POWER CRISIS OF BANGLADESH ITS PRESENTS & FUTURE

Daffodil International University

Department of Electrical & Electronic Engineering

This Thesis Submitted in Partial Fulfillment of the Requirement for the Degree of Bachelor of Science in Electrical and Electronic Engineering.

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DECLARATION

We hereby declare that this Thesis on "Power Crisis of Bangladesh Its Presents & Future" is submitted to Daffodil International University for partial fulfillment of the requirement of the degree of B. Sc. in Electrical & Electronic Engineering.

It has not been submitted to any other University or institution for the award of any degree previously. This project report does not breach any provision of copy right act.

We further undertake to indemnify the university against any loss or damage arising from breach of the forgoing obligation.

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Abstract

It is believed that the organizational inefficiency of the 'BPDB' and 'Power Division' of Ministry of Power, Energy, and Mineral Resources (MPEMR) of Bangladesh is the main cause for current electricity crisis. Although there are changes in public sector management in the electricity sector of Bangladesh due to the NPM, the organization continue to value the bureaucratic and hierarchical organizational culture. Bangladesh government has taken several programs and has adopted policies for privatization and public-private-partnership. Still the Bangladesh government has not succeeded to mitigate the crisis. This industry faces long time negligence, corruption and inefficiency. Currently the crisis situation has become acute due to inadequate fund, weak governance and above all inefficiency. But the political interferences in organizational management, in bureaucratic activities, in personnel management and even in private investment process, are creating a huge problem for the development of this sector. This paper defines the Organizational management, efficiency, and weak governance of Bangladesh's electricity industry. This paper examines the extent to which the electricity crisis of Bangladesh is the result of organizational inefficiency of the 'BPDB' and 'Power Division' of Ministry of Power, Energy, and Mineral Resources (MPEMR) of Bangladesh. This organizational inefficiency is actually shared between inefficiency of public organization and political interferences. It is discussed in this paper not only the organizational inefficiency causes the electricity crisis but also political interference, wrong policies , inadequate fund also responsible. This paper will show how the organizational culture, structure and strategies of the ministry and BPDB have resulted in the crisis. Moreover country's corrupted and chaotic political system, the roles of parliament and civil servants are also discussed in this essay. Current electricity crisis can be considerably overcome by increasing the efficiency of the 'Power Division' as well as by stopping the political interference in decision making and in bureaucracy.

Chapter 1

Introduction

1.1. Introduction:

Bangladesh is a country endowed with huge natural resources. There are lots of sources of energy from the nature. Electricity is a type of converted energy from another form of energy. According to Global Energy Network Institute, Bangladesh has small reserves of oil and coal, but potentially very large natural gas resources. Commercial energy consumption is around 71% natural gas, with the remainder almost entirely oil (plus limited amounts of hydropower and coal). Only around 18% of the population (25% in urban areas and 10% in rural areas) has access to electricity, and per capita commercial energy consumption is among the lowest in the world. The rest of the total population in Bangladesh is still in the dark. Bangladesh's per capita electricity generation of 182 kWh p.a. is still among the lowest in the world. (Power cell, 2012). A large number of populations of Bangladesh are still leading their life in the dark. Over 80% of people depend on traditional energy sources such as firewood, cow dung and agricultural residues for their energy needs (WEC, 2001). In the year 2008, the amount of electricity production of Bangladesh was 34957000000. At the present production level of electricity, only proper management of its distribution and load may Power plays a great role wherever people lives and works in industry, agriculture, and transportation etc. The living standard and prosperity of a nation vary directly with increase in use of power. As technology is advancing the consumption of power is steadily rising. Sufficient and reliable source of electricity is a major prerequisite for a sustained and successful economic development effort and poverty reduction. In Bangladesh, 90 million of the populations out of 140 million do not have direct access to electricity and remaining 50 mil-lion people have access but reliable and quality power is still beyond their reach (BPDB, 2007). In order to achieve the growth rate, availability of a reasonably priced and reliable source of electricity is a prerequisite. Present generation of electric power in Bangladesh is not sufficient to meet the consumers growing demand. So it is not possible to ensure a constant supply of electric power to all consumers through-out the country. Moreover the demand is increasing day by day. So it is essential to set up more generating station for over demanding load. On the other hand, the existing power stations have lost their lifetime; they are not reliable for steady generation. So it has to be replaced old generating units in various power stations. Shortage of power is serious problem and strong barrier for the development of our country. GOV of Bangladesh has so many limitations to set up sufficient power station. The GOV has given top priority to development of the sector considering its importance in overall development of the country. The GOV has set the goal of providing electricity to all citizens by 2020.

1.2. Objectives of the Study:

This research aims at exploring the electricity situation and improving the situation through load management system. Its specific objectives are:

1. To focus on the present status of electricity.
2. To identify the trend of demand-supply gap of electricity in Bangladesh.
3. To trace out the relationship between load management and demand and supply of electricity.
4. To show how can sound load management lead to improvement of electricity situation
5. To find out ways to solve the crisis in the electricity sector.

1.3. Method of the Study:

The study is mainly based on secondary data. Information relevant to electricity crisis and load management in Bangladesh context has been gathered on perusal of research studies and available literature. Most of the data collected from Annual Report published by Bangladesh Power Development Board (BPDB), Rural Electrification Board and World Bank, Power Plant Development Project in Bangladesh form Japan International Cooperation Agency (JICA). Some data used in this study have been taken from various published articles, research papers and periodical magazines. Besides these different web sites have been used as another source of information. All the data gathered there from have been analyzed with simple statistical tools to draw inference about the research hypothesis.

1.4. Electricity Crisis:

Electricity is a vital part of functioning as a society. Human civilization is advancing tremendously from the diversified use of electricity. Its crisis occurs when the generation of electricity is less than the demand. Electricity crisis has become a common affair of our daily life which is called load shedding. It creates problems of far reaching consequences in the economic and social development of the country.

1.5. Load Management:

Load management is the process of balancing the supply of electricity on the network with the electrical load by adjusting or controlling the load. [1] Load management is the peak performers for peak performance||. Mainly electricity peak hour occurs from 5pm at 11 pm. In this period, customers consume more electricity in different purpose. So the generated electricity can't able to satisfy the electricity demand .Due to this create shortage of electricity which lead to load shedding. In the year 2009, load shedding was imposed on 351 days which varied up to 30.49% of maximum demand (BPDB Annual Report-2012). Load management is a means of controlling the amount of electricity being used at any one time when peak demand periods of electricity occur. Load management is a technique to reduce the load shedding minimum. Load shedding is deficiency in the fulfillment of demand due to shortage of supply of electricity. Demand for electricity on Friday is only 5,100 MW which is topped on Wednesday and Thursday at 5,300MW. Furthermore, if load shedding is considered, table 3 again depicts that on two Friday's load shedding are 0 MW and 98 MW

respectively. But in other days of the week suffer load shedding for larger MW of electricity. In 7-day week, the demand for electricity is not equal. During weekends the consumption of electricity is slow down than that of other days of the week. On the weekend all Governments and autonomous organization remain closed. Moreover, a good number of private offices including bank and educational institutions enjoy holiday on that day.

1.6. Demand Supply Situation of Power in Bangladesh:

1. Generation: 5000 – 5300 MW (Capacity- 7119 MW)
2. Highest so far: 5244 MW (August 29, 2011)
3. Gas shortage causes 400 - 600 MW less Power Generation
4. Peak Demand: 6000 MW (with DSM)
5. Load shedding up to 800 MW during hot summer days (with DSM)
6. Shortage and unreliable power supply has constrained economic growth

1.7. Age of Power Plants:

Age Group (Years)	Generation Capacity (MW)
40 +	208
31 – 40	156
21 – 30	1268
11 – 20	1412
01 – 10	4075
Total	7119

- 23 % of Capacity have more than 20 Years life [2]

Inefficient organizational management of the Power Division of the Ministry of Power, Energy, and Mineral Resources (MPEMR) as well as the BPDB has partially created current electricity crisis in Bangladesh. The influences of the three other major factors, i.e., financial resources, adequate generation capacity, private investment are also important for electricity generation along with the organizations efficiency and effective policy. Even the private sector participation and reformation processes have not been succeeded to overcome this crisis. Political interference and corruption in private investment and in bureaucracy as well as the conflicts between ruling party and opposition have more aggravated this crisis. Ineffective Parliamentary supervision, centralized organizational structure, bureaucratic culture and weak strategies to increase electricity productions are also criticized. Current crisis in electricity sector can be considerably overcome by increasing the efficiency of the 'Power Division' and 'BPDB' as well as by stopping the political interference in decision making and in bureaucracy.

1.8. Structure of Power Sector:

GOV of Bangladesh has made vision and policy statement regarding power sector improvement. It is GOV's constitutional responsibility to provide electricity to the people. In

the vision statement it is mentioned that providing access to affordable and reliable electricity to the majority of the people of Bangladesh by 2020 is a national goal of the next millennium. GOV is currently working with an interim target of providing electricity to 60% of the population by 2010. At present electricity coverage in Bangladesh is only 43% and per capital electricity consumption is about 140 kWh which is one of the lowest in the world

Government should take motivational programs to enhance awareness of the consumers during peak hours. Campaign should be essential to request the consumers through electronic and print media to be rational and economical in electricity use during peak hour by switching off, unnecessary loads like extra lighting, ironing, pumps, air conditioners and welding machines etc. Industries and large commercial customers like shopping malls should use their own captive generation and GO could transfer holiday in the markets and industrial belts. Implementation of pre-paid metering system will give additional facility.

1.9. Power Sector in Bangladesh:

Bangladesh's energy infrastructure is quite small, insufficient and poorly managed. The per capita energy consumption in Bangladesh is one of the lowest (136 kWH) in the world. Noncommercial energy sources, such as wood, animal wastes, and crop residues, are estimated to account for over half of the country's energy consumption. Bangladesh has small reserves of oil and coal, but very large natural gas resources. Commercial energy consumption is mostly natural gas (around 66%), followed by oil, hydropower and coal.

Electricity is the major source of power for country's most of the economic activities. Bangladesh's installed electric generation capacity was 4.7 GW in 2009; only three-fourth of which is considered to be 'available'. Only 40% of the population has access to electricity with a per capita availability of 136 kWh per annum. Problems in the Bangladesh's electric power sector include corruption in administration, high system losses, and delays in completion of new plants, low plant efficiencies, erratic power supply, electricity theft, blackouts, and shortages of funds for power plant maintenance. Overall, the country's generation plants have been unable to meet system demand over the past decade.

1.10. Current Position of Energy Sector:

At present, Bangladesh has energy supply from both renewable and nonrenewable sources, 38 percent of which comes from biomass. However, 75 percent of commercial energy is provided from natural gas. Currently, gas production per day is 2000 MMCF in our country. Use of imported oil accounts for the lion's share of the rest of the energy requirement. Our annual requirement of fuel is approximately 3.7 million metric ton. Apart from natural gas and crude oil, coal is mainly used as fuel in the brick-fields and at the Boropukuria Thermal Power Plant. Moreover, power is also being generated by using solar home system in off grid areas. In addition there are some poultry and dairy farms in which bio-gas plants are being set up and with this energy, power can be generated and is also used for cooking. The amount of power generation from such plants is currently about 1 MW. Steps have been taken to generate electricity by Bio-Mass Gasification Method in the country. We also have a bright potential to produce electricity from wind and mini-hydro or wave-energy. Recently, solar power based irrigation pump has been used in a number of areas of the country. Its wide use will lessen the pressure on diesel and electricity.

1.11. Cross Border Electricity Trade:

Realizing the ever increasing demand of electricity for socio-economic development and progress of the country, the government has initiated sub-regional cooperation in the field of power generation, grid connectivity and overall energy security. Cooperation has been initiated through SAARC, SASEC and BIMSTEC etc. for sharing of hydropower through cross-border connectivity and capacity development. Through these cooperation efforts Bhutan's and Nepal's hydro power potential could be utilized for the sub-region. Sub-regional grid could enable flow of surplus electricity within the countries and minimize the demand-supply gap of electricity of the nations.

A historical bilateral tie took place in January 2010 where the Hon'ble Prime Ministers of Bangladesh and India agreed on a major cooperation between the two neighboring countries. This initiative highlighted the development of economic cooperation between the countries.

1.12. Viewpoints and Objectives of the Master Plan:

When reviewing the Power System Master Plan (MP), the fundamental objective is to formulate the Master Plan for the attainment of stable power supply by achieving the 3Es; Economic Growth, Energy Security and Environmental Protection simultaneously. The government of Bangladesh set the maximum target to reduce poverty in a period as swift as possible by achieving high economic growth. Planning electrification via the stabilization and efficiency of the electric power supply system can be expected to reduce poverty. This Master Plan will aim to promote development that will provide a self-reinforcing cycle of poverty reduction and 3E simultaneous achievement. In addition, this Master Plan will propose the vision in line with Government energy policy, and stipulate 6 value-up plans to achieve the vision.

1.13. Renewable Energy Development Program:

Development of renewable energy id one of the important strategies adopted by Government for going green. Under the existing generation scenario of Bangladesh, renewable energy has very small to the total generation. The present share of renewable energy is about .05%. BPDB has taken steps for the last few years in the development of renewable energy implementation of energy efficiency measures to achieve the target of renewable energy policy 2008 of the Government.

Chapter 2

Present Scenario of Power Sector in Bangladesh

2.1. Present Structure Of Power Sector:

Different utilities are working under the guidance of Power Division, Ministry of Power, Energy & Mineral Resources (MPEMR) [3]:

- Generation
  - Bangladesh Power Development Board (BPDB),
  - Independent Power Producers (IPPs),
  - Electric Generation Company of Bangladesh Ltd. (EGCB)
- Transmission
  - Power Grid Company of Bangladesh Ltd. (PGCB)
- Distribution
  - Bangladesh Power Development Board (BPDB),
  - Dhaka Electric Supply Company Ltd. (DESCO),
  - Dhaka Power Division Company Ltd. (DPDC),
  - Rural Electrification Board (REB) [through Rural electric Co-operatives called Palli Bidyut Samati (PBSs)]
  - West Zone Power Distribution Company Ltd. (WZPDC)
- Formation stage
  - North Zone Power Distribution Company Ltd. (NZPDC)
  - South Zone Power Distribution Company Ltd. (SZPDC)
  - Central Zone Power Distribution Company Ltd. (CZPDC)

GOV of Bangladesh has made vision and policy statement regarding power sector improvement. It is GOV's constitutional responsibility to provide electricity to the people. In the vision statement it is mentioned that providing access to affordable and reliable electricity to the majority of the people of Bangladesh by 2020 is a national goal of the next millennium. GOV is currently working with an interim target of providing electricity to 60% of the population by 2010. At present electricity coverage in Bangladesh is only 43% and per capital electricity consumption is about 140 kWh which is one of the lowest in the world

Government should take motivational programs to enhance awareness of the consumers during peak hours. Campaign should be essential to request the consumers through electronic and print media to be rational and economical in electricity use during peak hour by switching off, unnecessary loads like extra lighting, ironing, pumps, air conditioners and welding machines etc. Industries and large commercial customers like shopping malls should use their own captive generation and GO could transfer holiday in the markets and industrial belts. Implementation of pre-paid metering system will give additional facility.

2.2. Generation Capacity:

Total generation capacity was 8,100 MW which includes 1297 MW IPP, 2248 MW SIPP/Rental Power Plant & 226 MW in REB (for PBS). The maximum peak generation was 6,066 MW which was 24.05 % higher than that in the previous year. [4] The reasons for lower peak generation with respect for lower peak generation with respect to generation capacity were:

1. Some plants are out of operation for maintenance, rehabilitation & overhauling.
2. Capacity of some plants derated due to again &
3. Gas storages

Generation Capacity by Plant & Fuel Type

By type of plant		By type of fuel	
Hydro	220 MW (2.72%)	Gas	5417 MW (66.88%)
Steam Turbine	2193 MW (27.07%)	Furnace Oil	1752 MW (21.63%)
Gas Turbine	1145 MW (14.14 %)	Diesel	511 MW (6.31%)
Combined Cycle	1292 MW (15.95 %)	Hydro	220 MW (2.72 %)
Reciprocating Engine	3250 MW (40.12 %)	Coal	200 MW (2.47%)
Total	**8,100 MW (100 %)**	**Total**	**8,100 MW (100%)**

The generation capacity mixes in shown below:

2.3. Energy Generation:

Total net energy generation (excluding REB) in FY 2012 was 33,397 GWh, which was about 13.28% higher than previous year's net generation of 29,485 GWh. Net energy generation in public sector was 15,201 GWh and 18,196 GWh in the private sector. [4]

Hydro	777 GWh (2.33%)
Natural Gas	26085 GWh (78.11%)
Furnace Oil	4154 GWh (12.44%)
Diesel	1498 GWh (4.49%)
Coal	883 GWh (2.65%)
Total	**33,397 GWh (100%)**

Total net energy generation in public & private sector power plants (excluding REB) by type of fuel are as follows:

