3 hectare for plant and 13 hectare for residential purposes) was acquired for the project. Physical infrastructures like

residential quarters, site office, rest house, internal road, electric sub-station, pump house etc. were established in the project area. The then Pakistan government gave formal approval for 70 MW, 140 MW and 200 MW Nuclear Power Plant (NPP) in 1963, 1966 and 1969, respectively. Following liberation the ECNEC had approved the pp for a 125 MW nuclear power plant in 1980. A number of suppliers had submitted proposals for the project both before and after liberation. However, the project could not be implemented due to several problems with financing as the main obstacle.

Considering the changed circumstances in national and international level the government of Bangladesh expressed its firm commitment to implement the Rooppur nuclear power project (RNPP). It may be mentioned that the inordinate delay in project implementation has brought about a number of changes in the planning process. For example since grid size is growing, it will eventually grow to a size where accommodation of a larger plant of 600 mw with advantage of economy of scale would be required. The growth of the grid to such a size incidentally matches the time needed for implementation of such a plant. Such changes would necessitate updating data, information and some of the past studies.

DECISION MAKING PROCESS

Nuclear power projects are very complicated and any decision on it, unless taken at an appropriate level of the government, might be rendered ineffective. Continuity of decision over a long time is also an important requirement. In the case of Bangladesh, The Government has recognized the need for a proper institutional framework with adequate financial and administrative power, accountability and transparency that can either itself and/or through a joint venture with others, build and operate nuclear power plants. In 2000 a Nuclear Power Action Plan (BANPAP) was approved by the government. The BANPAP proposed a Nuclear Power Authority of Bangladesh (NPAB), which at the national level shall be responsible to an apex body named National Nuclear Power Council (NNPC) Headed by the Honourable Prime Minister. This NPAB should be the nuclear power operating organization (Licensee). NNPC will be served by the Governing Body of the NPAB. There shall be a Governing Body of the NPAB, headed by the Minister in charge of the Ministry dealing with nuclear power as its Chairman. Until creation of the NNPC and the NPAB, BAEC is appointed authority by the BANPAP and the 1973 Presidential Order to deal with all activities for implementation of RNPP and the Ministry of Science & Technology (MOST) will work as the focal Ministry.

Before establishment of the formal institutional framework of NNPC and NPAB, the government has decided to execute the responsibility of those institutions by high level national committees. Recently, the Government of Bangladesh has formed a Cabinet Committee on implementation of Rooppur Nuclear Power Project (RNPP) Headed by the Honourable Prime Minister (Bangladesh Gazette, June 13, 2010). The Ministers and Secretaries of relevant ministries are the members of the Cabinet Committee. The Cabinet Committee will review the implementation progress of the project, determine the ownership and project execution approach of the RNPP, finalize the financing and purchase of the RNPP and finalize the contractual agreement(s) with supplier. The Cabinet

Committee will also identify the barriers in implementing RNPP and provide recommendations/directions for overcoming the barriers. The Cabinet is presently working to define ownership of the RNPP, arranging fund for RNPP, finalization of project execution methodology and mode and conclusion of the contract(s) with supplier. Basically, the Cabinet Committee has been assigned with the Functional responsibilities of the NNPC.

The government has formed a Technical Committee on the RNPP headed by the Honourable Minister of the Ministry of Science & Technology (MOST). The secretaries, head of the relevant organizations, academicians, chairman and representatives of BAEC are the members of the Technical Committee. This committee will take necessary steps to establish organizational structure of the project implementation phase of RNPP. The committee will take initiatives to prepare comprehensive documents for consideration of the Cabinet Committee on RNPP taking into accounts of various issues namely the project implementation mode, technology transfer, project implementation period, financing mechanism, regulatory issues. Basically, the Technical Committee is taking the responsibilities of the proposed NPAB. Presently, this committee is executing various activities related to project decision making phase activities of the IAEA Milestone Documents.

During the 2008 National Parliament elections, a declaration to implement the nuclear power project was made by all major parties, and a decision for immediate implementation of the NPP was taken by the national parliament in 2010.

A National Committee, chaired by the Prime Minister was established in 2010. A Technical Committee was established chaired by the State Minister of Ministry of Science & Technology (MOST). Under the technical committee, there is a working group convened by the Secretary of Ministry of Science & Technology (MOST). Also under this working group, there are eight (8) working sub groups which are given below.

1. Heavy equipment transportation planning
2. Grid system,
3. Nuclear fuel cycle, waste management and environmental monitoring
4. National participation
5. Funding and financing
6. Development of Human Resources
7. Ownership, project execution and project management
8. Legal and regulatory aspects, international obligations.

The Government has also formed a Working Group for accomplishment of various activities to take preparation for RNPP construction. The Working-Group is responsible for identifying various activities for materializing the government decision on implementation of the RNPP. The Working Group will identify the required areas of cooperation from the supplier source(s) for the project.

To accelerate the activities for starting construction of RNPP, the Government has formed eight Working Sub-Groups each of which consists of the representatives from the relevant ministries, organizations (namely Bangladesh Power Development Board, Power Grid Company of Bangladesh), academic institutions and the representatives of BAEC. The names of the Working Sub-Groups are as follows: (1) Legal and Regulatory Aspects as well as International Obligations, (2) Ownership, Project execution and Project Management, (3) Funding and Financing, (4) Development of Human Resources, (5) Grid System Development, (6) Nuclear Fuel Cycle and waste management and (7) National Participation. These Working Sub-Groups are responsible for assessing the Nuclear Infrastructure of the country in the respective areas and identify the gaps of nineteen infrastructure items of Phase II (Decision Making Phase). The Groups will take initiatives in addressing the gaps of the nineteen items of the IAEA Milestone Document in order to take final preparation of the construction of RNPP.

A road map is formulated to carry out the responsibility of the NEPIO through formation of the above-mentioned Cabinet Committee, Technical Committee and Working Group and Sub-Groups for implementation of RNPP. The Committees on RNPP and Working Group have build-in-mechanism for linkages with relevant ministries and government agencies for R&D support, HRD, regulatory aspects, nuclear safety, security, safeguard, T & D and integrate RNPP into the overall electricity generation planning and Power purchase.

PRESENT STATUS OF NUCLEAR POWER PROGRAMME OF BANGLADESH

Introduction

The nuclear power generation has become an inevitable option for Bangladesh which has already been reflected in the government policy documents. The updated National Energy Policy projected nuclear power as an important option of meeting the ever-growing energy demand. The policy outlined the programme to be taken to implement two units of nuclear power plants by 2020 and to meet about 10% of electricity demand by 2025 and 25% of total electricity generation beyond 2025 by implementation of nuclear power projects. The revised policy also recommended for implementation of two units of medium size nuclear power plants by 2020 in order to improve the supply situation of electricity in the country. Additional two or three more units of larger size above 1000 MW(e) by 2025 will contribute about 10% of the total energy mix for power generation. However, continued efforts will be made to achieve 25% of total electricity generation from nuclear power beyond 2025. The Perspective Plan of the Planning Commission of the government of Bangladesh for the

period 2010 – 2021 has recommended the following energy mix to achieve the generation of 20,000 MW by 2021 in which the share of nuclear power is assumed about 10% in overall generation.

Present Status of Rooppur Nuclear Power Project

The present government is working on selection of suitable technology, financing, selection of ownership, human resource development, grid system development etc. for implementation of NPP by 2020. A government supported Annual Development Project for the 2008 – 2011 cycle has been approved in 2008 to accomplish essential activities to Implement Rooppur Nuclear Power Plant which is now under execution. Bangladesh Atomic Energy Commission (BAEC) under supervision of the Ministry of Science & Technology (MOST) is presently conducting/reviewing some site specific studies as well as updating data to complete the Site Safety Report and to make the site suitable for heavy construction as per IAEA recommendations/guidelines. The application for the site license of RNPP has been put forward to Nuclear Safety & Radiation Control Division (NSRCD), BAEC in order to take appropriate actions.

On 2 November 2011, Bangladesh signed an Inter-Governmental Agreement (IGA) with Russia for a Nuclear Power Plant (NPP) with two units, each of 1,000 MWe. Under the IGA, Russia will also provide financial support for the first NPP in Bangladesh, supply the nuclear fuel and take back the spent nuclear fuel. The target for commissioning the first NPP and starting commercial operation is 2020-2021.

The IGA covers the following main aspect:

a) Design, construction and commissioning of the first NPP with two VVER units, each with 1000 MWe;
b) Development of necessary infrastructure in Bangladesh for NPP operation;
c) Development of the legal basis and regulation for nuclear safety and emergency response;
d) NPP technical design including the Preliminary Safety Analysis Report (PSAR) and other documentation;
e) Planning and monitoring of the first NPP construction activities and services performed by the contractor, quality management, training of personnel;
f) Long-term supply of nuclear fuel and take back of spent fuel;
g) Cooperation in the management of radioactive waste and decommissioning of NPP units.

Subsidiary agreements or contracts will be negotiated in the above mentioned areas, with specific terms and financial arrangements.

INIR Mission

Prior to the mission, the INIR mission team reviewed the self-evaluation report and supporting materials. Input was sought from IAEA staff members with relevant experience.

Several INIR mission team meetings were conducted prior to the mission, including full team meetings in Vienna on 04 November 2011 and Dhaka on 08 November 2011, to discuss the team's initial views on the infrastructure status.

The mission was conducted from 09-15 November 2011. Given the long history of the Bangladesh nuclear power programme planning and the conclusion of IGA for the NPP, the team reviewed conditions for both Phases 1 and 2.

The mission was coordinated on the Bangladesh side by the Secretary for the Ministry of Science & Technology (MOST). The meetings was held at BAEC offices. The interviews were conducted over five days. The preliminary draft report was prepared and discussed with the counterparts. The preliminary mission results were presented on 13 November 2011 to the Minister of SC. A more detailed presentation of the preliminary mission results was presented to senior officials in an exit meeting on 15 November 2011.

The INIR Mission was conducted in a cooperative and open atmosphere. The mission team recognized that the Bangladesh nuclear power program and associated infrastructure is progressing. From the time the self-evaluation report was submitted until the time the INIR mission was conducted in November 2011, a few notable developments had taken place, including the signing of the IGA on 2 November 2011 and preparation of the organizational framework of the new Regulatory Body.

The INIR mission team concluded that the Government has made a clear commitment to a nuclear power programme, which is important to sustaining the planning process and to implementing the project. The mission team noted, however, that in the last decade several draft policies and action plans that have not been fully updated or approved. The mission team observed that once the project is initiated, sustained policies, and sustained leadership will be necessary to complete the negotiations and implement the project.

The INIR mission team concluded that the Bangladesh mostly reached Milestone 1, having "made a knowledgeable decision" regarding its nuclear power program. There are two open issues that still require attention from Phase 1 management and funding/financing. The INIR mission team concluded that the Bangladesh nuclear power program in general has progressed into Phase 2, being in the stage of preparation to negotiate the agreement(s)/contract(s) with selected NPP Vendor.

The main conclusions were in several areas as summarized below. To assist Bangladesh in making progress in its infrastructure development, the Mission team made 50 recommendations. The key recommendations are summarized as follows:

Preparations for contract negotiations should be made. To become a "knowledgeable customer" and to be ready to negotiate with the vendor, the BAEC will need to develop specifications for the contract which cover technical, economic, commercial and training aspects for the fuel supply, the reactor units, supporting infrastructure and spent fuel take-back and waste disposal. Bangladesh should have

a clear understanding of the two options—Government ownership (turnkey) or BOOT and prepare analysis of options for decision-makers (including risk analysis), as well as have the capabilities within BAEC to negotiate and prepare the contract. The coordination among the Government committees overseeing the programme and with the implementing organizations (the future owner and the regulatory body) will need to be strengthened to allow for timely decisions to be taken and implementation to be facilitated.

The regulatory body should be strengthened. The draft Bangladesh Atomic Energy Regulations Act of 2011 should be promulgated as soon as possible to establish an independent regulatory body. The regulatory body should be prepared to issue the site license. An agreement with the Russian regulator for training and technical support during the licensing of the first NPP in Bangladesh is in process and should be finalized. Eighteen needed regulations identified during the mission, eight of which have already been drafted, should be finalized and issued.

Management of the nuclear infrastructure development should be strengthened. As the programme progresses into the next stage after the IGA and prepares to negotiate with the vendor, BAEC is undergoing significant changes. BAEC should be prepared to carefully manage these changes: NPED, as the future owner, should become a knowledgeable customer for the Russian vendor and its organization inside BAEC should grow accordingly. The NSRCD will become an independent organization and move to a separate building which has already been constructed. Bangladesh should commit to ensure appointment of leaders (especially in future owner and regulatory body) with appropriate training and experience for leadership and management of safety. Integrated management systems (including quality management) should be planned and implemented in both BAEC and the regulatory body which define the organizational goals and key processes in sufficient detail. A unique coordinator should be identified as the project manager responsible and accountable for the NPP development.

A national project plan should be developed. The project plan should include the relevant actions from other national authorities responsible for infrastructure activities necessary for the NPP. The project plan should include timeframes and financial evaluations. The BANPAP should be updated, which could serve as an outline for such a project plan.

On-going activities should be completed. Siting studies should be completed as soon as possible in conjunction with the NPP vendor. Roles and responsibilities for nuclear power infrastructure should be clarified with other national authorities (e.g. Ministry of the Environment). A national level human resource plan should be developed covering the regulatory body, the future owner-operator and the future

waste management organization. Where appropriate, integrated training should be provided. A strategic plan for stakeholder management and public information should be implemented. A policy for the fuel cycle including take-back of spent fuel should be developed. A policy for long-term management of Low and Medium level radioactive waste (RW) that will not be sent back should be developed which would include a financing scheme.

In addition to these recommendations, the INIR mission team made 20 specific suggestions to support continued improvement and strengthening of Bangladesh program.

The INIR mission team further recognized 2 good practices, which are worthy of the attention as a model in the drive for excellence in infrastructure development: the preparation of a safeguards policy paper and the ranking of the nuclear facility as a key protected infrastructure for the purposes of physical protection.

2.3. FUTURE DEVELOPMENT OF NUCLEAR POWER

LINKAGE OF NUCLEAR POWER PLANNING WITH THE MACRO LEVEL PLANNING

In Bangladesh, the medium to long-term and short-term (annual) macro planning are conducted under term plans (Five Year Plan) and Annual Development Programmes, respectively. The Term Plan is divided into various sectoral plans. Development targets of electricity generation, transmission and distribution over a plan period are set under the energy sector. Thus, any decision on nuclear power programme is taken by considering the overall programme for the sector. Various studies are conducted to assess energy demand during the plan period and on the supply side the technologies for generation are identified by considering the relevant factors such as economics, fuel option, environmental dimension, project gestation period, availability of finance, etc. The National Energy Policy, with a perspective period of 25 years is also consulted for the purpose. In the case of Bangladesh, the need for introducing nuclear power is identified in all these macro-level plans and policy documents. The existing executive framework for the project, which is discussed in a later paragraph, has been proved useful in establishing the linkage with the macro level planning.

It is also equally important to assess the economic aspects of nuclear power as a component of a least cost generation plan. The environmental impact of various options should also be assessed properly as one of the tools for decision-making.