2.4. Plant Efficiency & Maintenance:

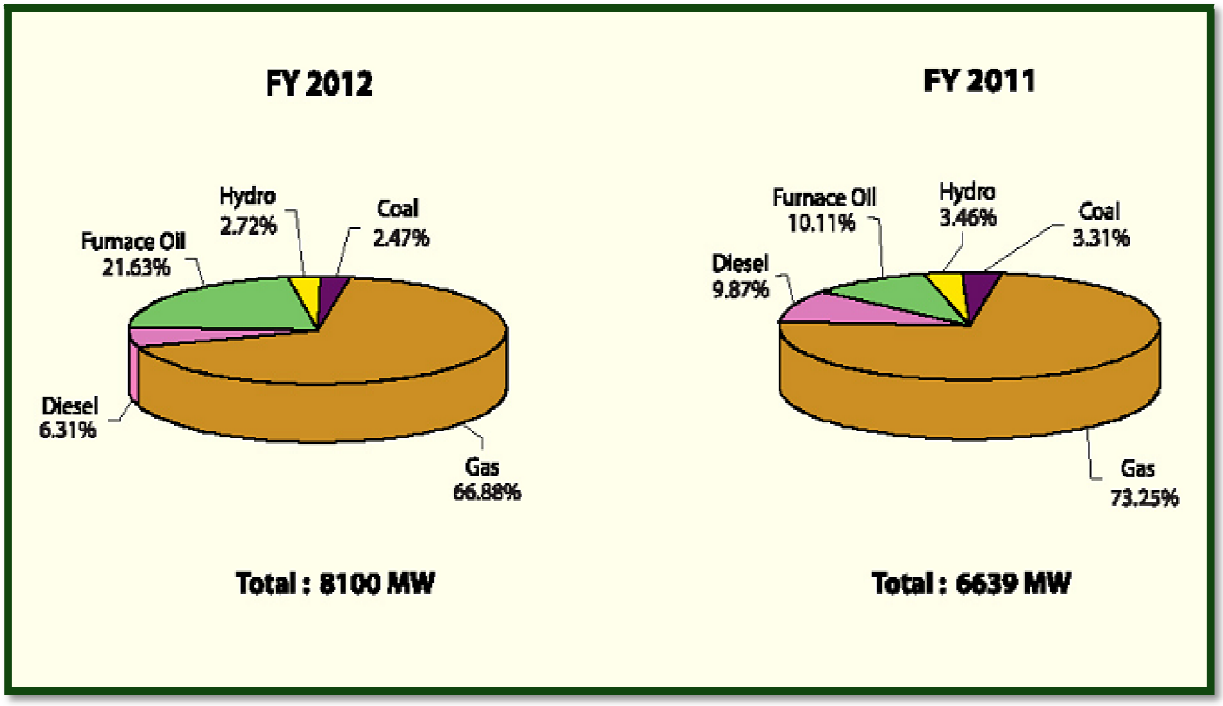
The overall thermal efficiency (Net) of public sector power plants in FY 2012 was32%, higher than previous year's 31% efficiency. [4]

Three year's maintenance plan has been prepared at the beginning of FY 2012 to improve overall thermal efficiency. Bellow the list of major power plants was under maintenance in the year under review:

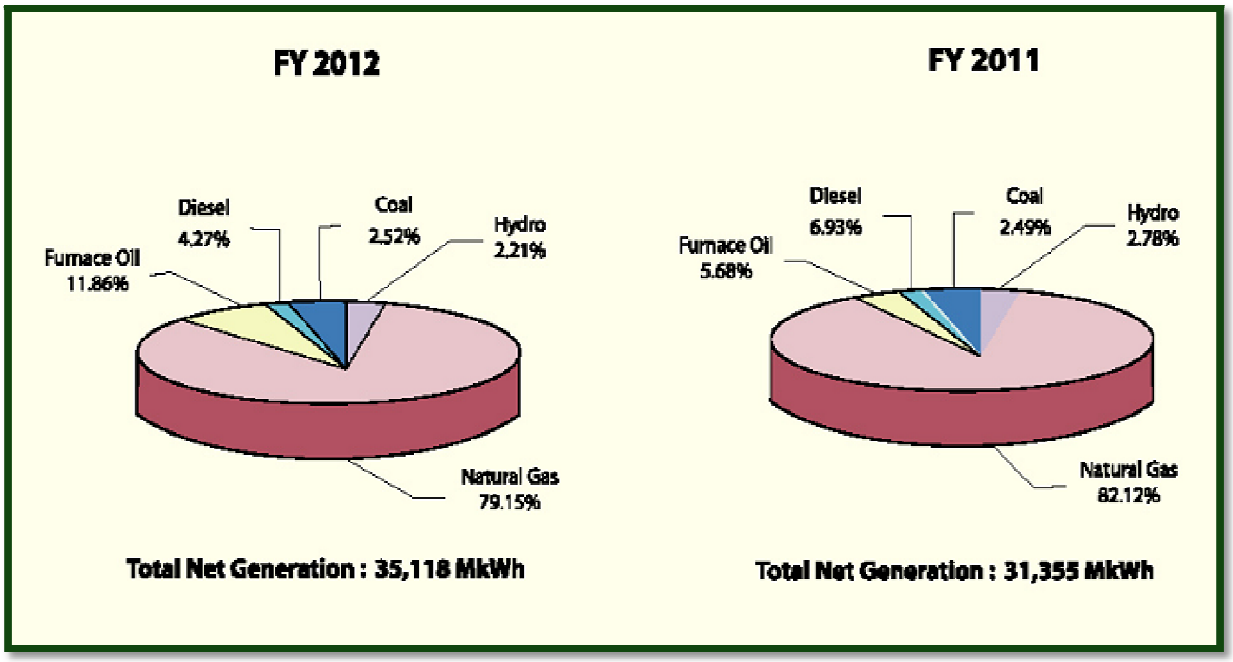
MAINTENANCE OF POWER PLANTS IN FY 2011-12

Sl. No	Name of Power Station	Present Capacity (MW)	Type of Maint. (HGPI/MI/OH)	Duration of Maintenance		Remarks
				Starting Date	Completion Date	
1	Baghabari 71 MW	71	HGPI	27/01/2012	27/02/2012	
			Generator Maint.	07/03/2012	04/06/2012	
2	Sylhet GT	10	Generator Maint.	26/07/2011	23/10/2011	
3	Shiddirganj ST	150	Boiler Major Maint.	01/08/2011	18/07/2012	
4	Chittagong ST-Unit 1	180	Overhauling	03/10/2010	12/07/2011	
5	Chittagong ST- Unit 2	180	Boiler Major Maint.	26/03/2011	26/11/2011	
6	Ghorashal Unit-2	55	Rehabilitation	26/04/2010	-	December, 2012 (Expected)
7	Ashuganj Unit-1	55	Turbine Overhauling	09/11/2010	-	December, 2012 (Expected)
8	Ashuganj Unit-3	140	Turbine Overhauling	10/11/2011	18/03/2012	
9	Ashuganj Unit-4	150	Overhauling	11/09/2010	29/08/2011	

2.5. Generation Capacity (National) By Fuel Type with Comparison: [4]



2.6. Generation (National) By Fuel: [4]



2.7. Transmission:

During FY 2011 – 12, Madanganj – Munsiganj 10km double circuit 132kv transmission line was constructed & energized. Besides, for power evacuation from newly installed power stations to the national grid, the following 132kv lines were constructed & energized:

1	Daudkandi PP to Daudkandi ss	1.2 km
2	Gopalganj PP to Gopalganj ss	1.2 km
3	Shiddhirganj desh energy PP to Siddhirganj ss	2.5 km
4	Faridpur pp to Faridpur-Bheramara line	1.0 km
5	Bera pp to Bagagari-Ishridi line and Amnura pp to Rajshahi-Chapai line	12.6 km
6	Keraniganj pp to Hasnabad-kallayanpur line	7.5 km
Total		**26.0 km**

Total length of 132kv transmission line increased to 6148 circuit km from the previous year of 5969 circuit km. the total length of 230 KV transmission line remained same as the previous year of 2647 circuit km.

- Grid Substation:

In this fiscal year, 2 nos. 132/33 KV sub – stations, one in Megnaghat and other in Munshigonj, 2*50/75 MVA capacity each installed and commissioned. Besides, MVA capacities in some 132/33kv sub – stations were enhanced in FY 2012. Total capacity of 132/33kv sub – stations increased to 11157 MVA as of June 2012 from the previous year of 10492 MVA. Total capacity of 230/132kv sub – stations remained same as the previous year of 7225 MVA.

Transmission Summary

01	230 kV Transmission Line (Circuit km)	2,647
02	132 kV Transmission Line (Circuit km)	6,148
	Total Transmission Line (Circuit km)	**8,795**
03	No. of 230/132 kV Sub-Station	15
04	No. of 132/33 kV Sub-Station	103
	Total no. of Sub-Station	118
05	230/132 kV Sub-Station Capacity (MVA)	7,225
06	132/33 kV Sub-Station Capacity (MVA)	11,141
	Total Sub-Station Capacity (MVA)	**18,366**
07	Transmission Loss (%)	3.22 %

2.8. Grid System Operation:

In FY 2012, total duration of power interruption in the grid network was 40 hours 08 minutes.

INTERRUPTION OF NATIONAL GRID FOR FY 2011 & FY 2012

Sl. No.	Type of Fault	Total Number of Faults		Total Duration	
		FY 2011	FY 2012	FY 2011 Hours/ Minutes	FY 2012 Hours/ Minutes
1.	Partial Power failure due to trouble in generation	98	71	07/06	05/19
2.	Partial Power failure due to trouble in grid S/S Equipment	05	04	123/13	27/52
3.	Partial Power failure due to fault in transmission line	01	00	02/28	00/00
4.	Partial Power failure due to the lightning on transmission line/Thunder Storm	00	01	00/00	00/39
5.	Partial Grid failure	05	04	03/28	06/18
6.	Total Grid failure	00	00	00/00	00/00
	Total	**109**	**80**	**136/15**	**40/08**

2.9. Bulk Electricity Sales by BPDB:

BPDB has been functioning as a single buyer in the power market of Bangladesh. BPDB purchases electricity from the public & private generation entities and sales bulk electricity to all the distribution utilities including its six distribution zones. Distribution entities purchases electricity from BPDB is as follows:

- West Zone Power Distribution Company Ltd. (WZPDC)
- Dhaka Electric Supply Company Ltd. (DESCO),
- Dhaka Power Division Company Ltd. (DPDC),
- Rural Electrification Board (REB)
- BPDB's six distribution zones.

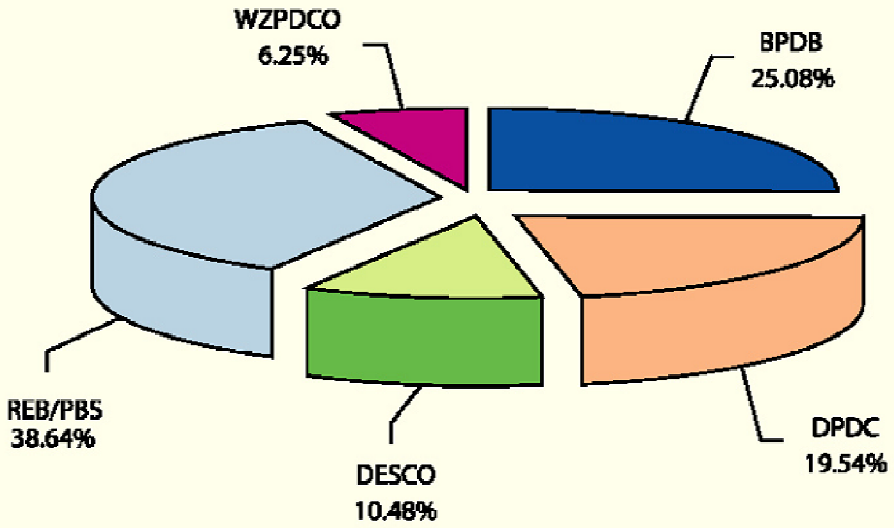
In FY 2012 bulk electricity sales to the distribution utilities increased to 32443 MkWh from 28627 MkWh which is 13.33% higher than the previous year.

The revenue collection from the utilities was also increased to 103236 MTk which form 74303 MTk which is 38.94% higher than the previous year.

Utility Wise Bulk Energy Sales by BPDB As Single Buyer

In GWh

Year	BPDB zones	DPDC	DESCO	WZPDCL	REB	Total
2004-05	5,993.05	5,134.77	1,843.13	388.57	7038.65	20398.18
2005-06	5,180.25	5,315.76	2,030.00	1372.78	8062.43	21961.22
2006-07	5,305.32	5,243.00	2,190.69	1281.95	8039.93	22060.89
2007-08	5,625.61	5,203.95	2,573.77	1375.23	8654.85	23433.41
2008-09	6,042.25	5,448.81	2,742.55	1490.63	9032.27	24756.51
2009-10	6,744.27	5,749.39	2,933.72	1673.44	9525.30	26626.12
2010-11	7,337.87	5,964.05	3,122.74	1842.52	10359.41	28626.59
2011-12	8,136.45	6,340.32	3,400.99	2028.93	12536.76	32443.45



Total Sales: 32,443 MkWh

Utility Wise Billing & Collection Statistics of BPDB

Name of Utility	Billed Amount (Million Tk)		Collected Amount (Million Tk)		Accounts Receivable (Million Tk)		% increase over the previous year	Coll/Bill Ratio (%)	
	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12		2010-11	2011-12
BPDB's Dist. Zones (in/c PS & GK)	24283.23	31410.67	23492.60	29852.43	5748.15	6992.97	21.66	96.74	95.04
WZPDCL	4660.55	6542.42	4446.54	5998.98	1091.41	1666.26	52.67	95.41	91.69
DPDC	15600.15	24242.98	15039.28	20994.97	30730.12	35088.35	14.18	96.40	86.60
DESCO	8099.29	12249.37	7766.29	12218.50	1741.74	4463.50	156.27	95.89	91.58
REB/PBS's	24704.92	37398.01	23557.94	34171.09	5087.73	8694.44	70.89	95.36	91.37
Total	**77348'14**	**111843.45**	**74302.64**	**103235.96**	**44399.15**	**56905.52**	**28.17**	**96.06**	**91.41**

2.10. Distribution:

BPDB has been function as a retail seller of electricity within its following six distribution zone

- Distribution zone, Chittagong
- Distribution zone, Mymenshing
- Distribution zone, Rajshahi
- Distribution zone, Comilla
- Distribution zone, Sylhet
- Distribution zone, Rangpur

2.11. Distribution Network:

In the FY 2012, BPDB renovated & extended about 497 km distribution lines as a part of continuous improvement of the system. BPDB covered electrification in 236 thanas/upozillas and 4810 villages within its six distribution zones up to the end of this fiscal year. The distribution network possesses:

33 kv line	3712 km
11 kv line	11213 km
0.4 kv line	18936 km
33/11 kv sub-station	148 nos.
Total capacity of 33/11 kv sub-station	2739/3410 MVA
11/0.4 kv dist. sub-station	17994 nos.
Total capacity of 11/0.4 kv dist. sub-station	**2968 MVA**

2.11.1. Number of Consumers:

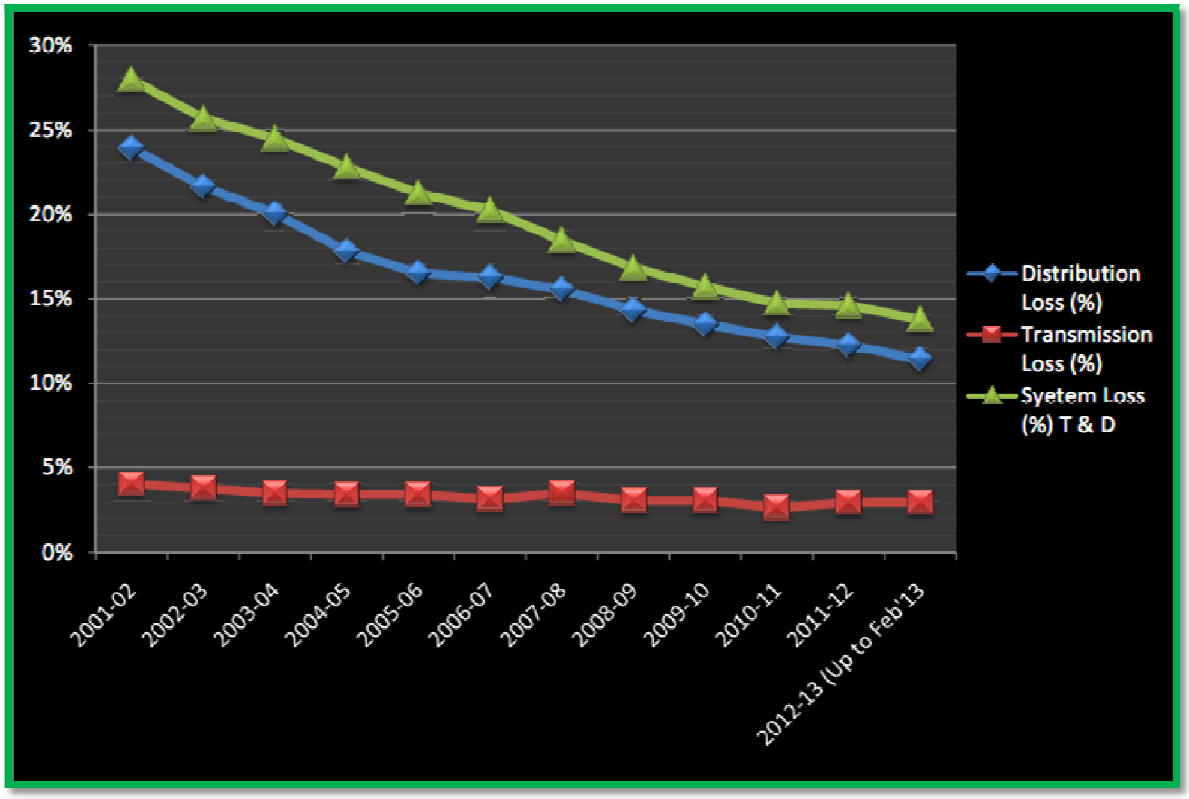
During this fiscal year, BPDB provided total 2, 53,801 new connections and total number of consumers increased to 24, 32,055 and the annual increment was 12.61%

2.11.2. Distribution System Loss:

BPDB's distribution zones imported 8136MkWh energy from the single buyer for retail sale in six zones and sold 7148 MkWh to the consumers in the FY 2012 that result 12.15% distribution system loss which was 13.06% in FY 2011. [5]

System loss is one of the key performance indicators. Continuous monitoring of the performance of the utilities, reforms & target -oriented measures are underway by Power Cell to reduce the system loss. The system loss (distribution) has come down to 12.26% in FY 2011- 2012 from 23.92% in FY 2001-2002.