In many developing countries, the new trend is to deregulate the electricity sector. Private entrepreneurs are attracted to invest in the entire range of activities, including generation. Of late, entrepreneurs have established generating plants in Bangladesh under Power Purchase Agreements. In the transitional phase, extreme care has to be taken in choosing the technology and fuel options for evolving the optimum generation plan. In particular, the conditions of power purchase agreement for the private sector generation may upset

overall optimization of the system. Other factors deserving attention include the administered price of indigenous fuels and energy tariff. Centralized planning for generation may thus need some structural changes and review of strategies by considering the above changes.

THE NEED FOR AN INTEGRATED APPROACH TO PLANNING

The macro-micro linkage is an important pre-requisite for the integrated approach to nuclear power project planning. However, the other important facet is the need for integration among various elements of micro planning of nuclear power programme. The two broad strings of activities that have to be addressed with equal earnestness and seriousness right from the inception of a nuclear power programme are:

(a) Technical, economic and financial management of the nuclear power programme; and
(b) Safety and regulatory aspects.

Since the above two categories of functions are to be ultimately conducted independent of each other, the planning for nuclear power, including capacity building and human resource development activities as well as the necessary legal frameworks for each of these, need to be addressed properly. Issues like management of radioactive waste including a policy on ultimate disposal of high level wastes also require attention at the early stage. Other issues, like capacity building in quality management, identification of codes, guides and standards, project management, etc., also deserve due consideration. In particular, the human resource development programme should be developed in such a way that the core manpower acquires at least working knowledge in the above-mentioned key areas of the nuclear power programme.

Bangladesh Nuclear Power Action Plan

A blanket administrative provision is essential to ensure efficient implementation of a government decision on the national nuclear power programme. Its overwhelming role is evident from the wide range of national as well as international agencies, whose concerted participation is essential for the success in realizing the decision effectively. Such a provision is best served through a National Nuclear Action Plan, adopted at the appropriate level of the government. The main purpose of this document is to identify:

- Various activities needed for implementation of the nuclear power programme;
- The agencies responsible for each of these activities;
- Enabling measures like funding, for conducting the activities.

The government of Bangladesh adopted the National Nuclear Action Plan (BNPAP) for meeting the above-mentioned purposes for early implementation of the nuclear power project in the country in 2000.

The Table of Contents the BANPAP are as follows:

Presently, Bangladesh is revising and updating the Bangladesh Nuclear Power Action Plan according to national and International aspects of nuclear power programme.

2.3.2. PROJECT MANAGEMENT

In the 1st meeting of the National Committee headed by the honourable Prime Minister dated 2nd March 2011 on the subject related to direction and monitoring for the implementation of Rooppur Nuclear Power Plant Project, it has been decided that Rooppur Nuclear Power Plant Project will be implemented under the ownership of the Government of Bangladesh. In that meeting, the process of BOOT and Turnkey has also been considered.

In the light of the National Committee, an Inter-Governmental Agreement (IGA) was signed on the construction of the nuclear power plant between the Government of People's Republic of Bangladesh and Russian Federation on 2nd November 2011 in order to implement Rooppur Nuclear Power Plant Project. According to the section-2 of IGA, Bangladesh Atomic Energy Commission (BAEC), Ministry of Science and Technology (MOST) have been considered as customer and competent authority of the Rooppur Nuclear Power Project respectively. On the other way, Atomstroyexport on behalf of Russian federation and Rosatom have been identified as the contractor and competent authority respectively.

In this continuation, the different aspects of the project implementation have been discussed on the meeting held in the Prime Minister's office on the last 25th January 2012 convened by the economic advisor of the honorable Prime Minister. In that meeting, a detailed discussion of the pros and cons of BOOT and Turnkey process was held considering the present progress of Rooppur Nuclear Power Plant Project.

Under the auspices of the Russian Federation Government, there is provision to implement the Rooppur Nuclear Power Project through the establishment of a joint venture company under the BOOT operator. If this project is implemented under this process, the Government of Bangladesh will not have direct responsibilities on the process of implementation as well as funding of the project. Moreover, the involvement of the local experts for the different phases of the project implementation and operation of the plant is not mandatory. Depending on the consideration that the overall risks rendered on the BOOT operators in case of the implementation and operation of the project, the cost of the electricity generated from Rooppur Nuclear Power Plant will be relatively high. On the other hand, because of the supply of the electricity in an affordable price mostly depends on the BOOT operator, there will be uncertainty in the energy security of the country in long term future. In addition, the provision in the human resource development for the nuclear technology including technology acquirement will be narrower and hence there will be perplexity on the handover of the plant to Bangladesh. Moreover, if initiatives are taken to implement the Rooppur Nuclear Power Project in cooperation of Russian Federation following BOOT process, there will be necessity to change, re-correct the conditions of the signed Inter-Governmental Agreement between two countries. As a result, bilateral discussions will be needed between the two governments in order to re-construct the already completed agreement following BOOT process and it will be completed in a long process. By the approval of both governments on the corrected agreement following BOOT process, it will be signed again. In this case, there can be procrastination in the implementation of the project.

On the other hand, Rooppur Nuclear Power Plant Project can be implemented under the ownership of Bangladesh Government following Turnkey process in cooperation with Russian Federation depending on the signed IGA with Russian Federation. In this case, Bangladesh has to take responsibilities of collecting funds including all management systems of the implementation of the project. Still, the maximum probable risks can be

rendered on the supplier country in the phase of design, construction and commission of the nuclear plant through completing a proper Turnkey Contract with the supplier country. Considering the nuclear infrastructure, the Rooppur Nuclear Power Project can be implemented through completing a Turnkey Contract with the supplier country following the international rules under the local jurisdiction. A proper institution can be given responsibilities under the auspices of Bangladesh Government in the completion of the design, construction, commissioning and overall implementation of the Rooppur Nuclear Power Plant Project.

2.3.3. PROJECT FUNDING

It is necessary to prepare a financing plan including necessary infrastructure, all site studies and the construction of the plant in the light of the signed agreement with Russian Federation in order to estimate the actual cost of the implementation of Rooppur Nuclear Power Plant Project. The financing plan shall include the construction of Rooppur Nuclear Power Plant in a safe and cost-effective manner, site characterization of the Rooppur site area, pre-design and design documentation drafting, construction of the two units each of 1000 MW and their related physical infrastructure as for example waste disposal facility, interim spent fuel facility, grid facilities, calibration laboratory facilities, safeguard equipment and facilities, emergency response facilities and organization, communication system development, transport access, human resource development, training facilities, public information center etc. The terms and condition of the financial contract shall be drafted for the State Credit from the supplier's country. In this case, interest rate should be kept minimum. Apart from the State Credit, the part which Bangladesh Government will carry, shall be explored from different sources as for example Annual Development Project (ADP), soft loan etc.

2.3.4. ELECTRIC GRID DEVELOPMENT

The power generated at different power stations are evacuated through a national grid system comprising 230 kV & 132 kV network operated and maintained by the government owned company named Power Grid Company of Bangladesh Ltd. (PGCB), which is the first utility in the power sector of Bangladesh having ISO9001:2000 certification. The responsibilities of the PGCB include (1) Operation and maintenance of grid substations and transmission line, (2) Load dispatching (overall operation of the grid network), (3) Operation and maintenance of communication system including Optical fiber network, (4) Protection, relay coordination and (5) Transmission network Planning & Design. The PGCB carries out its activities so as to achieve the following goals:

- Economic upliftment of the country by reaching electricity to all through reliable transmission,
- Efficient and effective management of national power grid for reliable and quality transmission of electricity as well as economic dispatch through out the country.

At present, the national grid system has the capability to handle a maximum load of about 7000 MW. The transmission lines of the grid system and grid substations that are under the control of PGCB are as follows:

A. Existing Transmission line

(a) 230 kV : 2644.5 Circuit km

(b) 132 kV : 5741 Circuit km

B. Existing Substations

(a) 230/132 kV : 12 (6300 MVA) + 1 No. Switching Station

(b) 132/33 kV : 75 (7844 MVA)

Besides these, the Dhaka Power Distribution Company (DPDC) and Dhaka Electric Supply Company (DESCO) maintain about 77 circuit km of 230/132 kV transmission line. Bangladesh Power Development Board (BPDB) has two 230/132 kV substations with a total capacity of 550 MVA, while the BPDB, DPDC and DESCO have eighteen 132/33 kV substations having a total capacity of about 2055 MVA.

The grid system of Bangladesh has a National Load Dispatching Center (NLDC) located in Aftabnagar, Rampura, Dhaka. According to the plan, 400 kV transmission lines are going to be hooked up with the grid system in neat future. The 400 kV lines will mainly be used to import electric power from India. Some of the key parameters of the above grid system are given below:

A) As per Grid Code

(a) Variation of voltage: ± 5% (normal), ± 10% (For Emergency)

(b) Variation of frequency: ± 1% (normal), ± 2% (Abnormal)

(c) Fault clearing time: Within 100 ms

B) As per Present Condition

(a) Variation of voltage: ± 10% (normal), ± 20% (For Emergency)

(b) Variation of frequency: ± 1% (normal), ± 2% (Abnormal)

(c) Fault clearing time: Within 150 ms

As per the present power system expansion plan the dependable generation capacity of the country will be about 12000 MW against maximum demand about 11000 MW in 2017. The install capacity is projected to increase to about 33000MW by 2030. It is expected that by 2020 the contribution from nuclear generation will be about 2000 MW and by 2030 it will be increased to about 5000MW. Keeping all the above in mind the PGCB needs to take up measures to upgrade the national grid so as to make it compatible with the generation capacity of the country and in particular, make the grid ready for accommodating the

upcoming nuclear power plant having a capacity of 1000MW by 2017 a second unit of same capacity by 2020. For this purpose detailed power system studies including Load flow studies, Transient stability studies, Long duration system dynamics studies involving loss of generation, etc. are to be conducted as soon as possible.

2.3.5. SITE SELECTION

SITE SAFETY REPORT OF THE PROPOSED ROOPPUR NUCLEAR POWER PROJECT

Bangladesh prepared a draft site safety report on Rooppur Nuclear Power Project in the year of 2000. Recently, the government of Bangladesh has taken steps to carry out several site specific new studies and also review/update the previous studies/data to finalize the site safety report. BAEC has conducted the following site specific studies of the proposed Rooppur Nuclear Power Project to estimate the specific safety parameters required for designing and constructing the nuclear power plant at Rooppur.

(i) **Site Specific Geological, Geophysical and Geotechnical Study of Rooppur Nuclear Power Project**

(a) Review of geology and fault information; Compilation of earthquake database; Analysis of seismic source and seismicity characteristics; Probabilistic seismic hazard assessment (200, 475, 975, 2475 years);
(b) 1D Site response analysis (Site specific) study; Development of site specific response spectrum;
(c) Determination of liquefaction resistance by cyclic triaxial test;
(d) Assessment of liquefaction potential of the site;
(e) Supervision of Geophysical Investigation by P-S logging and
(f) Analyses of Soil Stabilization and Slope Stability.

Bangladesh Atomic Energy Commission had made agreements with Bureau of Research, Testing and Consultation (BRTC), Bangladesh University of Engineering and Technology (BUET), Dhaka, Bangladesh and Ground Water Hydrology Division (GWH), Bangladesh Water Development Board (BWDB), Dhaka, Bangladesh to perform services in respect of above-mentioned "Site Specific Geological, Geophysical and Geotechnical study of Rooppur Nuclear Power Project".

Summary of the Study:

- Tectonically Bangladesh is divided broadly into three (3) divisions :
  - Stable Shelf (in the northwest),
  - Bengal Foredeep (in the centre), and
  - Chittagong-Tripura Belt in the east).

- In addition there is a SW-NE trending 25 km wide Hinge Zone separating the Bengal Foredeep from the Stable Shelf. The proposed Nuclear Power Plant site at Rooppur is located near this Hinge Zone in the Stable Shelf part.

- During the last decade, the occurrence and damage caused by a number of earthquakes (magnitude between 4 and 6) inside the country or near the country's border, has raised the awareness among the general people and the government. These earthquakes are located far away from the Rooppur site.
- There is no indication of surface faulting around the site;

(ii) **Study on Site related hydrological and morphological characteristics of Ganges River in the vicinity of site, and flooding effect due to global climate change impact and man-made major interventions**

Bangladesh Atomic Energy Commission has taken steps to finalize a report on hydrological and morphological characteristics of the site area in collaboration with Institute of Water Modelling IWM), Bangladesh through an agreement. IWM has already conducted the requisites of the site study whose summary is given below.

- Global climatic change has significant impact at the project area from hydrology and hydraulic points of view (depth & extent of flood).
- There is no impact of tsunami at the power plant site.
- Due to construction of proposed Ganges Barrage, the water level will be up to 17m PWD. The crest level of existing embankment and pakshey bridge guide bund is 16.5 m PWD and 16.7mPWD respectively.
- There is no hydraulic impact at the RNPP site due to Gorai river restoration project.
- With global warming scenario, it is found that computed water level is over 18mPWD in the vicinity of RNPP site while the existing embankment height is 16.5mPWD.
- Possibility of left bank erosion of Ganges River at RNPP site is insignificant.
- The recommended location for the intake point is 401177.95m easting and 659569.00m northing.
- The recommended location for the outfall point is 403952.90 m easting and 659543.00m northing.

(iii) **Updating/Reviewing the previously prepared Site Safety related study/data**

The site related demographic, meteorology data, transport planning and emergency response planning have been updated.

2.4. ORGANIZATIONS INVOLVED IN CONSTRUCTION OF NPPS

It is planned that a core group will be formed long before-hand the construction of the plant and that group will be involved with the construction of the plant with the main contractor.

In case of the Rooppur Nuclear Power Project, the scope of the participation of the national industry in the project will be limited to items that do not have safety implications and such works, if undertaken by local parties, will be coordinated under the supervision and total responsibility of the prime contractor from supplier side. However, the local participation should be maximized. It is desirable that about 30% of total investment mostly for site preparation, site development and development of local infrastructure such as workers' township, roads and also building of some non-nuclear safety related structures in the project site can be undertaken locally. Bangladesh believes a step by step increase of national participation for subsequent units. On the other hand, the national policy to widen the participation of national industries is not analyzed yet.

2.5. ORGANIZATIONS INVOLVED IN OPERATION OF NPPS

While signing the main contract, a separate contact will be signed about training a group of core operators group within BAEC who will be skilled enough to obtain a licence from the main contractor's country. This core group will work under the main contractor's operator for a substantial amount of time.

2.6. ORGANIZATIONS INVOLVED IN DECOMMISSIONING OF NPPS

Alike construction and operator core group, a separate group will also be formed for decommissioning who will obtain training and skill from the main contractor's country.

2.7. FUEL CYCLE INCLUDING WASTE MANAGEMENT

Existing Waste Management Facility

Bangladesh is not operating any NPP. The country has a research reactor and there is a facility for isotope production. Program on waste management is focused to that related to research reactor and industrial uses of radiation/nuclear sources.

BAEC has established the Central Radioactive Waste Processing and Storage Facility (CWPS) in the campus of AERE, Savar under the Govt. Annual Development Project and the IAEA Technical Co-operation Project (BGD/4/022, 2001-2004). The functions of this facility are: collection, segregation, packaging, conditioning, treatment, and storage of low and intermediate level radioactive wastes from different nuclear facilities.

The design of the facility was based on the IAEA generic reference design. The main building is a single storey building (total area 1163 m2; size: 40 m x 35 m), divided internally into a number of rooms and areas for different purposes. The main building consists of a suitable combination of mainly two areas: one for receiving and processing waste from the generators, includes the necessary equipment, machinery and support services for treating and conditioning the waste, the second one for storing radioactive wastes.