FY	Distribution Loss (%)	Transmission Loss (%)	System Loss (%) T & D
2001 – 02	23.92%	4.05%	27.97%
2002 – 03	21.64%	3.79%	25.69%
2003 – 04	20.04%	3.48%	24.49%
2004 – 05	17.83%	3.42%	22.79%
2005 – 06	16.53%	3.44%	21.25%
2006 – 07	16.26%	3.15%	20.25%
2007 – 08	15.56%	3.51%	18.45%
2008 – 09	14.33%	3.06%	16.85%
2009 – 10	13.49%	3.08%	15.73%
2010 – 11	12.75%	2.66%	14.73%
2011 – 12	12.26%	2.96%	14.61%
2012 – 13 (Up to Feb 2013)	12.26%	2.96%	14.61%



2.12. Demand Forecast**:**

In the Power System Master Plan (PSMP) -2010 study is now underway. The preliminary demand forecast was made based on 7 % GDP growth rate. The actual demand could not be supplied for the last few years. The maximum demand served so far is 5244 MW (2.The electricity development is required to be accelerated to increase access and attain economic development. The desirable economic growth rate would be about 7% p.a. **[6]** Based upon this preliminary study the anticipated peak demand would be about 10,283 MW in FY2015, 17,304 MW in FY2020 and 25,199 MW in 2025. According to PSMP- 2010 Study year-wise peak demand forecast is given below.

Fiscal Year	Peak Demand (MW)
2010	6,454
2011	6,765
2012	7,518
2013	8,349
2014	9,268
2015	10,283
2016	11,405
2017	12,644
2018	14,014
2019	15,527
2020	17,304
2021	18,838

2022	20,443
2023	21,993
2024	23,581
2025	25,199
2026	26,838
2027	28,487
2028	30,134
2029	31,873
2030	33,708

2.13. Generation Planning:

Generation Planning is the most important part of the power system and the reliability of the whole power system depends largely on the reliability of power generating system. The generation in the system should be such that it can supply the demand at all times under the outage of normal maintenance and forced outage. To develop generation addition sequence Power System Master Plan of 2010 used PC-based WASP (Weign Automatic System Planning Package) and PDPAT software. This software determines least-cost generation addition sequences based upon the load characteristics, schedule maintenance, forced outage, and reliability level plant cost etc. The least cost generation addition sequence includes peak and base load plants of optimum unit size. Since then BPDB has been using PC-based WASP for generation planning. Annual LOLP (LOSS-OF LOAD PROBABILITY) of 2% is being used as reliability criteria. The equivalent to about 8 days/year of LOLE (LOSS-OF-LOAD-EXPECTATION).

Indigenous natural gas, coal, nuclear, cross-border trade and hydro resources are mainly considered for generation planning as fuel. In case of generation plant sitting regional balance in generation is being given due importance. Other factors such as availability of fuel, cooling water, transportation of heavy equipment, proximately to grid network & load center etc. are also considered for plant sitting.

2.14. Distribution Project:

For the development of distribution system in the urban areas, BPDB takes different Town Distribution Projects. Before taking any Town Distribution Project, a study is conducted to asses different types of works required for the development. Similarly Rural Electrification Board develops distribution system in the rural areas through different Rural Electrification Program.

- Minimizing the cost of laterals, feeders, sub-transmission systems, substations, equipment required for control and protection and cost of losses while respecting the limits set by permissible voltage values, voltage dips and flicker
- Maintaining service continuity, reliability and security of the system
- Taking into account factors like transformer impedance, insulation levels, availability of spare transformers and mobile substations, dispatch of generation and rates that are charged to customers

For long term planning, the factors that are to be considered are:

- The timing, location and type of energy demand
- The duration and frequency of outage of equipment
- Labor and money
- Increasing or decreasing prices of alternative energy sources
- Changing socio-economic conditions
- Regulations of Federal and State governments

Distribution planning involves various activities like load forecasting (type, location and amount), electrical and mechanical design, economic and other considerations in planning. Automation has also become important in distribution planning.

2.15. Transmission Planning**:**

The purpose of long-term transmission system planning is to determine the type and timing of new transmission facilities that will be required to transmit power from the new generating plants to the main load centers at least cost, with an acceptable level of reliability. The transmission planning process relies upon an adequate definition of the locations of the new generation and the expected growth in demand at the major load demand centers. The degree of precision that can be assigned to each of these factors declines rapidly the further into the future the analyses are pursued, so that transmission planning becomes more conceptual and less precise in the latter part of the planning period.

The overall planning process for the transmission system proceeds from the development of a conceptual system through to a least-cost sequence by successive analysis and adjustment. The first step is to estimate and assess the principal power flows that would need to be transported across the country. This assessment is carried out by calculating the range of power flows at major interfaces in the system during several key years in the planning period. Of prime importance is power flow requirements between the Eastern and Western Zones. Generation expansion in the two zones affect these power flows and the timing at which a second, and perhaps third, interconnector will be required.

- The primary system voltage level (132 KV, 230 KV, 400 KV)
- The principal tower type (single or double circuit)
- The approximate routing
- A limited range of conductor sizes
- A limited range of transformer ratings
- Reactive compensation requirements.

The costs of schemes that satisfy the design criteria are then estimated to establish the least-cost transmission alternative for each generation sequence. Considerations taking into account less tangible factors, such as flexibility and reliability, are used to choose between competing transmission schemes.

The ranges of major power flows across the interfaces between geographic subsystems is determined from the preliminary generation options and locations, the system demand forecast, different daily and seasonal load levels, and known operating constraints. Using judgment and approximate methods such as transmission line load ability, preliminary transmission expansion alternatives are postulated. The conceptual transmission schemes include the definition of several variables.

2.16. Load Flow Analysis:

System load cases flow are established for key years like FY 1995, 2000, 2005, 2010 and 2015. For these years, maximum power flow requirements are established by considering combinations of load level and generation scenarios. Various transmission alternatives are postulated to achieve a reasonable load flow situation for normal and outage conditions, while minimizing the transmission additions.

2.17. Transient Stability Analysis:

The principal transmission additions required is determined by testing the transient stability performance of a selected number of the proposed transmission alternatives. This performance represents the ability of the system to withstand sudden short circuits and outage of the associated faulted equipment, without collapsing due to loss of synchronism between generators on the system.

2.18. Environmental Consideration:

Due consideration is given to the basic environmental requirements of the overall planning methodology of BPDB. Principal considerations are the amount of stack gas and cooling water emissions from thermal plants, and it is ensured that transmission line corridors do not infringe on any known protected areas. However, the non-mechanized farming practices in Bangladesh are generally such that once line construction is completed, active farming resumes directly under the lines, and often between the legs of individual towers. Recognizing also that there is a growing shortage of farmland in Bangladesh, an effort is made to redevelop existing sites wherever possible.

2.19. Demand Side Management:

Demand – side management (DSM) means modifying energy use to maximize energy efficiency. DSM tries to get maximum benefit out of existing energy generation. DSM involves changing energy use habits of consumers and encouraging them for using energy efficient appliances, equipment etc. at their premises.

BPDP has taken a number of steps for demand side management, which are as follows:

- To shift irrigation load from peak hour to off peak hour, BPDB has started campaign through electronic print media. In the last few years, it is estimated that about 40MW irrigation load was shifted from peak hour to off peak hour.
- BPDB has taken motivational programs to enhance awareness of the consumers during peak hours. Consumers are being urged through electronic and print media to be rational and economical in electricity use during peak hour by switching off unnecessary loads like extra lightning, ironing, pumps, air conditioners, welding machines etc.
- As part of demand side management program, BPDB has taken steps to use CFL in BPDB's offices and also trying to motivate consumers to use Energy Efficient Lamps.
- Industries operating in two shifts are being requested not to operate during peak hours.
- Industrial operating in two shifts is being requested not to operate during peak hours.
- Holiday staggering for industries has been implemented, which contributes about 150MW load shifting.
- Load Management Committee has been formed in every distribution zone/circle/division to monitor the proper load distribution during irrigation.
- As part of DSM, BPDB is monitoring shop/market closure time at 8 p.m. It is estimated that this measure contributes about 350 MW load shifting from peak hour.

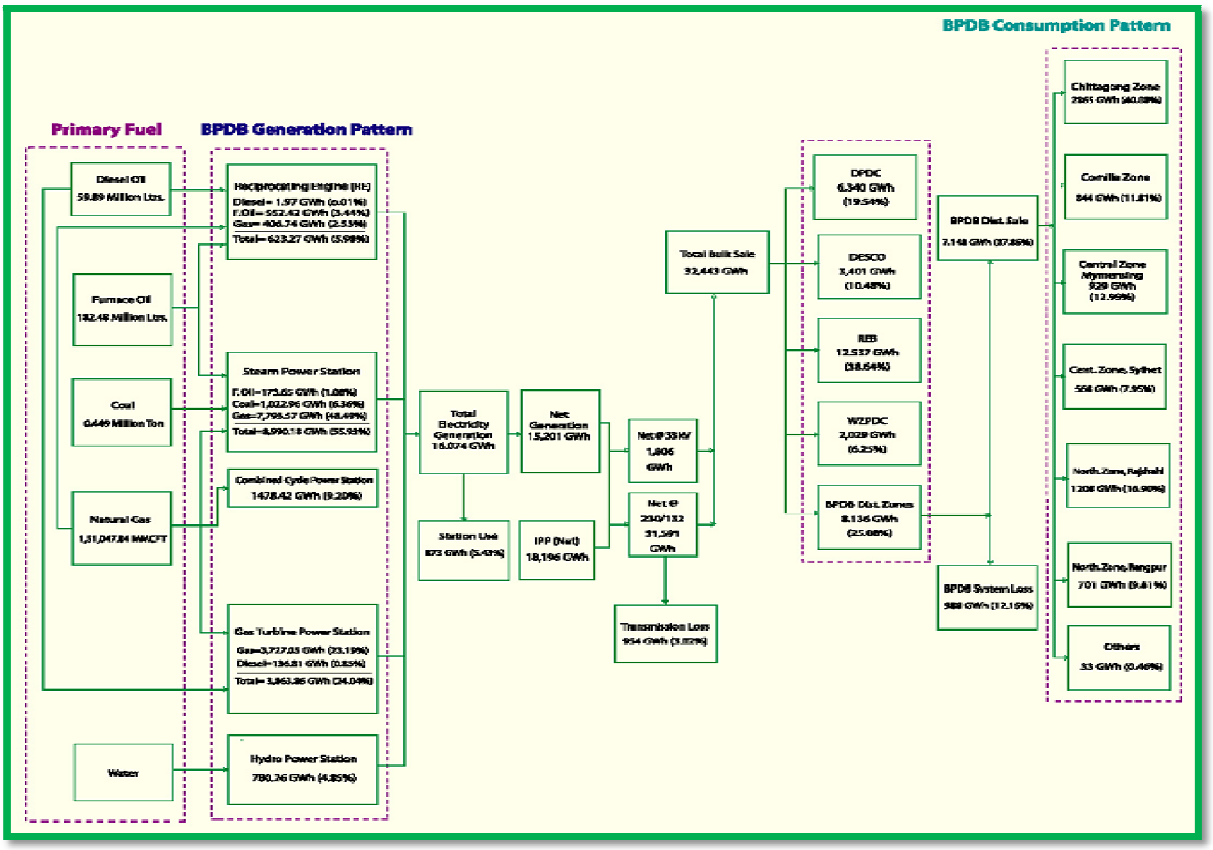


Fig: Energy Flow Chart FY 2012

Chapter 3

Power sector's in Bangladesh

3.1. Power Sector in Bangladesh:

Bangladesh's energy infrastructure is quite small, insufficient and poorly managed. The per capita energy consumption in Bangladesh is one of the lowest (136 kWH) in the world. Noncommercial energy sources, such as wood, animal wastes, and crop residues, are estimated to account for over half of the country's energy consumption. Bangladesh has small reserves of oil and coal, but very large natural gas resources. Commercial energy consumption is mostly natural gas (around 66%), followed by oil, hydropower and coal. [7]

Electricity is the major source of power for country's most of the economic activities. Bangladesh's installed electric generation capacity was 4.7 GW in 2009; only three-fourth of which is considered to be 'available'. Only 40% of the population has access to electricity with a per capita availability of 136 kWh per annum. Problems in the Bangladesh's electric power sector include corruption in administration, high system losses, and delays in completion of new plants, low plant efficiencies, erratic power supply, electricity theft, blackouts, and shortages of funds for power plant maintenance. Overall, the country's generation plants have been unable to meet system demand over the past decade.

In generating and distributing electricity, the failure to adequately manage the load leads to extensive load shedding which results in severe disruption in the industrial production and other economic activities. A recent survey reveals that power outages result in a loss of industrial output worth $1 billion a year which reduces the GDP growth by about half a percentage point in Bangladesh. A major hurdle in efficiently delivering power is caused by the inefficient distribution system. It is estimated that the total transmission and distribution losses in Bangladesh amount to one-third of the total generation, the value of which is equal to US $247 million per year.

3.2. Renewable Energy:

Bangladesh has 15 MW solar energy capacities through rural households and 1.9 MW wind power in Kutubdia and Feni. Bangladesh has planned to produce 5% of total power generation by 2015 & 10% by 2020 from renewable energy sources like air, waste & solar energy.

3.3. Recent Plans:

The Ministry of Power and Energy has been mobilizing Tk 40,000 core ($5.88 billion) to generate 5,000 MW of electricity to reduce load shedding into a tolerable level within next four and half years during the term of the present government. Under the plan, the Power Development Board (PDB) would produce 500 MW gas-fired electricity between July and December 2009 to overcome load shedding within December. The PDB would hire furnace-oil based 1,000MW of electricity from private sector from January to June 2010, the plan said. In 2011, the government would install furnace-oil based 800 MW capacity of power plant. The PDB officials would seek suitable place to establish the plant, a senior official of the PDB said. Besides the government would also hire another diesel or furnace oil based power plant having capacity of 700 MW in 2012 to keep load shedding into mild level, the official said. However, the government also contemplates to establish four coal-fired based power plants with capacity of producing 500 MW of electricity each with public and private partnership (PPP) in Rajshahi and Chittagong region. The government has initially tried to create fund of Tk 6,000 core ($1 billion) to implement the plan, sources said. The power

division has tried to utilize the government's budgetary allocation of Tk. 2000 core for PPP in this regard, sources added. "If we can create the fund of Tk. 6,000 core, it would be possible also to mobilize Tk 40,000 core under PPP to produce 5,000 MW of electricity within four and half years.

3.4. Nuclear Power Plant:

Bangladesh plans to set up the 1,000 MW power plants at Rooppur, 200 km (125 miles) northwest of the capital Dhaka, by 2011.

3.5. Power - Introduction & Background:

The present Government is committed to implement “Vision 2021” for building Bangladesh as a happy, prosperous country of medium income through maintaining macroeconomic stability and achieving rapid economic growth by 2021. In the outline of Bangladesh Perspective Plan (2010-2021) projections of raising the existing 6 percent growth rate of GDP to 10 percent by 2021 and increasing the per capita income of US$ 690 to around US$ 2000 have been set up. A prerequisite for achieving this growth is the ensuring of adequate investment in National Priority Sectors.

According to the Perspective Plan of the Government, a preliminary estimate of expected increase in investment in order to reach the projected GDP growth rate requires investment to be 32 percent of GDP by 2015 and 38 percent of GDP by 2021. Analyzing the investment situation of past years, it is observed that the contribution of public investment in the total investment has comparatively declined while the function of private sector has augmented. In the Fiscal year 2008-09, investment in public and private sector was respectively 19.6 and 4.6 percent of GDP. It is projected that this rate will increase to respectively 25.9 and 6.1 percent by 2015. The lion’s share of the mentioned investment will be achieved through Public-Private Partnership, Private Sector investment and Foreign Direct Investment. It need not be over emphasized that a strong infrastructure is necessary to attract private and foreign investment. The energy and power supply deficit in the existing infrastructure has become an impediment to achieve development goals. The Government is firm to create an investment-friendly atmosphere to attract private ventures according to the set target. The Government has given priority to infrastructure development especially in power and energy sector as means of attaining higher growth.

Currently, the shortage in electricity production is about 1500-1800 MW as per the demand of peak hours. As the concept of applying Energy Mix has not been given due consideration there is an overwhelming dependence on natural gas as primary fuel for power generation. At present, 88 percent of the power plants are run by natural gas. Due to limited gas extraction, these power plants cannot generate enough power.

Moreover, around 63 percent of total production comes from public sector while private enterprises contribution is inadequate. In addition, there are also problems relating to management of the growing demand. The Government has already adopted a comprehensive plan to resolve the prevailing difficulties. According to the plan, the shortage of electricity production will be overcome through PPP (Public Private Partnership) and private investment alongside government investment by 2012, and electricity for all will be ensured by 2021. Besides, use of coal and other fuels will be enhanced in order to reduce dependence on natural gas for power generation. The demand for electricity will

also be addressed through the use of renewable energy and regional cooperation. Initiatives have been taken to bring qualitative change in demand side management and use of fuels in order to save power and energy. In future, such initiatives will continue and will be well-arrayed.

When the present Government assumed office, the power generation was 3525 MW which has now been increased to 4020 MW currently. The production capacity will be enhanced to 11,500 MW by 2015 and it requires USD 9.00 billion investment out of which USD 8.00 billion is expected to be provided by private sector.

Development and investment in the power and energy sector is different from other sectors due to the sector specific characteristics. Huge primary asset accumulation and procurement are required for investment in the power and energy sector. Strategies have been made to meet this need by involving private sector with Government. Keeping this in view, the importance of external investment is infinite. On the other hand, consumer's economic consideration is given priority over commercial interests in price calculation of electricity, gas and other fuel oil. Efforts are continued to attract private ventures considering the risks in large primary investment and profit. However, estimation and reevaluation of power and other energy is required price is to be made more with commercial consideration in order to involve the private sector.

The existing problems and solutions in power and energy sector are enumerated in Bangladesh Perspective Plan outline (2010-2021). The total production of power is targeted at 8,500MW by 2013, 11,500MW by 2015 and 20,000MW by 2021. To reach these goals the Government has taken immediate, short, medium and long term work-plans for enhancing power generation in order to ensure overall and balanced development of this sector.

A modest effort has been made through this brochure to reveal the adopted plans and their implementations by the persistent efforts of the Government in order to resolve the prevailing situation of power and energy sectors before the Nation through the Parliament. The power shortages in Bangladesh along with reasons for lower per capita electricity consumption compared to other developing countries have been analyzed in this pamphlet. At the same time, in order to overcome the problems of power sector after identifying those, the steps taken so far and steps to be taken are discussed here. Priority has been given to arrange enhanced power generation, renovate and extend the infrastructure facilities for transmission and distribution, attract investors through private sector and PPP initiatives, encourage the use of renewable energy, create multifarious fuels, demand side management etc. to the develop power sector.

3.6. Shortage of Electricity:

Shortage of electricity may be considered in two forms. Firstly, reviewing the scenario of per capita electricity consumption and percentage of population having access to electricity in Bangladesh compared to other countries and; secondly, determining gap between demand and supply of electricity in perspective of country's economic situation and GDP growth.

3.7. Per Capita Electricity Consumption:

While analyzing the cause of electricity shortage it transpires that, at present our per capita electricity production is only 220 kw/hour. It is seen that comparing with the per capita

electricity consumption of BRICS countries (Brazil, Russia, India, China, and South Africa) as well as SAARC (South Asian Association for Regional Cooperation) countries such as Pakistan, Srilanka the per capita consumption of Bangladesh is very low.

3.8. Access to Electricity:

Only 47 percent of the total population has access to electricity. Presently (April 2010) the quantity of transmission and distribution line are respectively 8,359 Line Kilometer and 2, 66,460 Line Kilometer. Besides the urban areas 53,281 villages have been brought under electricity coverage. In order to bring the total population under electricity coverage emphasis should be provided to produce electricity from renewable sources besides using non-renewable energy.

3.9. Projection of Demand for Electricity:

One of the aspects to the demand for electricity is the tremendous rise of intensity of electricity use with the pace of economic development. In 1980, there was electricity demand of 30 Gigawatt (GW) per 1000 Crore taka of GDP which increased into 80 GW in 2002. With an economic growth of 12 percent on an average the capacity for electricity generation should double every six years. Considering the projection of economic growth the generation of electricity should increase 4 times to 20,000 MW by 2021.

Demand for electricity is increasing with the improvement of living standard, increase of agricultural production, development of industries as well as overall development of the country; but due to the failure in the last few years to increase electricity generation capacity proportionately to the demand, there exists 1500-1800 Megawatt electricity shortage at present. Especially a huge shortage exists during the evening peak demand. Due to the crisis of gas supply, lack of necessary maintenance and rehabilitation of old power plants, it is not possible to utilize the total installed capacity. The shortage of electricity can be from the load-shedding made during the peak demand (5800 MW) of summer which is about 1800 Megawatt each day.

3.10. Electricity Generation Structure:

Bangladesh Power Development Board (BPDB), Ashuganj Power Station Company Limited (APSCL), Electricity Generation Company of Bangladesh (EGCB) is producing electricity in the public sector. On the other hand, through IPP (Independent Power Producer) and through Rental electricity is produced in the private sector which is purchased by the Government at a fixed rate. Besides that big industries produce 1200 MW electricity for their own use from which additional 88 MW is supplied to the national grid. At present nearly 63 percent of total electricity production is produced from public entities. BPDB alone produces 46 percent of total electricity production.

3.11. Use of Different Types of Energy:

Natural Gas is used as primary energy in most of the existing power plants. 88 per cent of total electricity is produced from gas-based power plants. Besides gas, a small amount of electricity is produced using diesel, furnace oil and coal. In addition, almost 3 percent of total electricity is produced from Karnafuly Hydro Power Plant. Due to the increase of

multiple use of gas in fertilizer, industries, factories and other sectors it is not possible to supply adequate quantity gas (extracted from the existing gas fields) to meet the demand of the power plants. Due to insufficiency of gas supply at present approximately 500MW less electricity is produced from existing power plants.

From the above discussion it is evident that in the power sector the following issues are to be addressed with due importance at the moment

- Inadequacy of supply of electricity compared to demand
- Dependency on single energy (gas) for electricity generation
- Investment or participation of private sector in electricity generation is at the minimum
- To meet the increasing demand of electricity huge amount of investment is needed, the lion's share of which should come from private sector or from public-private partnership
- Shortage of electricity is not attributed to generation alone but transmission and distribution are also responsible for the existing short fall
- Limited use of renewable energy

The Perspective Plan of the Government and the Work Plan framed in according to the Perspective Plan towards mitigation of the above mentioned problems are discussed in the following chapters.

3.12. Power Sector in Outline Perspective Plan of Bangladesh:

Following Vision for power sector development has been mentioned in the Outline Perspective Plan of Bangladesh (2010-2021):

- Electricity Generation in the country by 2013 - 8500 MW
- Electricity Generation in the country by 2015 - 11,500 MW
- Electricity Generation in the country by 2021 - 20,000 MW
- Electricity for all by 2021

There is a planning of the Government of achieving the following objectives for making the vision a reality:

The Following issues have been identified to reach the objectives

- To ensure energy security
- Making the power sector financially viable and able to facilitate economic growth;
- Increasing the sector's efficiency;
- Introducing a new corporate culture in the power sector entities;
- Improving the reliability and quality of electricity supply;
- Using natural gas (including imported LNG), coal and oil as the primary fuels for electricity generation;
- Increasing private sector participation to mobilize finance;
- Matching supply and demand for electricity;
- To ensure energy security for all;

- To reduce the consumption of natural gas, thereby releasing gas for use as fertilizer, or to increase the use of coal for electricity production to release gas for alternative use;
- Finalization of the coal extraction plan;
- Reasonable cost-effective price policy for gas, coal and electricity, these being under government control;
- Energy mix for electricity generation;
- Energy conservation;
- Promotion of renewable;
- Efficiency of the power sector; and
- Reduction of system loss.
- Importation of LNG

To address the issues the following constraints, possibilities and strategies are identified:

3.13. Constraints**:**

- Absence of adequate public and private investment in power generation;
- Absence of Cost Reflective Tariffs;
- Absence of Primary Energy Supply Chain.

3.14. Possibilities**:**

Coal-based power plants using domestic and imported coal;

- Rooppur Nuclear Power Plant;
- Availability of new gas both offshore and onshore;
- Public-Private Partnership Projects;
- Prospect pf participation of local investors in the sector.
- Medium-term agreement to import LNG and steps to be taken

3.15. Strategies:

- To diversify the use of primary energy, such as gas, coal and liquid fuel, for power generation;
- To have provision for dual fuel in power plants wherever possible;
- To increase power generation through renewable sources, such as solar, wind, small hydro etc;
- To implement nuclear fuel based power plant;
- To finance power generation projects through Public-Private Partnership, government funding for IPP;
- To increase sector efficiency, reform measures must be implemented.

3.16. Work Plan (2010-2015)**:**

3.16.1. Power Generation**:**

- In the Outline of Perspective Plan of Bangladesh, the main driving force for the Power sector would be the Public Private Partnership (PPP) initiative. Power sector is characterized by time consuming nature of raising fund and requirement of large

scale initial investments. To address these limitations through PPP initiative, Independent Power Producer (IPP) policy has been formulated in 1996. Private sector has been drawn in to the power generation through IPP, SIPP, Rental, Quick Rental and Joint

- Under the yearly power generation plan, Government has taken initiatives to produce 792 MW by 2010, 920 MW by 2011, 2269 MW by 2012, 1675 MW by 2013, 1170 MW by 2014 and 2600 MW by 2015; in total 9426 MW of electricity. The Government has taken initiatives to set up 1000-1200 MW Quick Rental Power Stations which can produce electricity in the shortest possible time and help to reduce the power crisis in 2010 and 2011 to a tolerable level.

3.16.2. Time Bound Work Plans:

According to the Outline Perspective Plan of Bangladesh, the time bound work plans for power generation are as follows:

- Immediate:

Under the immediate plan, Quick Rental Stations will be established using liquid fuels and capable to produce electricity within 6-12 months. In the first phase, works are underway to set up plants with total capacity of 360 MW in three locations of the country which are expected to go into production by 2010. In addition, work is under way to set up quick rental power stations that can produce 1000-2000 MW in 2010 and by the first half of 2011 and another 432 MW from the private sector.

Sl No.	Name of the Power Station	Capacity (MW)	Fuel	Expected time of Completion	Current Status
		Public Sector (PDB)			
1	Faridpur Peaking Power Plant	50	HFO	July 2011	**Contract signed**
2	Chittagong Peaking Power Plant	100	HFO	July 2011	**Contract signed**
3	Baghabari Peaking Power Plant	50	HFO	July 2011	**NOA9 Accepted**
4	Hathazari Peaking Power Plant	100	HFO	July 2011	**Contract signed**
5	Comilla Peaking Power Plant	50	HFO	July 2011	**NOA Accepted**
6	Rajshahi Peaking Power Plant	50	HFO	September 2011	**Contract signed**
7	Bera,Pabna,Peaking Power Plant	70	HFO	September 2011	**Contract signed**
8	Gopalganj Peaking Power Plant	100	HFO	September 2011	**Contract signed**

9	Santahar, Peaking Power Plant	50	HFO	September 2011	**Retender floated**
10	Sylhet Combined Cycle Power Plant	150	Gas	December 2011	**Contract signed**
11	Chandpur 150MW Combined Cycle	150	Gas	December 2011	**Construction underway**
Total	**920**				

Figure: List of projects that will be implemented by 2011

- Short-Term:

Under the short term plan, power stations that are liquid fuel based and implementable within 12 to 24 months will be established. Works for setting up power stations with a generation capacity of 920 MW under public sector has been started.

- Medium Term:

Under the medium term plan, initiatives have been taken to set up power plants with a total generation capacity of 7714 MW that are implementable within 3 to 5 years time of which, 2600 MW will be coal based.

Table: List of projects that will be implemented by 2012

SL NO.	NAME OF THE POWER STATION	CAPACITY (MW)	FUEL	EXPECTED TIME OF COMPLETION	CURRENT STATUS
		Public Sector			
1	Ghorashal Peaking Power Plant (PDB)	200-300	Gas / Diesel	June 2012	**Retender floated**
2	Khulna 150MW Gas Turbine (GT)	150	Gas / Oil	June 2012	**Financial proposal**
3	Shirajganj 150MW Gas Turbine (PDB)	150	Gas / Oil	June 2012	**Tender evaluation in final**
4	Kaptai Solar Plant (PDB)	5	Solar	June 2012	**Under scrutiny of the Ministry**
5	Katakhali, Rajshahi Peaking Power Plant, IPP (PDB)	50	HFO	April 2012	**Evaluation of PQ11 underway**
6	Syedpur Peaking Power Plant, IPP (PDB)	100	HFO	April 2012	**Evaluation of PQ underway**

7	Jamalpur Peaking Power Plant, IPP (PDB)	100	Gas / HFO	May 2012	**PQ announced**
8	Chapainawabganj Peaking Power Plant, IPP (PDB)	100	HFO	May 2012	**PQ announced**
9	Comilla Peaking Power Plant, IPP (PDB)	50	Gas / HFO	May 2012	**PQ announced**
10	Khulna Peaking Power Plant, IPP	100	HFO	May 2012	**PQ announced**
11	Wind Power Plant, IPP (PDB)	100	Wind	June 2012	**PQ announced**
12	Solar Power Plant, IPP (PDB)	9	Solar	January 2012	**PQ announced**
13	Tangail 20MW, IPP (REB12)	20	HFO	June 2012	**-**
14	Chandpur 15MW, IPP (REB)	15	HFO	June 2012	**-**
15	Bhola 150-225MW, CCPP	100	Gas	June 2012	**Evaluation of PQ underway**
16	Keraniganj 150-225MW, CCPP , SC (GT)	100	Gas / HFO	July 2012	**PQ announced**
17	Madanganj 150-225MW, CCPP , SC (GT)	100	Gas / HFO	July 2012	**PQ announced on 05/04/2010**
18	Bibiana 300-450MW (1st unit), CCPP , SC (GT)	200	Gas	August 2012	**RFP15 given**
19	Bibiana 300-450MW (2nd unit), CCPP , SC (GT)	200	Gas	October 2012	**Evaluation of PQ underway**
20	Meghnaghat 300-450MW Combined Cycle(2nd unit)	200	Gas / HFO	October 2012	**Evaluation of PQ underway**
Both Public & Private Sector					

21	Mymensingha Peaking Plant, (PDB and RPCL16)	150	Gas / HFO	June 2012	-
22	Gazipur (RPCL)	50	Gas / HFO	June 2012	-
23	Rauzan, Chittagong (RPCL)	20	Gas / HFO	June 2012	-
	Total	**2269**			

Table: List of projects that will be implemented by 2013

Sl. No.	Name of the Power Station	Capacity (MW)	Fuel	Expected time of Completion	Current Status
Public Sector					
1	Shidhdhirganj 2*150MW GT (EGCB)	300	Gas	June 2013	Tender evaluation report sent to World Bank
2	Bhola 150MW CCPP (PDB)	150	Gas	June 2013	Feasibility study underway
3	Barapukuria 125MW (3rd unit) (PDB)	125	Coal	June 2013	Preparation of DPP17 underway
4	Ashuganj 150 MW CCPP (APSCL18)	150	Gas	June 2013	Preliminary study underway
Private Sector					
5	Savar Peaking Power Plan	100	Gas / HFO	January 2013	Preparation of PQ underway
6	Kaliakoir Peaking Power Plan	100	Gas/HFO	January 2013	Preparation of PQ underway
7	Bibiana 350-450MW CCPP (ST)	100	Gas	August 2013	RFP issued
8	Srirajganj 300-450MW CCPP	300	Gas	June 2013	Purchase process will start shortly
9	Bhola 150-225 MW CCPP (2nd unit) (SC)	50	Gas	June 2013	Evaluation of PQ underway
10	Keraniganj 150-225 MW CCPP (ST)	50	Gas/HFO	July 2013	PQ announced on 05/04/2010
11	Madanganj 150-225 MW CCPP	50	Gas/HFO	July 2013	PQ announced on

12	Bibiana 300-450MW (2nd unit, ST)	100	Gas	October 2013	Evaluation of PQ underway
13	Meghnaghat 300-450 MW	100	Gas/HFO	October	Evaluation of PQ
	Total	1675			

Table: List of projects that will be implemented by 2014

Sl. No.	Name of the Power Station	Capacity (MW)	Fuel	Expected time of Completion	Current Status
Public Sector					
1	Haripur 360 MW CCPP (EGCB)	360	Gas	June 2014	Evaluation of PQ underway
2	Bheramara 360 MW CCPP (NWPGC)	360	Gas	June 2014	Scrutiny of DPP in the Ministry underway
3	Shidhdhirganj 450 MW CCPP (EGCB)	450	Gas	June 2014	
	Total	1170			

Table: List of projects that will be implemented by 2015

Sl. No.	Name of the Power Station	Capacity (MW)	Fuel	Expected time of Completion	Current Status
PPP/IPP					
1	Chittagong , PPP (Joint Venture)/IPP	1300	Coal	March 2015	**Feasibility study will start soon**
2	Khulna (South), PPP (Joint Venture)/IPP	1300	Coal	March 2015	**Draft contract with NTPC under process**
	Total	**2600**			

- Long Term:

To achieve the targets mentioned above under the Outline of Perspective Plan of Bangladesh, growth of power generation capacity is estimated to be 10% every year and by the year 2012 the total generation capacity will be 20000 MW with a per capita electricity usage of 600 Kwh.

3.17. Diversification of Energy Sources:

According to the plan, high dependency on gas based power generation has been reduced in the short and medium terms and the plants that will be newly built are designed to be

dual-fuel based. In addition, emphasis has been given to various power saving efforts so that the saved power can be transmitted to the other thrust areas.

CFL (Compact Fluorescent Lamp) Distribution Program is due to start on June 19, 2010 through which a total of 200-350 MW of electricity can be saved.

According to the energy source diversification plan, there is a continued effort to produce and buy captive power from renewable and non renewable sources. So far, contracts have been signed to purchase 88 MW of electricity from captive generation sources. Initiatives have been taken to import electricity from the neighboring countries and export (in future) through the sub-regional cooperation. According to a decision at the Prime Minister level with India, works have already been started to build 400 KV transmission line and HVDC (High Voltage Double Circuit) sub stations through Regional Grid Interconnection. India has made the commitment to supply 250 MW of electricity from their "Unallocated Resource".

The use of renewable energy has risen considerably in the recent times in developed and developing countries. In Asia, India and China have achieved considerable success in innovating and using the technology of renewable energy. Although the initial installation cost of renewable energy is higher, but it will gradually decline and will come down within the purchasing capacity of the people. As the global reserve of fossil fuel is gradually decreasing, the Government has taken steps to extend and develop the use of renewable energy to ensure the future energy security. Under this plan, targets have been set to produce electricity from renewable sources as 5% of total production by the year 2015 and 10% by 2020. Renewable Energy Policy has also been adopted to attract and encourage the private sector. In addition, the Government is going to set up Sustainable Energy Development Authority (SEDA) has been set up to expand and develop renewable energy, to promote energy saving and energy efficiency and to create awareness among the users of electricity.

3.17.1. Power Tariff:

The per unit production cost of electricity is expected to rise (20%-30%) in the upcoming 2-3 years due to the installation of high cost liquid fuel based peaking plants which are implementable in 18-24 moths. Accordingly, the Energy Regulatory Commission may increase the tariff of power step by step. However, power tariff will come down after 2014 as the implementation of gas and coal based power plants will be completed.