Main operating area is divided into three parts: (1) an enclosure for solid wastes sorting, compaction (9m x 10.98m x 4.88m h); (2) Conditioning (cementation) enclosure sub-divided into cementation area 6.6m x 6.0m (active room); grout preparation room: 3.65m x 6.0m (non-active) & pulverization room: 3.65m x 6.00m; and (3) liquid effluents treatment (LET) enclosure (6m x 7.3m) having provisions for treatment of aqueous liquid wastes by combined technique (Ion-exchange + ultra-filtration).

The following major equipments are available in the CWPSF for segregation, treatment, conditioning storage and transportation of low and intermediate level liquid and solid wastes within the facility:

(1) Aqua-Express (liquid waste treatment plant): For treatment of low and intermediate level liquid radioactive waste.

(2) In drum-mixer: The electrically driven mixer unit for the cementation of small volume of liquid wastes, sludges, an ion-exchange resin, etc.

(3) Solid waste sorting box: The sorting cabinet has been set-up to segregate the different types mixed solid low level wastes.

(4) In drum compactor: An in-drum compactor operates on the compactable waste drum to give compacted waste drum (expected volume reduction factors are in the range between 2 to 5).

Radioactive wastes are being generated through the operation and maintenance of 3MW(t) TRIGA MARK-II Research Reactor, Radioisotope production labs, 14 MeV Neutron Generator, research and commercial irradiators; and from different industries, research labs (such as INST, AECD, IFRB, ICDDRB, etc), universities, agricultural applications etc.

There are eighteen Nuclear Medicine Centres (NMC) including two private and one Nuclear Medicine Institute (NMI) in Bangladesh. Nuclear Medicine Facilities (NMF's) are using radioisotopes such as: I-131, Tl-201, P-32, Cr-52 and I-125. Most of the NMFs use Sr-90 for eye applicator. In addition, there are ten industrial radiotherapy facilities and three gamma irradiator facilities are using Co-60, Cs-137 and Ir-192 radioisotopes for a variety of purposes in research, industry and other fields. There are ten radiotherapy installations with ten Co-60 Teletherapy units, one linear accelerator, 3HDR and 2LDR brachytherapy units.

The radioactive wastes arising are generally spent ion-exchange resins, graphite, lead and polythene plugs, resistance temperature device, solid trashes, contaminated vials, hand gloves, plastic syringes, tissue papers, shoe-covers, protective cloths, plastic and metallic wares, contaminated apparatus/equipment, aqueous and organic liquids, spent and disused SRS, activated carbon, gaseous discharges, etc. The radio nuclides involved are e.g., Co-60, Cs-134, CS-137, Sr-90, Ir-192, Tc-99m, I-131, I-125, C-14, H-3, Ra-226, Am-Be neutron

sources, Cm-244, Am-241, Cr-51, Mn-54, Zn-65, P-32, Sc-46, etc. Moreover, if the proposed nuclear power plant is established in the country, more anthropogenic radionuclides will be involved in these wastes in future.

Approximately 6.61m3 of LILW have been collected and safely stored at CWPSF. For the storage of these wastes the facility has earned approximately Taka 16,72,299 in the last financial year. For improvement and strengthening in terms of operational capability, safety and security of RW including spent radioactive sources and overall security of the facility. CWPSF is expected to serve waste management need in the country and, in the course of time, it may be turned into an International level training centre in the field of radioactive waste management. It is essential for safe conduction and culture of research and application in nuclear science and technology maintaining the relevant safety of man and environment and future generations to come. The facility is expected to be helpful in piloting waste management tasks in large scale in the near future. The Safety Analysis Report (SAR) of the facility has recently been prepared in collaboration with the International Atomic Energy Agency (IAEA) and it is expected that the facility will be licensed very soon.

Approach to Nuclear Fuel Cycle

Bangladesh believes that a healthy market exists at the front end of the fuel cycle. Currently, all reprocessing plants are state owned and any guarantee from a supplier would have the implicit or explicit agreement with the corresponding government. Based upon the existing nature of the nuclear business worldwide, Bangladesh is considering a long-term contract and transparent suppliers' arrangements with supplier(s) through backing of the respective government in order to ensure availability of fuel for the nuclear power reactor of the country. Examples would be: fuel leasing and fuel take-back offers, commercial offers to store and dispose of spent fuel, as well as commercial fuel banks. On the other hand, at present there is no international market for spent fuel disposal services. Storage facilities for spent fuel are in operation and are being built in several countries. There is no international market for service in this area, except readiness of Russian federation to receive Russian supply fuel.

Bangladesh is considering accessing detailed technical descriptions of the nuclear fuel assemblies offered from the supplier side, including physical, thermo-hydraulic, thermodynamic and mechanical data as well as calculations for batch planning (short term and long term). This technical description should refer to the following items: General NSSS, Core, Fuel pellets, Fuel cladding and Fuel rods, Fuel assembly, Fuel performance, In-core inventories, Reactivity budget and control characteristics, Use of burnable poison, Reactivity coefficients, Neutron fluxes, Core thermo-hydraulic characteristics, Manufacturing methods, References for the offered fuel assemblies, Evolution of burn-up, Safety design aspects. The supplier shall provide the QA programme, Handling and inspection methods for new and spent fuel and Tools for fuel and control rod manipulation and the scope of supply and services.

The first core as well as the first reload should be included in the scope of supply for the plant. The Bidders should include the supply of further reloads as an option. Please note that in case of technologies with provisions for on-line fueling, each reload means the full replacement of all in-core fuel elements.

Bangladesh is considering that the supplier should (i) make their commitment to deliver within their scope of supply all relevant data and information on the fuel elements so that if situation demands Bangladesh can have the option to procure subsequent reloads through competitive Bids from qualified fuel manufacturer; (ii) provide the technical specifications for the yellowcake and the enriched uranium; which may be required for ordering and manufacturing the fuel and also (iii) provide a complete technical description of each part of the supplies, in accordance with the requirements made by Bangladesh. The major concerns of Bangladesh about the nuclear fuel cycle are as follows.

1. The owner/operator of the nuclear plant in Bangladesh needs to ensure availability of fuel for the nuclear power plant covering its entire life cycle from supplier(s).

2. The above life cycle assurance of supply shall include all services related to the front end of the fuel cycle. Fuel leasing-fuel take-back" model or partial 'fuel-leasing-fuel take-back' model is conceivable for Bangladesh.

3. Alternate sources of services and supply of the front end of fuel cycle should be identified to accommodate any unforeseen circumstances.

4. Depending on the size of the nuclear power programme, efforts will be made to acquire the technology of fabrication of fuel elements based on imported raw materials and enrichment services in order to ensure security of fuel supply.

5. Pending a final decision on the back-end of the fuel cycle, the nuclear power plants will have provision for on/ off -site spent fuel storage, size of which shall be sufficient to store the spent fuel generated over their respective life cycles.

6. Sufficient security and physical protection and safety of the fuel storage at site will be provided in accordance with the relevant provisions of the non-proliferation regime as well as national law and regulations on nuclear safety and radiation control.

Bangladesh will consider any suitable model of nuclear fuel cycle under responsibility of the IAEA as the guarantor of service and supplies, e.g. as administrator of a fuel bank. Bangladesh is committed to introduce Nuclear Power plant for electricity generation. Presently, the country is considering the assurances of fuel supply and services not involving ownership of facilities. The country has a full commitment on peaceful uses of atomic energy and strongly recognizing the importance of the assessments of multilateral nuclear approaches, namely “Assurance of non-proliferation " and " Assurance of supply and services". Thus, based upon current international practices in nuclear business, a suitable approach to nuclear fuel cycle with stronger bilateral arrangements with the supplier’s country is an important option to Bangladesh.