3.17.2. Transmission & Distribution:

In addition to power generation, it is very important to develop a dependable and quality power transmission and distribution network to ensure quality and uninterrupted power supply to the consumers. To transmit the newly produced power to the doorsteps of the consumer, it is urgently needed to build new transmission and distribution infrastructure in addition to renovation and preservation of old distribution networks.

For resolving the electricity crisis, government has some plans for increasing electricity generation and at the same time has undertaken massive development plans for efficient and uninterrupted transmission and distribution system. At present total length of 230 KV electric line has been upgraded at 2644.5 circuit kilo meters and for 132 KV electric lines, the length is 5715 circuit kilometer. For strengthening the electricity transmission system and for meeting up the gradual increasing future demand for electricity, government has

set a target of “Providing Electricity in every house by 2021”. As part of achieving this target, government has already undertaken a priority based investment plan (Three year road map for power sector reform) for the year 2007-09 under which massive work plan has been chalk out for building an additional 3000 kilo meter of transmission lines by 2015. In this regard, PGCB has undertaken activities for building concerned transmission lines for supplying electricity through regional cooperation.

Up to December, 2009, about 117 lakes customers have been provided with electricity connections through building 2,66,460 kilo meter distribution lines with necessary infrastructure. New projects are being undertaken for expanding the electrification program as well as for the development and capacity enhancement of the existing transmission and distribution system. Through these programs, initiatives have been made for building an additional 60,000 kilo meter distribution lines by 2015.

Providing electricity in rural areas is an important feature of the distribution system. Up to December, 2009, Rural Electrification Board through their 70 associations has given a total number of 79, 55,881 connections in 53,281 villages by building 2,21,749 kilo meter distribution lines. Out of the total connections, 68,75,627 nos are residential, 1,49,581 nos are irrigation, 7,87,844 nos are commercial, 1,29,218 nos are industrial and 13,611 nos are other types of connections. About half of the total power is provided by REB in the country. They mostly obtain this from Power Development Board since their own capacity for production in very little. Compared to the demand, their ability for transmission and distribution is limited. Their efficiency is also not beyond doubt. It is necessary to restructure this institution to turn it into a strong and professional body.

Government has undertaken time-based work plan for generating electricity. For implementing these work plans, attempts have been undertaken by PGCB for constructing transmission lines and sub stations in order to supply the generated electricity in the load centers at different voltage level. Description of some major transmission projects are as follows:

Table: Possible important transmission projects

Transmission Line	Voltage Level	Length (KM)	Possible Date of Completion	Present Situation
Bibiana- Kaliakoir	400 KV	194	2011-2012	DPP is sent to the Ministry
Chittagong- Meghnaghat	400 KV	260	2014-2015	Soon the preparation of PDPP will be started
Aminbazar-Maoa-Khulna	400 KV	200	2014-2015	Soon the preparation of PDPP started
Fenchuganj-Bibiana-Comilla	230 KV	160	2011-2012	PDPP is sent to the Ministry
Bheramara-Bahrampur-(India)	400 KV	30	2012-2013	Evaluation of

Rigional Interconnection transmission line and HVDC Sub-station (600 MVA) 19				Tender Documents is going on
Barisal-Bhola	230 KV	60	2012-2013	Evaluation of Tender Documents is going on
Construction of Transmission line for Evaquation of power from rental power station implementing at a short term basis and picking power station at the government sector	-	-	2010-2011	In the implementation process

3.18. Year-Wise Power Generation Statistics**:**

Year-wise power generation statistics is shown below on the basis of the plan that will generate around 9426 MW extra power to the national grid by 2015.

Table: Year wise power generation statistics

Year	Government Sector	Private Sector	Total (Megawatt)
Year 2010	360	432	**792**
Within 2011	920	--	**920**
Within 2012	505	1764	**2269**
Within 2013	725	950	**1675**
Within 2014	1170	--	**1170**
Within 2015	--	2600	**2600**
Total Extra Generation			**9426**

3.19. Year-Wise Expected Power Demand And Supply:

It will be possible to meet the prevailing power deficit by 2011 through the plan of generating 2800 MW excess electricity into the system within 2011 to resolve the power scarcity problem. Currently there is a shortage of 1250 MW electricity supply as compared to demand.

The Government has formulated plans regarding production as well as supply considering the increased growth in power demand resulting from economic development along with the ongoing rising demand in electricity. Following the plan, although around 9426 MW extra power will be added to the national grid by 2015, in total power supply capacity will reach to 11500 MW due to the retirement of some existing old power plants. On an average, the demand for electricity is assumed to enhance by 10.5 percent each year starting from 2009 to 2015. On the contrary, the capacity for power generation will be

augmented at 18.5 percent to achieve the ability of producing surplus electricity by 2011. Considering the growth in power demand, an overall scenario of expected power demand and supply after increasing electricity production according to plans has been shown in the following Table.

Table: Year-wise Possible Power Demand and Supply

	2009	2010	2011	2012	2013	2014	2015
Probable Demand (MW)	5566	5808	6298	6832	7709	8699	9812
Capacity Retired (MW)*	-	48	-	-	448	378	-
Expected Supply Excluding Quick Rental (MW)*	4289	4956	5177	7029	8326	9545	11625
Expected Supply Including Quick Rental (MW)*	4289	5109	6363	8683	9764	10527	12601
Deficit/ Surplus Excluding Quick Rental (MW)*	-1277	-852	-1121	197	617	846	1813
Deficit/ Surplus Including Quick Rental (MW)*	-1277	-699	65	1851	2055	1822	2789

3.20. Power Saving Activities:

To ensure energy conservation and efficient use of electricity under load management and system supervision, it has been possible to save around 350 MW of electricity by undertaking actions like keeping Shopping –malls and Shopping centers closed after 8 p.m. Establishing Solar Panels in government, semi-government, autonomous bodies and industries have been initiated. The relevant consumers are encouraged to keep the temperature of Air-cooler at 250 Celsius or higher and are prohibited to use Air-cooler in the evening peak hours. Initiatives have been underway to establish 20.0 lakh pre-paid meters countrywide to facilitate electric bill payment for consumers and to control and determine power load by distributing institution. A number of steps have been taken to control electricity demand on the receiving end by using power saving handy equipments. Steps have been taken to replace around 4 core ineffective electric lamps by power saving Compact Fluorescent Lamps (CFL) under Efficient Lighting Initiatives for Bangladesh (ELIB) programme. It will be possible to install 1.05 crore power saving CFL bulbs by 2010. This will also ensure Clean Development Mechanism (CDM) facilities.

In order to overcome the present power deficit situation, targets are fixed up in the outlines of Bangladesh Perspective Plan and on reaching these goals it will be possible to have access to power by all citizens within 2021.A huge investment is required to go towards the preferred level from the prevailing power deficit situation. Initiatives have been on to ensure

public as well as government-patronized private investments and Foreign Direct Investments. In this sector investment to amount of taka USD 9.00 billion is required out of which USD 8.00 billion is expected to come from private sector in order to raise power generation to 11,625MW within 2015.Initiatives have been taken in this comprehensive plan to transmit, distribute, adopt demand side management, use renewable fuels, rationalize prices separately at private investment and consumers' level due to the existing difficulties of transmission, distribution, power supply and sources along with production in power sector. The prevailing power crisis will be reduced in 2012 if this plan is implemented on time and every citizen will have access to power in 2021.

Chapter 4

Crisis of Power Sector

4.1. Energy Sector:

In recent times, establishment of important physical infrastructures, setting up of new power plants and the pace of industrialization in the country has slowed down due to energy supply shortage. The sluggish industrialization which has hindered development activities is apprehended to create a negative impact on employment and consequently on the people's livelihood. This dismal state of energy sector has resulted from lack of initiatives and insufficient investment in the sector during the past years. Realizing the necessity for its improvement, the present government has indicated energy sector as a priority sector.

4.2. Current Position of Energy Sector:

At present, Bangladesh has energy supply from both renewable and nonrenewable sources, 38 percent of which comes from biomass. However, 75 percent of commercial energy is provided from natural gas. Currently, gas production per day is 2000 MMCF in our country. Use of imported oil accounts for the lion's share of the rest of the energy requirement. Our annual requirement of fuel is approximately 3.7 million metric ton. Apart from natural gas and crude oil, coal is mainly used as fuel in the brick-fields and at the Boropukuria Thermal Power Plant. Moreover, power is also being generated by using solar home system in off grid areas. In addition there are some poultry and dairy farms in which bio-gas plants are being set up and with this energy, power can be generated and is also used for cooking. The amount of power generation from such plants is currently about 1 MW. Steps have been taken to generate electricity by Bio-Mass Gasification Method in the country. We also have a bright potential to produce electricity from wind and mini-hydro or wave-energy. Recently, solar power based irrigation pump has been used in a number of areas of the country. Its wide use will lessen the pressure on diesel and electricity.

4.3. Non-renewable energy:

The proven reserve of natural gas which is the principal source of nonrenewable energy of the country is gradually depleting. The supply of gas as a primary source of energy will be dried out soon if immediate steps are not taken for exploration of new gas fields and extraction there from. In the use of commercial energy, the notable ones include the following:

- Natural gas
- Oil from minerals and other sources
- Coal and coal like substance
- Compressed natural gas (CNG)
- Natural Gas Liquid (NGL)

4.4. Renewable Energy:

In our country renewable energy such as biomass, solar power and wind power are being used since time immemorial. [8]Especially in areas which are outside gas coverage, usage of biomass for cooking and solar power and wind for drying of different grains as well as clothes are known to all. However, we are still lagging far behind in the scientific use of such energy. Moreover, the use of renewable energy has become popular worldwide in

view of depleting reserve of non-renewable fossil fuel. Renewable energy is environment-friendly. At present, the different categories of renewable energy that are being used in limited ways in our country are as follows:

- Hydro-Electricity
- Solar Power Generation Using Solar Rays
- Wind-Mill Power Generation Using Wind Power
- Production Of Bio-Gas Using Waste
- Electricity Produced By Biomass Gasification Method Using Wood, Rice Husk, Etc.

4.5. Natural Gas:

Major Source of our primary energy is natural gas. It is considered as one of the driving forces of the economy of our country as three-fourths of the total commercial energy is provided by natural gas. As many as 23 gas fields have been discovered since 1955 when the first gas field was found in Sylhet. In the past, in order to export gas, different initiatives were taken by exaggerating the actual reserve of natural gas and being over-enthusiastic about exploration of new gas fields.

Meanwhile, exploration of new gas fields and extraction activities by the native organization, BAPEX slowed down. At the same time, the propaganda about exaggerated gas reserve created a delusion among the people and ultimately hindered economic use and conservation of the valuable resource.

4.6. Present Reserve and Production Levels of Natural Gas:

The existing natural gas is mainly used in electricity, fertilizer, industry, transport and housing sectors. The reserve and production situation of gas up to 2010 are as follows:

- Total number of gas fields- 23
- Number of gas fields which are in production- 17 (number of wells-79)
- Total reserve of extractable gas (proven and probable)- 20.5 TCF (Trillion Cubic Feet)
- Total consumption of gas up to April 2010- 8.5 TCF
- Total reserve remaining- 12 TCF
- Daily gas exploration- about 2000 MMCF (Million Cubic Feet)
- Production by Petrobangla- 960 MMCF
- Production by International Oil Companies- 1004 MMCF
- Daily demand of gas-2500+ MMCF
- Daily shortage of gas supply- 500+ MMCF
- Gas production increased from January 2009 to January 2010- 208 MMCF

4.7. Consumption and Demand of Natural Gas:

Per capita consumption of energy in Bangladesh is on an average 160 kgoe (Kilogram Oil Equivalent) while it is 530 kgoe in India, 510 kgoe in Pakistan, 340 kgoe in Nepal and 470 kgoe in Sri Lanka. The average consumption in Asia is 640 kgoe. It is evident that per capita average consumption of energy in Bangladesh is significantly lower than the average of Asia. Even it is lower than those of South Asian countries. In recent times per capita energy

consumption has been used as an indicator to determine the living standard and stage of development of a country.

Considering the average rate of consumption of gas in the country of the last 17 years and in line with Vision 2021, to implement the target of producing 11500 MW new electricity by 2015, a projection has been done according to the sector wise annual demand of gas from 2009 to 2015. Projection for probable demand of gas up to 2015 is shown in the table below:

Sector	2009-10	2010-11	2011-12	2012-13	2013-14	20014-15
Power	278.2	300.5	324.5	50.5	378.5	415.8
Captive Power	120.9	142.6	164.0	188.6	216.9	238.6
Fertilizer	94.0	94.0	94.0	94.0	94.0	94.0
Industry	133.9	160.7	184.8	214.4	246.5	271.1
Household	88.9	99.5	111.4	124.8	139.8	153.8
CNG	37.2	44.7	51.4	56.5	113.0	124.3
Others	30.0	30.8	31.9	32.7	33.7	37.4
Total	**783.1**	**872.8**	**962.0**	**1061.5**	**1222.4**	**1335.0**

Table: A Conservative Estimates of Sector wise Allocation of Gas (In Billion cubic feet)

4.8. Investment in Gas Sector**:**

For overcoming the existing as well as projected shortage of gas supply for the later years, discovering new gas fields and enhances gas reserve by re-assessing the present reserve of the existing gas fields is the best approach. In addition to these, attempts should be taken for increasing the supply by drilling good number of wells. However, implementing these initiatives needs huge investment and a high level of technical, technological and professional expertise. Exploring and discovering oil and gas is a capital intensive and risky investment. It can be seen from various reports that for discovering a gas field, it needs an investment of about Taka 700 crore, whereas the rate of success is only 20-25 percent. So, although gas fields may exist in developing countries, it is not possible for them to invest such a huge amount for exploring and discovering those gas fields. An alternative to this may be involving the private sector especially the International Oil Companies (IOC) which are financially, technically and technologically very sound. In this case, national interests should be ensured while production sharing agreements are signed for the development of energy sector including gas.

4.9. Action Plan for the Development of Natural Gas Sector**:**

Government has identified the Power and energy sector as the top priority sector with the aim of ensuring long term energy security of the country. In this regard, Government is determined to overcome the critical situation prevailing in the gas sector to ensure the availability of energy. Salient features of the planned policy strategy of government in overcoming the energy shortage are as follows:

Policy Strategy:

- Adoption of time based action plan for discovering new gas fields
- Make BAPEX more effective in exploring oil and gas
- Speedy processing of tenders and signing agreements for offshore blocks
- Approval for importing liquefied natural gas by private sector as an alternative to natural gas and building necessary infrastructure
- Reduce the supply of natural gas to those sectors where alternative energy can be used and encourage them for using alternative energy
- Finalizing National Energy Policy and Coal policy to create opportunity for using energy from multiple sources Increasing financial capacity of BAPEX by forming Gas Development Fund

4.10. Coal:

The diversification of sources of energy has created ample opportunity for our coal. By establishing power plant based on coal and using it in the industries as a source of energy we can ensure the proper use of extracted coal. It is notable that the coal of Bangladesh is considered to be high quality due to its high level of hit generation capacity.

4.11. Coal: Reserve and Usage:

High quality Bituminous coal mines have been discovered at Khalashpur of Rangpur, at Boropukuria, Fhulbaria, Dighipara of Dinajpur and at Jamalganj of Bogra in the north-western zone of the country. The total reserve is around 2797 MT of this 5 coal mines and the hit generation capacity is equivalent to 37 TCF of gas approximately. [9] If initiatives are taken for exploration all over the country, there is enough possibilities to discover more coal mines. The coal reserves of existing 5 coal mines are shown in the table below:

Sl.	Exploration Year of location	Depth (Meter)	Magnitude of mine area (Sq. km.)	Actual Reserve (Million Ton)
1	Boropukuria, Dinajpur (1985)	119 – 506	6.88	**390**
2	Khalashpur , Rangpur (1995)	257 – 483	12.0	**143 (GSB)33, 685 (Hosaf)**
3	Fhulbaria, Dinajpur (1997)	150 – 240	30.0	**572**
4	Jamalganj, Bogura (1965)	900 – 100	16.0	**1050**
5	**Dighipara, Dinajpur(1995)**	**327**	**Not Available**	**200 (Partial Evaluation)**

Table: Coal Reserves of Five Coal Mines

Among the 5 coal mines, Boropukuria coal mine in Dinajpur has started commercial production by using underground mining method from September, 2005 with the annual target of 10 lac MT of coal extraction. A 250 MW power plant has been running by using

the extracted coal of Boropukuria through which power is being supplied to the National Grid. 7 lac MT coal, extracted from Boropukuria coal mine, is being used daily in this power plant.

4.12. Steps to be taken for removing the problem of Coal Sector:

Although there are enough reserves of coal in the country, there remains anxiety for the extraction methods and the technological security. At the same time, there are also expert opinions regarding the quick solution of energy problem through the importation of coal. To turn down this situation, Government's activities are as follows:

- Quick finalization of coal policy.
- Formation of coal extraction plan consistent with the demand of the country.
- Build up the mass awareness and mass involvement regarding the extraction procedure of coal especially for the open extraction method.
- If the coal extraction by open method from a coal mine is economically viable, a plan has to be prepared about the rehabilitation of the people of that area and ensure their livelihood, preserve the environment and infrastructure as well.
- Clarify the government position regarding coal import.

4.13. Nuclear Energy:

Since 1960s, a plan has been taken to establish a nuclear power plant in the country. But no effective action had taken in the last 50 years except land selection and acquisition for the nuclear power plant. Present Government, with the technical assistance of Russia, has made effective arrangement to establish a nuclear power plant with a capacity of 1000 MW in the pre-determined location at Rooppur. **[10]** In this respect, Bangladesh government has signed a framework agreement with the Russian National Nuclear Institute. It is expected that the country will be able to enter into nuclear age through the establishment of nuclear power plant by 2016.

4.14. Challenges of Nuclear Energy Sector:

In order to remove energy deficit and build up energy security in the country, the probable challenges are:

- Necessary fund provision.
- Ensure safety of the population and environment.
- Build up the trained and efficient manpower in order to administer and maintain the nuclear plant.
- Build up awareness among general people regarding the risk and prevention of nuclear power centre.

4.15. Production, Usage and Promotion of Renewable energy and Energy Saving Activities:

In order to reduce the reliance on natural gas and import-dependent oil the government has taken a number of steps to spread and develop environment-friendly, renewable energy.

Benefits to use renewable energy are as follows:

- Supply of raw materials for power generation is infinite
- Management cost is minimum though initial investment is comparatively high
- Technology used is easy and portable
- People living separately in places away from the main land can have access to power and energy facilities
- Future energy security is ensured
- Environment Friendly
- To ensure future energy security

Actions taken up on priority basis for implementation of energy saving programmes are as follows:

- Formation of Sustainable Energy Development Authority
- Preparation of Energy Conservation Act
- Expansion and development of renewable energy
- Implementation of cost effective energy procedure
- Ensuring of efficient use of energy
- Standardization of energy saving electronic machineries

It is necessary to encourage the production and use of such energy from a source which is not harmful to environment in order to ensure safe energy supply along with habitable surroundings.

4.16. Steps Taken To Produce And Extend Use Of Renewable Energy: [11]

- Setting up 14 thousand solar home system by REB
- Setting up a solar panel having capacity of 21.2 kilowatt for Prime Minister's Office
- Installation of around 5.30 lakh solar home system in rural areas with the aid of IDCOL (Infrastructure Development Company Limited) through NGOs
- Power generation by setting up wind-mill run power plants in coastal region of Kutubdia and Feni
- Establishing of a wind-mill run power plant of 100 MW(off-shore) capacity in Anowara of Chittagong and 4 solar power plants of 10-15 MW capacity (connected to grid)
- Actions are underway to implement pilot project as IPP to produce power from waste

Setting up several solar panel factory by IDCOL

- Public Effort:

In order to encourage people to use renewable energy, some of the significant steps taken by the Government are:

- The use of Solar Panel in all large public buildings to be mandatory within 3 years
- Solar Panel import made duty-free

- Immediate Steps to Be Taken:
  - Providing policy-strategic and financial support to wind-mill power generation
  - Encouraging setting up of Bio-digester Plant
  - Encouraging the establishing of solar panel producing industry
  - Providing adequate investment in power sector enterprises
  - Fixing maritime boundary with India and Myanmar
  - Reducing the tendency of quick withdrawal of invested money of international oil companies under Production Sharing Contract (PSC)
  - Determining rational price to ensure sustainable development of energy sector
  - Developing and sustaining skilled professionals with knowledge on various sources of energy
  - Finalizing of Coal Policy
  - Expediting the import of LNG
  - Expedite onshore bidding process

The target for achieving higher economic growth with power supply deficit has faded other achievements in infrastructural development of the country; therefore, private investors are not showing much interest in investments. Power is one of the significant raw materials for all sorts of industries starting from agricultural industries. Electrification is also necessary for increasing socio-economic activities in rural areas. In order to overcome the present power deficit situation, targets are fixed in the Outline Perspective Plan of Bangladesh. If we go ahead as planned, it will be possible for all citizens to have access to power within 2021. In addition, the use of coal for power generation will be enhanced through reducing the dependence on natural gas and contribution of renewable energy in electricity production will also be increased. A six year plan up to 2016 has been adopted to improve power scarcity and provide excess power for future. Vision of increasing economic growth to 8 percent by 2014 and 10 percent by 2017 through industrialization will be a reality with the implementation of this plan. It will ultimately help to reduce poverty and achieve Millennium Development Goals by employment generation in the country.

Chapter 5

Cross Border Electricity Trade in Power Sector

5.1. Power Exchange between India and Bangladesh:

The peak demand of Bangladesh is of the order of 4200-5500 MW and the peak deficit is about 1000-1500 MW. The interconnection between the electrical grids of India and Bangladesh would facilitate transfer of 500 MW Power in either direction. In the Initial years, it has been indicated that power would be required to transfer from India to Bangladesh. As per the preliminary discussion in regard to exchange of power between the two countries, it has been agreed that a quantum of 250 MW may be transferred to Bangladesh from the unallocated share of Central Sector Power Projects in Eastern Region. For further requirement of power by Bangladesh up to 250MW, it has been indicated that Bangladesh Authority may tie up the same through negotiation with various IPP power projects in India based on commercial principle. The transmission charges for the power to be transferred to Bangladesh would be decided as per CERC norms. The details on the interconnection link between India and Bangladesh are given below.

5.2. Cross Border Electricity Trade:

Realizing the ever increasing demand of electricity for socio-economic development and progress of the country, the government has initiated sub-regional cooperation in the field of power generation, grid connectivity and overall energy security. Cooperation has been initiated through SAARC, SASEC and BIMSTEC etc. for sharing of hydropower through cross-border connectivity and capacity development. Through these cooperation efforts Bhutan's and Nepal's hydro power potential could be utilized for the sub-region. Sub-regional grid could enable flow of surplus electricity within the countries and minimize the demand-supply gap of electricity of the nations.

A historical bilateral tie took place in January 2010 where the Hon'ble Prime Ministers of Bangladesh and India agreed on a major cooperation between the two neighboring countries. This initiative highlighted the development of economic cooperation between the countries.

5.3. Bangladesh- India Cooperation in Power Sector:

The Bangladesh-India cooperation formally initiated in November 2009 followed by a visit of high level Bangladesh delegation led by the Secretary, Power Division, Ministry of Power, Energy & Mineral Resources, during 18-22 November 2009. The MOU was signed between the two nations on 11th January 2010 during the visit of the Prime Minister, Government of the People's Republic of Bangladesh. Under the MOU the salient features of the cooperation on power sector between the two countries were:

- Exchange of power through Grid connectivity between the two countries
- Joint venture (JV) investment in power generation
- Capacity development of BPDB

5.4. Scope of Interconnection:

5.4.1. India Portion:

- Baharampur (India)-Bheramara (Bangladesh) 400kV D/C line: 71 km
- LILO of Farakka – Jeerat 400kV S/C line at Baharampur : 3 km
- Establishment of 400kV Switching Station at Baharampur

5.4.2. Bangladesh Portion:

- Baharampur (India)-Bheramara (Bangladesh) 400kV D/C line : 27 km

- LILO of Ishurdi – Khulna South 230kV D/C line at Bheramara: 4.5 km
- Establishment of 500MW HVDC back-to-back Station and 230kV Switching Station at Bheramara

The Indian portion is being executed by POWERGRID, India while the Bangladesh portion is being executed by PGCB (Power Grid Company of Bangladesh Ltd.), Bangladesh and POWERGRID is providing consultancy to PGCB.

5.5. Cost Estimate:

- India Portion – Rs. 160.32 Crore (USD 34.03 million) including IDC of Rs. 6.97 Crore.
- Bangladesh Portion – Rs. 736.84 Crore (USD 156.44 million) including IDC of Rs. 27.97 Crore.

5.6. Present status of the Project:

- LILO of Farakka-Jeerat 400kV S/C line at Baharampur has been successfully charged on 17.8.2013
- 400 kV Barampur- Bheramara Transmission line charged on 30-8-2013.
- After LILO of 220 kV Ishwardi-Khulna Transmission line Ckt-II charged on 8.9.2013 as HVDC Bheramara-Ishwardi-II and HVDC Bheramara-Khulna-.
- After LILO of 220 kV of Ishwardi-Khulna Transmission line Ckt-I charged on 10.9.2013 as HVDC Bheramara-Ishwardi-II and HVDC Bheramara- Khulna-I.
- 400 KV side DT 12/24 charged on 11-9-2013.
- 400 KV side 63 MVAR -02 nos reactors charged on 17-9-2013.
- 230 kV side DT 12/24 charged on 18-09-2013.
- 230 kV side 35 MVAR one reactor charged on 23-9-2013.
- 400 kV Converter Transformers energized on 25-9-13 and 230 kV converter transformers energized on 26-9-2013.
- HVDC BtB blocked on 26-9-2013
- HVDC BtB de-blocked on 27-9-2013 with 50 MW testing power flow from India to Bangladesh which ramped up to 175 MW.
- Reverse power flow tested with 50 MW from India to Bangladesh and Bangladesh to India.
- Regular power flow is planned on 5-10-2013.

Power Purchase Agreement (PPA) and Bulk Power Transmission Agreements (BPTA) with BPDB:

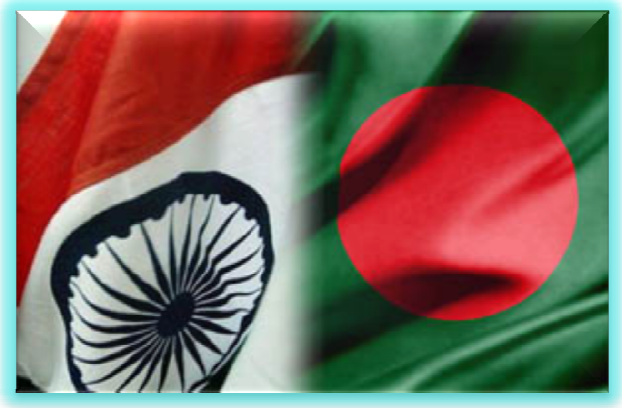
- The Interconnection of Electrical Grid between India and Bangladesh was discussed during joint meeting held between technical team from POWERGRID INDIA and PGCB on 24th November'2009 at Dhaka, Bangladesh.
- Power Grid Corporation of India Ltd. and Bangladesh Power Development Board (BPDB) entered in to Bulk Power Transmission Agreement on 26-7-2010.
- NTPC Vidut Vyapar Nigam Limited and Bangladesh Power Development Board (BPDB) entered in to Power Purchase Agreement on 28-2-2012. This Agreement shall be effective from the date of signing of this agreement and shall remain valid initially up to 25 (twenty five) years from 00.00 hours of the date of commencement of supply.

5.7. Funding:

India Portion of the project is funded through loan from domestic sources and POWERGRID's internal resources with debt: equity ratio of 70:30. Bangladesh Portion of the project is funded through ADB loan

5.8. India, Bangladesh Open 500 MW Power Transmission Link:

The governments of India and Bangladesh have completed construction on the Baharampur- Bheramara cross-border power transmission link between the countries. Indian Prime Minister "*Manmohan Singh*" said that the new transmission link will enable safe and reliable interconnection between the countries and will facilitate India to initially supply 500 MW power to Bangladesh. The Indian government will supply 250 MW of the initial capacity from its unallocated quota of power at Central Electricity Regulatory Commission-specified rates, while the remaining 250 MW will be contracted by Bangladesh from the Indian electricity market.



The transmission line enables the exchange of 500 MW electric powers with an option to upgrade the power flow to 1,000 MW in the future. Backed by the Asian Development Bank, the $193 million Bangladesh-India electrical grid interconnection project is established between the western electrical grid at Bheramara in Bangladesh and the eastern electrical grid at Baharampur in India. The link features 77 miles of 400 kV double circuit (D/C) transmission line between the electrical substations at Baharampur and Bheramara, a 400 kV switching station at Baharampur and a 500MW back to back high voltage direct current (HVDC) sub-station (400/230kV) at Bheramara and associated infrastructure. Earlier Power grid Corp. of India and Bangladesh Power Development Board had signed a contract for the development and operation of the project, which received approval from the Bangladesh Department of Environment on 11 July 2010.

Consequently, the parties had signed contracts for the 400kV D/C overhead transmission line (Bangladesh portion) and line-in line-out of 230 kV Ishurdi-Khulna D/C overhead line at Bheramara in December2010 and for the 500 MW HVDC substation in March 2011.

5.9. Project Update:

India–Bangladesh Electrical Grid Interconnection Project [**August 22, 2013**]

5.10. Developers:

Power Grid Corporation of India Limited (POWERGRID), India and Bangladesh Power Development Board (BPDB), Bangladesh

5.11. Project Details and Status:

The proposed 125 km transmission line will connect Behrampur in India and Bheramara in Bangladesh, which would enable transfer of electricity from the former to the latter. Of the total line length, 40 km would fall in the Bangladesh territory while the rest would be in India. The transmission systems of India and Bangladesh, which are based on 400 kV alternate current (AC) and 230 kV AC respectively, is proposed to be synchronized by installing a back-to-back high voltage direct current (HVDC) link. The line will have an initial transfer capacity of 500 MW, which will later be upgraded to 1,000 MW.

Of the USD196.8 million project cost, the Indian component will cost USD38.2 million, which will be funded by POWERGRID. For Bangladesh's segment, estimated to cost USD158.6 million, the Asian Development Bank (ADB) is extending a loan of USD100 million while the Government of Bangladesh will contribute USD58.6 million.

As per the 35-year power transmission agreement signed between BGDB and POWERGRID, Bangladesh can begin to import 250 MW of electricity from India from late 2012. The power and transmission tariff which BPDB will pay will be on a monthly basis to its Indian counterpart will be determined by India's Central Electricity Regulatory Commission (CERC).

The first activity identified the establishment of a grid connectivity that would allow power trading between the two countries. Based on detailed techno-economic analysis under taken by a joint technical team, it was agreed that the most effective option would be to set up an interconnection between Bheramara in Bangladesh and Baharampur in India. Scope of the project included a 400 KV, 30 Km double circuit line from Bheramara to Baharampur and the establishment of a 500 MW 400/230 KV back-to-back high voltage direct current (HVDC) substation at Bheramara. In proposed Bheramara HVDC center, existing in Ishardi-Khulna (South) 230 KV double circuit transmission line was designed loop in-loop out 5km. The transmission line was designed for an ultimate power flow of 1000 MW. ADB is financing the project from Bangladesh side.

In February 2011, PGCB awarded a BDT1 billion contract to construct the Bangladesh segment of the line to Spanish company Cobra Instalaciones Y Servicios SA. In April 2011, Siemens was awarded a USD107 million contract to set up the convertor station at Bheramara. However, in June 2011, ADB put on hold the disbursement of its approved USD100 million loan to Bangladesh as the power purchase agreement (PPA) between BPDB and the Indian electricity supplier NTPC Limited was yet to be signed. The two companies were to sign the PPA in March 2011. The delay was due to differences in views over the terms and conditions of the proposed PPA. Finally, in March 2012, BPDB and NTPC signed the PPA for exchange of 250 MW of power.

In July 2012, PGCB decided to double the capacity of the under-construction substation at Bheramara to facilitate greater power trade with India. For this, PGCB will construct another 500 MW substation at Bheramara. As of July 2012, POWERGRID had completed 60 per cent of its end of the work while PGCB had completed 40 per cent of its share of the work. In May 2013, it was announced that the cross-border link was facing delays. POWERGRID and PGCB were expected to complete the respective portions of the project work in May 2013 and July 2013, respectively. However, the slow pace of work on both sides is likely to delay the project

beyond the scheduled timeline. Though in July 2013, it was announced that interconnector was expected to be completed by mid-August 2013, and the construction works on the line are yet to be completed.

5.12. Brief Technical details of The Bheramara HVDC Back to Back Station:

Interconnection Between	INDIA				BANGLADESH		
AC System Frequency	50 Hz				50 Hz		
AC System Voltage	400 kV				230 kV		
Power Co.	Power Grid Company of Bangladesh						
Contractor	SIEMENS AG						
Scheduled Commissioning date	July 2013						
Estimated Cost	Tk						
Executed cost	Tk						
Main Purpose	Interconnection of two asynchronous Regions for bidirectional power flow.						
Main Data	Rated Power : 500 MW Direct Voltage: 158.1 kV Direct Current : 3189 A Overload : 1.1 pu for 2 Hour and 1.33 pu (not before and after 15 min of long overload) for 5 Sec.						
A.C. Networks	Both countries are connected to the AC network through 400 kV bus(India side) and 230 kV bus(Bangladesh side). There are three single phase 3 winding converter transformers at each side of the back to back station. Commutation reactance (% of Transformer base) : 16%						
	INDIA	AC Side	Valve side Y	Valve Side D	B'desh	AC side	Valve side Y	Valve side D
	1 phase Rated power MVA	201	100.5	100.5		201	100.5	100.5
	Rated Voltage kV	400/√3	66.8/√3	66.8		230/√3	66.8/√3	66.8
	Tapping range	-7% to +11% (step 1%)				-10% to +13% (Step 1%)		
AC Filters	At 400 kV(India side Bus) 4X91 MVAR, 12/24th Harmonic filters are							

	installed. Two shunt reactors of 63 MVAR are also installed on 400 kV Bus which are switchable by RPC. At 230 kV (Bangldesh side Bus) 2X91 MVAR, 12/24th Harmonic filters and 2 X91 MVAR, 3/12th Harmonic filters & 1X91 MVAR C-shunt are installed. Two shunt reactors of 35 MVAR are also installed on 230 kV bus which are switchable by RPC.
DC Filters	N.A
HVDC Valves	Each Valve in Quadruple valve structure consists of 26 No.(including 02 nos redundancy Thyristors) 8 kV, (5" LTT) thyristors connected in series. The Quadruple valve structure is suspended from top. Neutral bus is upper side and High Voltage bus on lower side. Snubber Ckt-1.6μ F/36Ω, Grading Capacitor 4.0 nF, Valve Reactor 4/Valve.
Valve Cooling	The valves are cooled by deionized water circulated in closed loop system. Conductivity of cooling water < 0.5 μS/cm , alarm if rises > 0.5 μS/cm, trip if value larger than 0.7 μS/cm more than 2 min, operating point 0.3 μS/cm. Water Inlet temperature Max trip 50 degree C.
Smoothing reactor	2 X 30 mH air core smoothing reactors have been installed.
DC Current & Voltage Measuring	Current- Zero Flux CT (3189/1.5945 V/1.5945 V) IdCN, IdSG Voltage-DC voltage divider
UPS	Valve cooling 80 kVA ,5 min backup;02 nos.Station UPS- 15 kVA,01 no 5kVA for BMS.