Bangladesh opines that as far as assurances of supply are concerned, the proposed multilateral approaches to nuclear fuel cycle could provide the benefits of cost-effectiveness for developing countries with limited resources. Bangladesh is strongly supporting the Agency’s approach of developing and implementing international supply guarantees with IAEA participation. Bangladesh is supporting the proposals of themultiple approaches to nuclear fuel cycle proposed IAEA brokered deal or with stronger bilateral or multilateral arrangements by countries/region/continent. The country is also supporting the international initiatives of creating, through voluntary agreements and contracts, multinational, and in particular regional, multinational nuclear approaches for new facilities based on joint ownership, drawing rights or co-management for front-end and back-end nuclear facilities, such as uranium enrichment; fuel reprocessing; disposal and storage of spent fuel.

2.8. RESEARCH AND DEVELOPMENT

2.8.1. R&D ORGANIZATIONS

BAEC has been engaged in research and development in various fields of peaceful applications of nuclear techniques since early sixties. Introduction of nuclear power in the country has always been a priority area. Development of human resources for the programmes was initiated in the sixties with the assistance of the International Atomic Energy agency, which is still continuing. However, since it was not possible to implement the nuclear power project for different reasons, activities of the organisation were diversified to make them responsive to the development needs of different sectors of national economy. Activities now encompass following areas.

(a) Medicine

One Institute and nine Nuclear medicine Centres have been established in different parts of the country. Nuclear and other state-of-the art techniques are used in such Centres and the Institute in providing diagnosis and other health care services to the people. This may be considered to be a major breakthrough both in terms of level and quality of services, type of techniques used, acceptability and dissemination of the techniques and cross-section of

people and area covered. A number of additional medical centres are planned to be built in near future.

(b) Agriculture

The Bangladesh Institute of Nuclear Agriculture is involved in R&D in radiation genetics, fertilizer uptake, plant-soil relations and other related areas. It has been possible to evolve a few varieties of crops having higher yields, disease resistance and early maturing characteristics. Some of the varieties have successfully passed field level trial production tests and are considered to have positive response from the growers. At present, activities in this field, including other programmes of the Institute, are being co-ordinated by the Bangladesh Agriculture Research Council.

(c) Food and Medical Products

R&D on radiation preservation of food, sterilization of medical products, radiation induced sterilization of insects, study on pesticide residues in post harvest agricultural products, etc., are being conducted. A commercial food irradiator, a joint venture with a private sector enterprise has been set up.

(d) Industry

BAEC is rendering non-destructive testing (NDT) services to different private and public sector organisations of the country. It is also imparting training to the personnel and is involved in their certification with IAEA/RCA assistance.

(e) Radio-tracer techniques

Radio-tracer techniques are being used in industries for detecting certain materials such as mercury in chemical industries and minute impurities in different samples. Such techniques are also used for measuring flow in natural gas network, in locating leaks in pipelines, for studying silt/sediment movement in the harbour, etc.

(f) Radiation Processing Technology

Radiation processing technology is being developed to improve quality of materials like wood, electric cable, etc.

(g) Vulcanization of Rubber Latex

Vulcanization of rubber latex using gamma radiation is being studied, especially to ascertain its application in producing hand gloves, family planning materials, etc.

(h) Radioisotope Production

The basic infrastructure for a radioisotope production laboratory has been built. When the envisaged Animal house for clinical tests is built, this facility would be equipped to conduct tests before products produced here are marketed for use. Production cells for isotopes like

125I, 131I and 99mTc have been installed and the isotope kit preparation programme has been under-taken. Trial production of sample isotopes has already been accomplished. When the radioisotope production unit is ready, it will be possible to produce isotopes as substitution to import.

(i) Development of nuclear analytical science

The Analytical laboratory for physical and chemical analysis of materials including the development of related nuclear techniques has been established to conduct research and to provide related services.

(j) Research reactor

A 3 MW research reactor has been installed for conducting research, training of personnel and production of short-lived radioisotopes for medical uses. It may be mentioned that in spite of its being the first major nuclear facility in the country, the local participation in its implementation was significant. Appropriate research laboratories based on the reactor facilities, such as radioisotope production, neutron activation analysis, neutron radiography, neutron spectrometry for elemental and structural analysis of materials are being developed.

(k) Exploration of nuclear and other related minerals

Prospecting of nuclear and related minerals is included in the overall programme of the BAEC. Surveys were conducted in the past in various regions of the country to ascertain the possibilities of finding Uranium and Thorium. This survey helped identify some areas where such materials are available at various levels of concentration. Extensive surveys, including drilling, are needed to ascertain the extent of reserves and the prospects of their mining on a commercial scale.

2.8.2. DEVELOPMENT OF ADVANCED NUCLEAR TECHNOLOGIES

Bangladesh has not yet engaged with advanced nuclear technologies.

2.8.3. INTERNATIONAL CO-OPERATION AND INITIATIVES

MEMBERSHIPS IN INTERNATIONAL ORGANIZATIONS

Bangladesh became a Member State of the Agency in 1972.

INTERNATIONAL AGREEMENTS

Bangladesh is a party to a whole range of commitments to the international nuclear non-proliferation and verification regime, such as NPT, Bilateral Safeguard Agreement with the

IAEA, the Protocol Additional to Safeguards Agreement, and the Comprehensive Test Ban Treaty (CTBT). Please see Appendix 1.

PAST TECHNICAL CO-OPERATION WITH IAEA

BAEC operates under the Ministry of Science and Information & Communication Technology (MOSICT), and is thus an integral part of the scientific network of the country. BAEC has been the national focal point for the IAEA including its Technical Cooperation (TC) program and the Technical cooperation program with the Agency has, so far, covered almost the entire range of BAEC activities, especially those, which have direct relevance to the national development agenda. The total assistance provided during the last 10 years (1991-2000) amounted to approximately US$6.885 million. More than half of this assistance (53.87%) was devoted to the human resources development areas, namely Experts, Fellowships, Training Courses, and Scientific Visits. The reminder was provided in the form of equipment and subcontracts. Area-of-activity wise, 88% of the assistance was provided in five areas, namely, agriculture (24.2%), application of isotopes and radiation in medicine (21.2%), nuclear engineering and technology (20.3%), nuclear safety (13.1%), and industry and hydrology.

ONGOING TECHNICAL CO-OPERATION WITH IAEA

The list of ongoing IAEA TC Projects is as follows:

2009-2011

Sl. NO.	Project Code	Project Title
01	BGD/4/024	Establishing Nuclear power

2005-2006

Sl. NO.	Project Code	Project Title
02	BGD/4/023	Rehabilitation and Refurbishment of Van de Graff Accelerator
03	BGD/9/011	Strengthening of the Safety of the Research Reactor
04	BGD/6/019	Body Composition Assessment and Impact on Fetal Development
05	BGD/6/018	Strengthening and Expansion of Nuclear Cardiology
06	BGD/5/025	Feasibility Study of Using Sterile Insect Techniques (SIT) in

		Sun-dried Fish Industry.
07	BGD/5/024	Phytosanitation Treatment for Insect Pests Infesting Fresh Fruits and Vegetables
08		IAEA TC Project for the year 2005-2006(Cycle)

2003-2004

Sl. NO.	**Project Code**	**Project Title**
09	BGD/2/010	Upgrading the Technetium Generator Production facilities.
10	BGD/4/022	Establishment of a Central Radioactive Waste Processing & Storage Facility
11	BGD/8/018	Isotope Technique, for Mitigating Arsenic Contamination in Groundwater

2001-2002

Sl. NO.	**Project Code**	**Project Title**
12	BGD/4/022	Establishment of Central Radioactive Waste Processing and Storage Facilities
13	BGD/8/018	Isotope Techniques for Mitigating Arsenic Contamination on Groundwater