Chapter 6

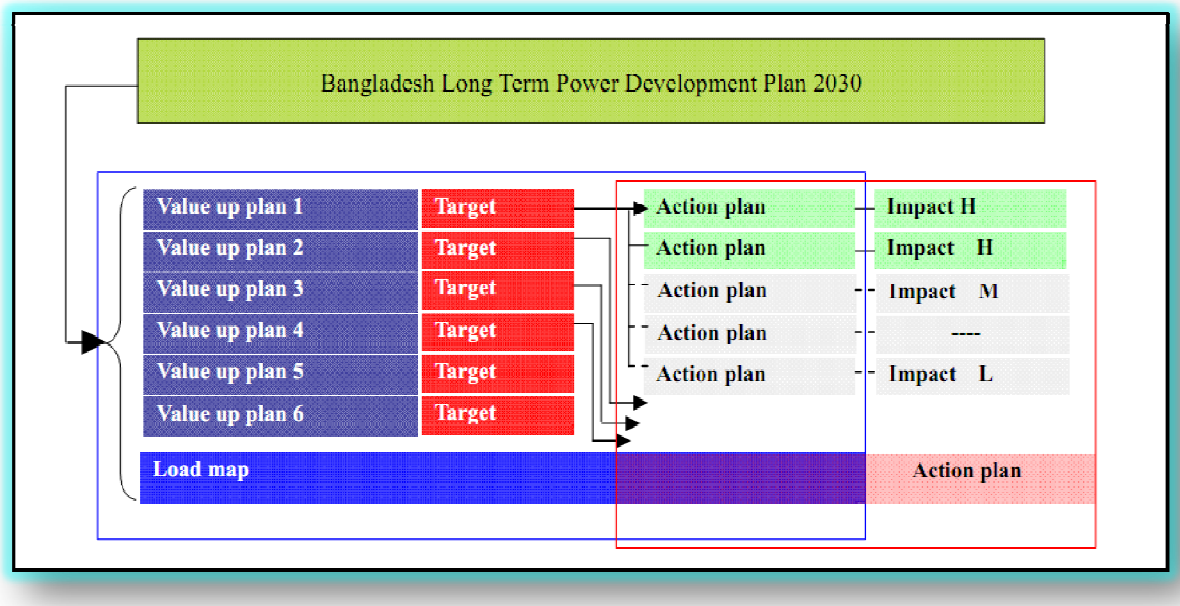
Master Plan & Future of Power Sector

6.1. Viewpoints and Objectives of the Master Plan:

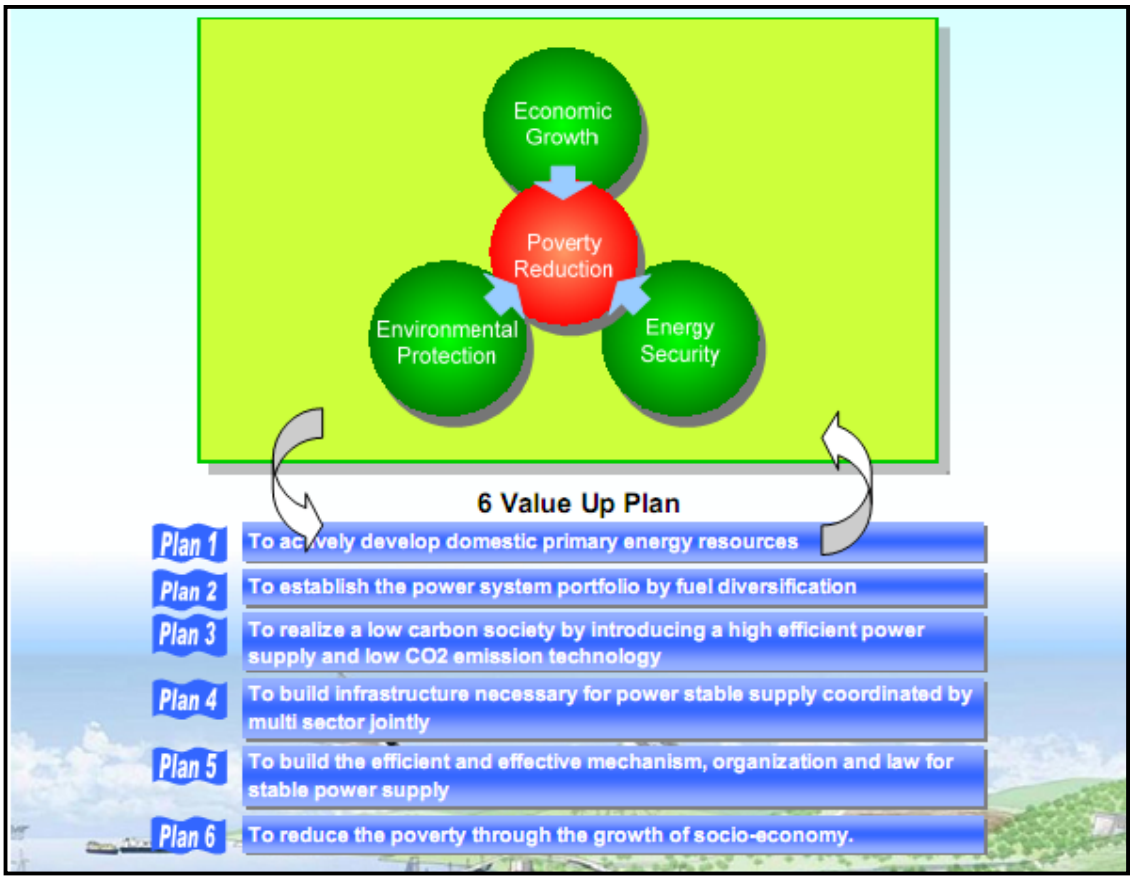
When reviewing the Power System Master Plan (MP), the fundamental objective is to formulate the Master Plan for the attainment of stable power supply by achieving the 3Es; Economic Growth, Energy Security and Environmental Protection simultaneously. The government of Bangladesh set the maximum target to reduce poverty in a period as swift as possible by achieving high economic growth. Planning electrification via the stabilization and efficiency of the electric power supply system can be expected to reduce poverty. This Master Plan will aim to promote development that will provide a self-reinforcing cycle of poverty reduction and 3E simultaneous achievement. In addition, this Master Plan will propose the vision in line with Government energy policy, and stipulate 6 value-up plans to achieve the vision.

6.2. Structure of the Vision, Roadmap, Action Plan and Target:

The structure of the Vision, Roadmap, Action Plan and Target is shown in the following figure. The Vision is proposed as Bangladesh's long term strategic power development vision 2030.[12] To achieve this Vision, 6 value-up plans have been stipulated, where each value-up plans have their own targets to achieve the plans. There are Action Plans to achieve the Targets, where each Action Plan indicates the action agents and potential impact. The Roadmap shown in this chapter extracts the Action Plans that will result in high potential impact, and describes the details.

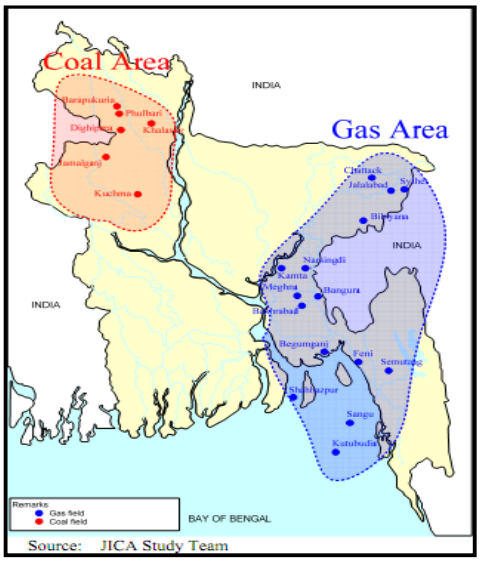


6.3. Long-Term Power Development Strategy for Bangladesh Vision 2030: [13]



Plan 1: To actively develop domestic primary energy resources:

- Target: To maintain domestic primary energy supply over 50%



To deal with Bangladesh's rapid economic growth and the accompanying increase of electric power, there is an urgent need to secure a source of energy that is essential to the economy and stability. The active development of domestic primary energy resources is the best and realistic way to supply energy resources. The main domestic primary energy resources are domestic coal and domestic natural gas. As shown in the following figure, domestic coal has been unevenly distributed in the Western part of Bangladesh, while natural gas is located in the Eastern area. As shown in Fig. 2-2 and Fig. 2-3, domestic gas supply will be expected to decrease in the future, while domestic coal supply will increase. In the event that fuel diversification advances during the later years, the MP aims to acquire a 25% share of domestic coal and a 20 percent share of domestic natural gas, and a 5% share of

national hydropower and renewable energy, thus ensuring the self – sufficiency of the primary energy resource to be over 50 percent by Year 2030.

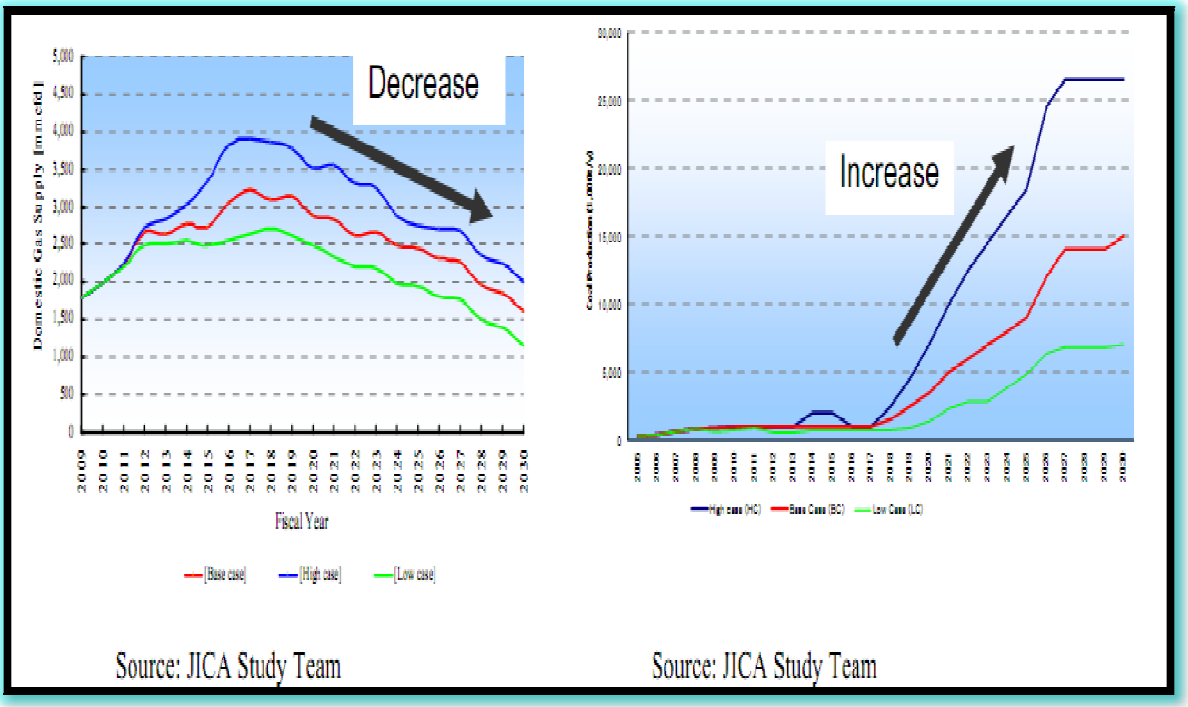


Fig. Domestic Gas Supply Scenario

Fig. Domestic Coal Supply Scenario

Domestic natural gas development

Action plans for domestic natural gas development are as follows;

- Re-evaluation of domestic natural gas reserve: to periodically re-evaluate domestic natural gas reserve in order to forecast future gas supply and justify the development and work over planning.
- Demand forecast for natural gas: to forecast the demand for natural gas on a rolling basis in order to match natural gas production planning.
- Exploration and development of domestic natural gas: to explore and develop domestic natural gas in order to enhance domestic natural gas production from new gas fields.
- Work over of existing natural gas field: to implement the work-over of the existing natural gas field in order to enhance natural gas production from existing gas fields

Domestic coal development

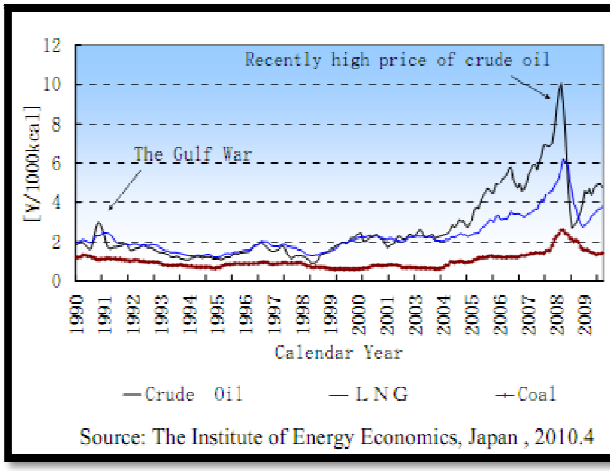
Action plans for domestic coal development are as follows;

- Finalization of Coal Policy: to finalize the current draft Coal Policy and to formulate the laws and/or regulations with regards to domestic coal development or coal mine development.
- Implementation and evaluation of the pilot mining: to implement and evaluate the pilot mine in order to judge the open cut mine feasibility, including the underground water treatment coal production rate, and social impact.
- Demand forecast for domestic coal: to forecast the demand for coal on a rolling basis in order to match coal production planning.

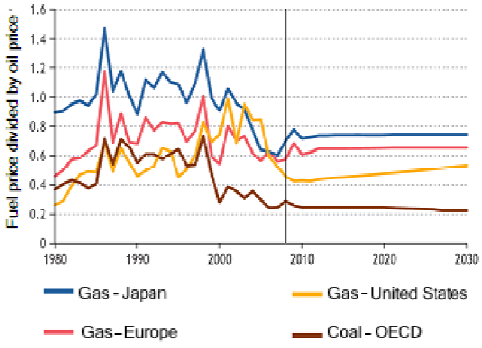
- Building for the mine engineer training system: to build the mine engineer training system in order to stand upon a self-reinforcing mine operation without dependence on foreign country's support.
- Considering the CBM and/or UGC technology: to consider the CBM (Coal Bed Methane) and/or UCG (Underground Coal Gasification) technology in order to promote the utilization of un-used or un-developed domestic coal.

Plan 2: <u>To Establish the Power System Portfolio By Fuel Diversification</u>:
Target: Fuel composition ratio as of 2030: coal 50%, natural gas 25%, oil/nuclear/renewable Energy 25%

As shown in plan 1, the MP prioritizes the use of domestic primary energy sources. However, in the case domestic energy supplies are not enough to fulfill the rapid demand growth for electricity and natural gas, it will be necessary to tap into other power sources from outside of Bangladesh. To achieve the best mix of energy supply including imported resources, it would be required to use economical and stable power source in consideration of environmental protection. Especially coal will be an important resource as the primary energy supply in Bangladesh hereafter, due to 1. Its price stability and volatility compared with oil and natural gas, 2. Longer reserve production ratio compared with oil and natural gas, and 3. Is unevenly spread throughout the world and is expected to be supplied stably, as shown in the following figures.



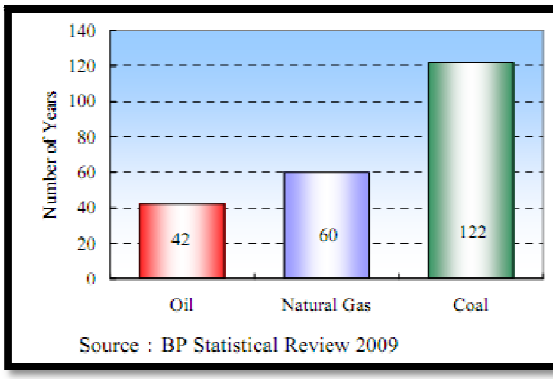
Source: The Institute of Energy Economics, Japan , 2010.4



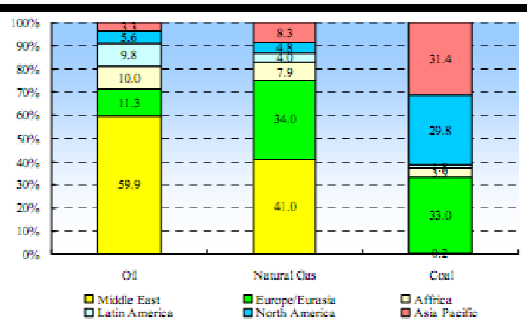
Source : IEA World Energy Outlook 2009

Fig: Fuel price process

Fig: Compare with fuel price divided by price



Source : BP Statistical Review 2009



Source : BP Statistical Review 2009

Fig: Confirmed Recoverable Reserves of Each Fuel

Fig: Resource Reserve of Each Area

Reviewed by the International Energy Agency (IEA), while coal consumption in the world was 3,200billion tons of oil equivalent (Mtoe) in 2007 (26% of primary energy), it will be 4,900 Mtoe in 2030, more than a 50% increase (26% of primary energy). About 90% of increased 1,700 Mtoe can be attributed to increased Asian consumption. The coal consumption share of Asia was about 60% in2007, and about 70% in 2035. Asia will be center of coal consumption. OECD shares will decrease from 36% in 2007 to 27% in 2035. On the other hand, shares of LDC will increase from 64% in 2007 to 73% in 2035. It is projected that coal will play a major role among primary energy sources in the next decade or so. 1When reviewing world power generation, coal use shares will not change significantly.2 It indicates that coal currently plays a major role in global power generation and this central role will still remain for some time. The major primary energy supply forecast in Bangladesh is shown in the below figure, where natural gas supply will decrease after 2017 while coal supply will increase as an alternative source of natural gas. In this MP, the target composition of power supply as of 2030 is set at 50% for domestic and imported coal, 25% for domestic and imported (in the form of LNG) natural gas and 25% for other sources such as oil, nuclear power and renewable energy.