2.9. HUMAN RESOURCES DEVELOPMENT

A number of 1660 personnel has primarily been selected in different phases for Rooppur Nuclear Power Plant Project. It is necessary to chalk out the framework of the training for the efficient manpower to implement the project, operate and properly maintain the plant. It is to be noted that according to the signed bilateral cooperation agreement between Russian Federation and Bangladesh, there are ample opportunities to develop human resource with the help of Russian Federation. Necessary infrastructures for the higher education and training on nuclear science and engineering need to be established in order to operate Rooppur Nuclear Power Plant safely and in a cost effective manner as well as implement nuclear power project of the government. The national universities can be requested to encompass the curriculum of nuclear science and technology in the graduation and post graduation levels as well as develop necessary education and research infrastructure. During the visit of Bangladesh delegation leaded by the honorable state minister of the ministry of Science and Technology to Russian Federation in the last 25-29th February, 2012, the Russian Federation has agreed to conduct a survey to evaluate the

present education system and its different facets of Bangladesh in order to draft a framework of the human resource development for the project. If this survey is conducted, it is easier to finalize the necessary human resource infrastructure of Rooppur Nuclear Power Plant Project and draft the framework of the necessary training program. In this regard, an initiative has been taken to draft a Memorandum Of Understanding (MOU) with the related organization of Russian Federation.

2.10. STAKEHOLDER COMMUNICATION

Planning for nuclear power at the Roopur site has been on-going for nearly 50 years with no public opposition and with support of the local community. A recent newspaper poll showed 65% of the public in favour, and a poll of students in Dhaka and around the site showed 60% in favour. The BAEC website has information on the RNPP project, including the national justification.

The Ministry of Information will develop a plan for public communication on behalf of the government once the contract is signed. Bangladesh informed the team that the draft BAER 2011 contains provisions for the responsibilities of the regulatory body for stakeholder involvement. BAEC's scientific information office responds to questions and inquiries regarding the RNPP.

Outreach to neighbouring countries has been done in a variety of contexts, including through cooperation agreements, consultations and assistance in the area of regulatory development. The National Parliament and local officials are involved and consulted in the planning. For example, representatives from the local community participated in the ceremony for the IGA signing.

At the local site, BAEC maintains an office. The local residents were resettled long ago from the land, which has been preserved for the RNPP use. IAEA and FNCA training has been provided to the BAEC and Ministry technical officials. While many elements of a public information programme in different organizations exist, an interagency plan and strategy for each organization was not evident. Stakeholder management systems in the future owner and the regulatory body should be developed in order to track inquiries and follow-up. Now that the IGA has been signed, additional information regarding the national criteria and technology selected should be developed.

INFORMATION TO THE PUBLIC

Public information and public acceptance may be considered as one of the key determinants for success of a nuclear power programme. Dialogues with the public, the people's representatives at various levels and the decision makers are considered to be important determinants in ensuring transparency and public acceptance. In the case of Bangladesh,

the acceptance of nuclear power is in general favourable, especially in and around the site. This is evident from the fact that, in spite of the inordinate delay and land being a precious commodity for the villagers, it has been possible to retain the land for the project for about four decades. The general perception is that construction of a nuclear power plant would create job opportunities and have other spin-off benefits for the residents. Moreover, way back in the 1960's the families affected by eviction were offered attractive compensation packages. Nevertheless, it is apprehended that opposition groups may be encountered as soon as construction work starts. An effective public acceptance programme has to be designed and implemented in order to enhance public acceptance.

An initiative has been taken to establish a Public Information Center in Bangladesh with the help of Russian Federation. The information center will help enhance the public awareness on nuclear science & technology in different phases of public. Thus, it will be easier to inspire the students of school and college to be involved with the knowledge gain and research on nuclear science and technology. An Memorandum of Understanding (MOU) will be signed on the establishment of the afore-mentioned information center between Rosatom, Russian Federation and Ministry of Science and Technology (MOST), Bangladesh. A proper site is to be selected in order to establish the Nuclear Information Center. But, the establishment of this center can be primarily be placed in Bangabandhu Sheikh Muzibar rahman novo-theater or Atomic Energy Center, Dhaka.

3. NATIONAL LAWS AND REGULATIONS

3.1. REGULATORY FRAMEWORK

3.1.1. REGULATORY AUTHORITY(S)

BAEC is responsible to regulate use of atomic energy, radiological practices and relevant activities under the provision of the Nuclear Safety and Radiation Control (NSRC) Act, (No. 21 of 1993) and the NSRC Regulations 1997. Presently, a new act is being formulated to develop capacity building of regulatory body appropriate for nuclear power programme.

3.1.2. LICENSING PROCESS

In order to obtain a licence, a person, shall apply for a licence to the commission in the prescribed form applicable for the specific class and practice, furnishing all pertinent information required by the applicable standard and guide.

3.2. MAIN NATIONAL LAWS AND REGULATIONS IN NUCLEAR POWER

Various legal instruments are some of the pre-requisites for success in implementing a nuclear power programme in a developing country. They are to be formulated in conformity with the existing laws of the country. These instruments may include, among others, provisions for enforcing nuclear safety and radiation control, nuclear liability, establishing independent organizations for safety and promotional activities, deregulation and involvement of the private sector in activities related to nuclear power, etc. Additional legal

provisions may be required if the country wishes to attract investors to invest in the nuclear power programme. This is necessitated by the fact that in most countries, at least in the initial phase of a nuclear power programme, all activities are vested in the public sector.

The introduction of NPP requires the early establishment of a national legal and regulatory framework to ensure safety at different phases of the nuclear power programme. Establishment of the nuclear regulatory body with the responsibility of development and promulgation of detailed safety regulations, arrangement for the safety evaluation, establishment of licensing procedures for nuclear facilities and specific activities and to oversight of such facilities and activities is essential for new entrance to NPP. The nuclear legislation should allocate the safety responsibilities and covers the radiation protection principles, third party civil nuclear liability, physical protection, fuel cycle activities, transport of nuclear substances and radioactive material, decommissioning, radioactive waste and spent fuel management.

The law titled "Nuclear Safety and Radiation Control Act, 1993" was passed by the National Assembly of Bangladesh in July, 1993 and is in force since then. According to this law, Bangladesh Atomic Energy Commission (BAEC) has been empowered to work as the nuclear regulatory body. The Nuclear Safety and Radiation Control Rules were formulated for that purpose in 1997. Presently, the Regulatory Body and the nuclear energy promoter are within the BAEC. The current status of the regulatory framework is clearly focused on the IAEA Basic Safety Standards (BSS 115) overlooking other Safety Standards which are important to embark on a nuclear power programme in Bangladesh. These other Safety Standards need to be considered at the early stage of the process since they concern the siting and site evaluation and also the design, construction, commissioning, operation, decommissioning and many aspects such as Waste, Spent fuel and Transport.

Recognizing the importance of strengthening nuclear regulatory infrastructure for successful implementation of NPP in the country, such a situation is being revised by BAEC under a new draft law entitled “Bangladesh Atomic Energy Regulatory Act, 2010”. This draft has been sent to the IAEA for technical comments. Recently, BAEC received the technical comments from the IAEA and the draft is being updated incorporating those comments and to be submitted to the Ministry for government approval. This Draft BAERA Act covers the scope of activities associated with the government regulation or rules for safe use of nuclear energy and ionizing radiation and with the safety of radioactive waste and spent fuel management and physical protection of nuclear or radiation facilities. Article 5 of this draft law establishes the Regulatory Body under the Ministry of Science and ICT. Necessary directives for enactment of the BAERA Act and establishment of independent nuclear regulatory body are essential.

In order to strengthen the nuclear regulatory infrastructure suitable for RNPP, a draft Bangladesh Atomic Energy Regulatory Authority Act has been prepared by BAEC following the IAEA guidelines and recommendations. The draft act was sent to the Agency for comments. The comments of the IAEA have been received and it was updated accordingly. The updated version of the Act is sent to the Ministry of Science and ICT for taking steps

vetting from the Legislative and Parliamentary Division of the Ministry of Law, Justice and Parliamentary Affairs, Bangladesh government. The Working Group and Working Sub-Group entitled the Legal and Regulatory Aspects have been reviewing the draft to finalize the draft for submission. It is expected that the draft act will be submitted soon for the approval. After approval, this law will establish the Regulatory Body which would be independent from any Licensees.

REFERENCES

[1] Bangladesh Country Analysis Brief:**Error! Hyperlink reference not valid.**.

[2] Bangladesh Bureau of Statistics, Government of Bangldesh, Statistical Year Book of Bangladesh, 2003.

[2] Bangladesh Bureau of Statistics, Government of Bangldesh, Statistical Year Book of Bangladesh, 2007, 2010.

[3] Bangladesh Economic Review 2003, Ministry of Finance, Government of Bangladesh.

[4] National Energy Policy, 1996, Ministry of Energy and Mineral Resources, Government of Bangladesh.

[5] National Energy Policy (Revised Draft, 2004), Ministry of Energy and Mineral Resources, Government of Bangladesh.

[6] Annual Report, Bangladesh Rural Electrification Board, 2004.

[7] Country Programme Framework of Bangladesh (Cooperation between IAEA and Bangladesh, 2003-2008).

[8] Center for Energy Studies (CES), BUET, Energy Related Data for Bangladesh, available at www.buet.ac.bd/ces/coal.doc.

[9] Annual Report, 2008-2009, Bangladesh Power Development Board

Annual Report, 2009-2010, Bangladesh Power Development Board

[10] Petro Bangla Annual Report 2008

Petro Bangla Annual Report 2010

[11] Outline Participatory Perspective Plan (2010-2021)

[12] Bangladesh Economic Review 2009

[13] Own sources of Bangladesh Atomic Energy Commission

[14] Retrieved from the web **Error! Hyperlink reference not valid.**

[15] National Energy Policy (NEP), 2008

[16] Retrieved from the web http://www.lged-rein.org/database.php ?pageid=67

[17] Retrieved from the web http://planetark.org/wen/51261

[18] Retrieved from the web http://www.lged-rein.org/gtz.php

[19] Power System Mater Plan, 2010

ACRONYMS

ADB	Asian Development Bank
BAPEX	Bangladesh Petroleum Exploration & Production Co. Ltd
BANPAP	Bangladesh Nuclear Power Action Plan
BAEC	Bangladesh Atomic Energy Commission
BCSIR	Bangladesh Council of Scientific & Industrial Research
BERC	Bangladesh Energy Regulatory Commission
BOO	Build-Own-Operate
BPC	Bangladesh Petroleum Corporation
BPDB	Bangladesh Power Development Board
CCGT	Combined Cycle Gas Turbine
CDM	Clean Development Mechanism
CFL	Compact Fluorescent Lamp
CNG	Compressed Natural Gas
DESA	Dhaka Electricity Supply Authority
DESCO	Dhaka Electric Supply Company
DPDC	Dhaka Power Distribution Company

EMRD	Energy and Mineral Resources Division of MPEMR
FY	Fiscal Year (July to June)
GDP	Gross Domestic Product
GOB	Government of Bangladesh
GSB	Geological Survey of Bangladesh
GSMP	Gas Sector Master Plan
GT	Gas Turbine
GTCL	Gas Transmission Co. Ltd
IDCOL	Infrastructure Development Company Ltd
IFRD	Institute of Fuel Research and Development
IIFC	Infrastructure Investment Facilitation Centre
IOC	International Oil Company
IPP	Independent Power Producer
JCTDSL	Jalalabad Gas Transmission and Distribution Co. Ltd
LGED	Local Government Engineering Department
LPG	Liquefied Petroleum gas
MDG	Millennium Development Goal
MIS	Management Information Systems
MPEMR	Ministry of Power, Energy and Mineral Resources
MOF	Ministry of Finance
MOSICT	Ministry of Science and Information & Communication Technology
MPEMR	Ministry of Power, Energy and Mineral Resources
NEC	National Economic Council
NEP	National Energy Policy
NGO	Non Government Organization
NPED (BAEC)	Nuclear Power & Energy Division

NRSE	New and Renewable Source of Energy
NSAPA	National Strategy for Accelerated Poverty Alleviation
PAEC	Pakistan Atomic Energy Commission
NSRCD (BAEC)	Nuclear Safety & Radiation Control Division
PC	Planning Commission, Power Cell
PBS	Palli Biddut Samity
PDB	Power Development Board
Petrobangla	Bangladesh Oil, Gas and Mineral Corporation
PGCB	Power Grid Company of Bangladesh Ltd
RSP	Poverty Reduction Strategic Paper
PSAR	Preliminary Safety Analysis Report
PSC	Production Sharing Contract
PSMP	Power Sector Master Plan
PSRB	Power Sector Reform on Bangladesh
RAPSS	Remote Area Power Supply System
RE	Renewable Energy
REB	Rural Electrification Board
RFP	Request For Proposal
RNPP	Rooppur Nuclear Power Project
RPC	Rural Power Co. Ltd
RPGCL	Rupantarita Prakritik Gas Co. Ltd
SGFL	Sylhet Gas Fields Ltd
SESC	Sustainable Energy Steering Committee
SOE	State Owned Enterprise
RETs	Renewable Energy Technologies
TGTDCL	Titas Gas Transmission & Distribution Co. Ltd

USGS	United States Geological Survey
VAT	Value Added Tax

APPENDIX 1: INTERNATIONAL, MULTILATERAL AND BILATERAL AGREEMENTS

INTERNATIONAL, MULTILATERAL AND BILATERAL AGREEMENTS

AGREEMENTS WITH THE IAEA

• NPT related safeguard agreement INFCIRC/301.	Entry into force:	11 June 1982
• Additional Protocol	Entry into force:	30 March 2001
• Improved procedures for designation of safeguards inspectors	Accepted on:	25 April 1995
• Supplementary agreement on provision of technical assistance by the IAEA	Entry into force:	31 December 1979
• RCA	Entry into force:	24 August 1987
• Agreement on privileges and immunities	Non-Party	

OTHER RELEVANT INTERNATIONAL TREATIES etc.

• NPT	Entry into force:	31 August 1979
• Convention on physical protection of nuclear material	Non- Party	
• Convention on early notification of a nuclear accident	Entry into force:	7 February 1988

• Convention on assistance in the case of a nuclear accident or radiological emergency	Entry into force:	7 February 1988
• Convention on civil liability for nuclear damage	Non-Party	
• Joint protocol	Non-Party	
• Protocol to amend the Vienna convention on civil liability for nuclear damage	Non-Party	
• Convention on supplementary compensation for nuclear damage	Non-Party	
• Convention on nuclear safety	Entry into force:	24 October 1996
• Joint convention on the safety of spent fuel management and on the safety of radioactive waste management	Non-Party	
• ZANGGER Committee	Non-Member	
• Acceptance of NUSS Codes	No reply	
• Nuclear Suppliers Group	Non-Member	

BILETERAL COOPERATION AGREEMENT

Bangladesh has bilateral agreements on nuclear cooperation the Government of USA, France and China. Recently, Bangladesh made bilateral Cooperation Agreement with Russian Federation on Peaceful Uses of Nuclear Energy.

APPENDIX 2: MAIN ORGANIZATIONS, INSTITUTIONS AND COMPANIES INVOLVED IN NUCLEAR POWER RELATED ACTIVITIES

Name of the Organization: Bangladesh Atomic Energy Commission (BAEC)

Address: E-12/A, Agargaon, Sher-E-Bangla Nagar, Dhaka-1207

Telephone number: 880-2-8141843

Facsimile number: 880-2-8130102

Web site address: www.baec.org.bd

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