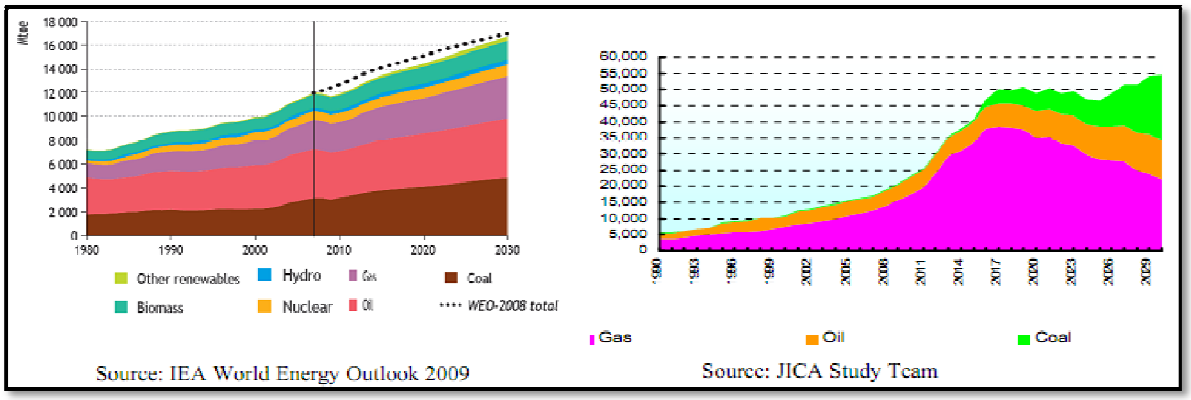


Fig: World Primary Energy Balance

Fig: Bangladesh Primary Energy Balance

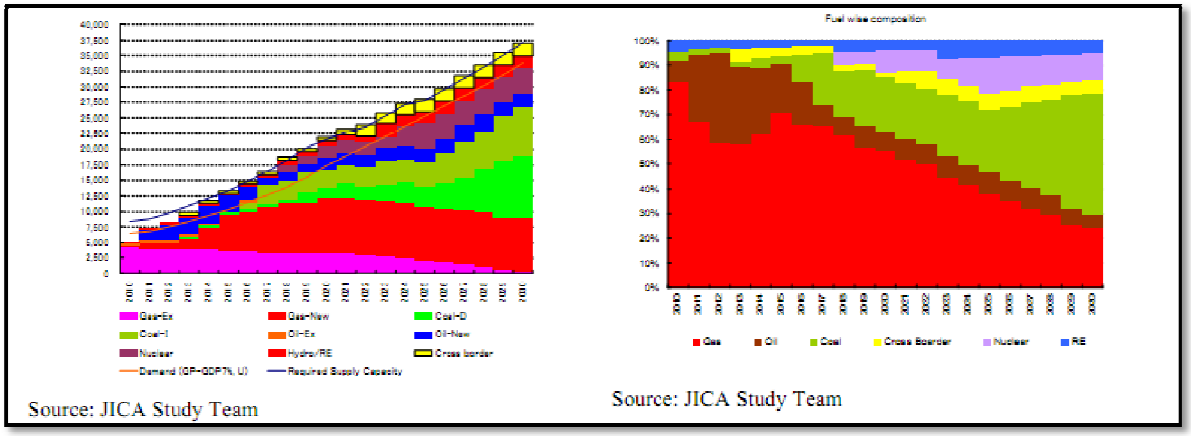


Fig: Power development plan up to 2030

Fig: Power development plan up to 2030

<u>Construction of imported coal power station</u>

- FS for imported coal power station: to carry out the FS for imported coal power stations
- DD for imported coal power station: to implement the detailed design reflecting the result of FS

- Procurement for imported coal: to examine the method on how to procure imported coal as this was the first time for Bangladesh to import coal by sea
- Establishment of the imported coal chain: to establish the imported coal chain, which provides a seamless coal delivery system from the mine mouth in the exporting country to the banker at the power station in Bangladesh
- Construction of a high efficiency USC power station: to construct a high efficiency power station by utilizing USC technology in order to prevent global warming.

Introduction of LNG facilities

- Procurement of LNG: to establish the LNG chain from the gas fields in exporting countries to re-gasification
- FS of the offshore LNG terminal: to implement a feasibility study for the offshore LNG terminal.
- Construction of the offshore LNG terminal: to construct an offshore LNG terminal, if the results of the FS are feasible.
- Consideration of the onshore LNG terminal: to consider the construction of the onshore LNG terminal in order to establish a long term LNG supply chain

Construction of the oil fired power station

- Establishment of an oil-fired power station (Rental Power) as an emergency measure: to establish the oil-fired power station or Rental Power as an emergency measure for the short term solution and to use them during peak demand periods for the long term

Import the electricity generated by hydro power from the neighboring countries or joint development

- There are huge potential hydro power sources in the neighboring countries such as India, Nepal and Bhutan so that they can be utilized in the context of the South Asia Regional Initiative (SARI) for joint development with Bangladesh and the countries.

Development of domestic renewable energy (wind and solar power)

- To develop wind and solar power as a domestic power supply source.

Plan 3: To Realize A Low Carbon Society By Introducing A High Efficient Power Supply And Low CO2 Emission Technology**:**

Target: To improve 10 points thermal efficiency on average

In order to lessen the coal power station's environmental impact, it is essential to improve thermal efficiency by utilizing the proven Clean Coal Technology that has been established in Japan. According to recent coal-fired power station operations, the world class thermal efficiency (45%, LHV basis) was achieved by using Ultra Super Critical (USC) technology as a part of the Clean Coal Technology. By utilizing such technology in Bangladesh, great improvements of thermal efficiency and contributions to reduce green house gas could be achieved, if compared with the situation by using the sub critical technology (40%, LHV basis) widely used in other Asia regions. In addition, there are environmental measures other than global warming, such as the reduction of NOx, SOx, and particulate matter. With regards to the comprehensive technology transfer regarding the environmental protection and the promotion of the technology, it makes it possible to achieve 3E, especially spontaneous environmental protection and economic growth, even while utilizing coal.

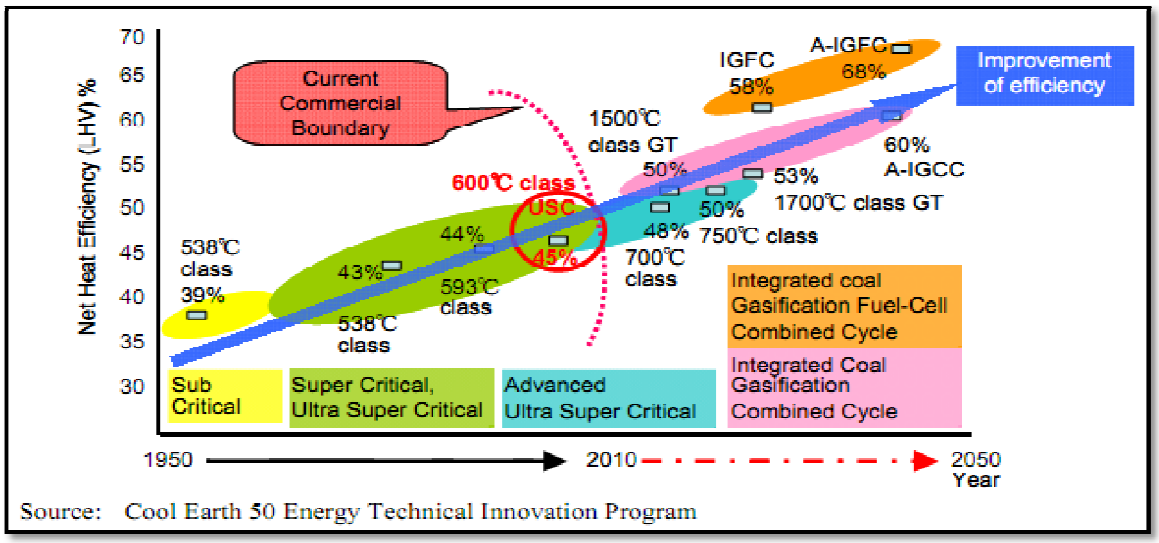


Fig: Efficiency Improvement of Coal Fired Power Plant

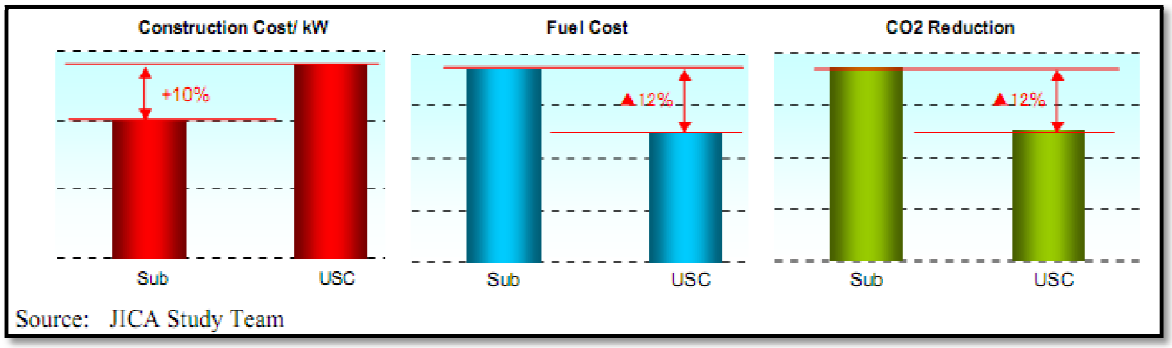


Fig: Subcritical Vs. USC (Image)

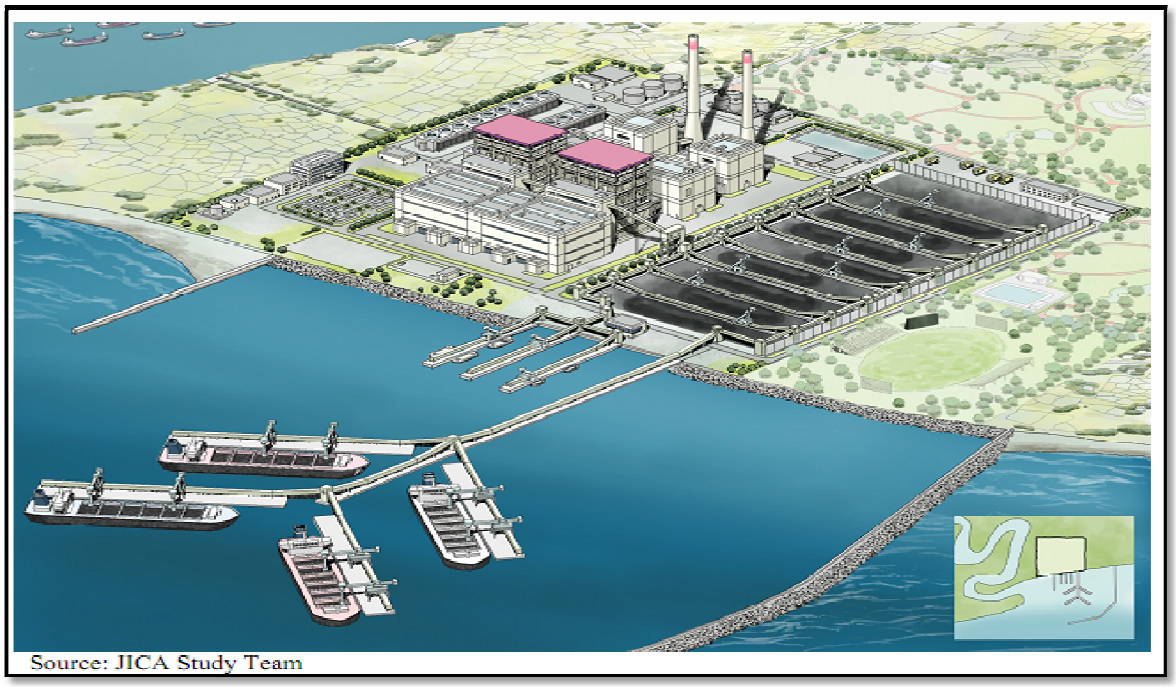


Fig: Domestic Coal Fired Power Station Bird's Eye View (Chittagong South Site) [13]

In line with the apparent curtailment of natural gas production, the improvement of gas utilization efficiency has become an urgent matter. To prioritize gas supply for higher efficiency power plants is practically necessary in order to improve the effectiveness of gas utilization in the whole power sector.
Therefore, during the construction of a new power station, including the demolishment of the old power station, power expansion planning and system operation planning will be implemented in comprehensive consideration of the stability, environment, economics and operates, in line with the introduction of the world's best efficient combined cycle power station, and high efficiency and low carbon emission thermal power technology.

Higher efficient gas power station

- Higher efficiency of the existing gas power station: to achieve higher efficiency via the re-powering of the existing power station.
- Construction of the combined cycle gas power station: to construct a higher efficient gas combined power station, and to improve the total efficiency via the allocation of gas to a higher efficient power station.

Development of domestic coal power station

- FS for domestic coal power station: to implement FS for domestic coal power station by using Clean Coal Technology
- DD for domestic coal power station: to implement a detailed design reflecting the result of FS
- Construction of high efficient USC power station: to construct a high efficiency power station by using USC technology in order to prevent global warming.
- Consideration of large scale coal power station: while the initial capacity is 600MW, however, the construction of the large scale power station (1000MW class) will be studied after 2020.

Reviewing O&M scheme

- To reviewing current O&M scheme, in order to reduce the number of unplanned starts and stops, and to improve the load factor.
- To establish the USC O&M scheme.
- To establish the environment and safety scheme

Energy conservation, Demand side management

- To rationalize the load dispatch by prioritization of gas allocation to higher efficient power station in order to reduce CO2 emission.
- To rationalize the customer side by energy conservation and demand side management in order to reduce CO2 emissions.

Plan 4: To Build An Infrastructure Necessary For Stable Power Supply Under Joint Coordination By The Multi-Sector**:**

Target: To jointly build a deep sea port facility by power, industry and commercial sector.

It is clear that the enhancement of power supply will be necessary in line with future power demand growth. As a power supply related infrastructure, it is also necessary to develop a gas transmission line, a fuel center, a deep sea port, a domestic waterway, a railway and so on. Vast amount of investment is required to build these infrastructures. It is impossible for the power sector to bear such huge investment alone. Hence, cooperation with other sectors such as industry and commercial enterprises will be needed to achieve cost reduction and a synergy effect.

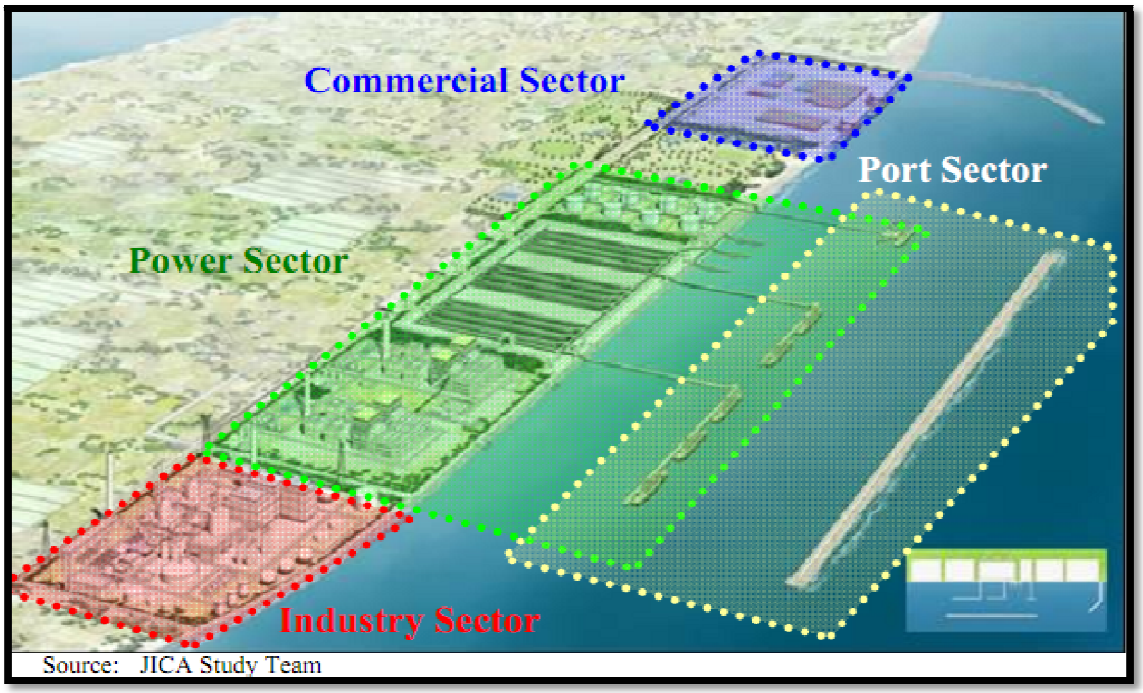


Fig: Example of Deep Sea Port Development

Construction of deep sea port

- As of today, the power sector, commercial sector and industry sector are individually planning to develop the port. However, the multi-sector will harmoniously develop a deep sea port where huge costs are required.

Improvement of the power transmission system

- To improve the power transmission system in line with power supply amount growth
- To develop cross border power trading.

Enhancement of gas transmission line

- To enhance the gas transmission line in line with domestic gas demand growth
- Construction of fuel center
- To implement a coal center FS.
- To construct a coal center.
- To jointly develop a fuel center (receiving facility for imported coal, LNG and oil) via multi sector cooperation.

Strengthening the domestic waterway

- To strengthen the domestic waterway via periodical dredging for internal ships from the coal center to the power station.

Strengthening the railway system

- To strengthen the domestic railway system in order to transport coal from the coal center to the power station.

Plan 5: To Build an Efficient and Effective Mechanism, Organization and Law for Stable Power Supply:

Target: To establish an organization for long-term stable fuel supply security

As Bangladesh has less experience in dealing with coal power station development, the MP recommend that Bangladesh set up an organization for coal procurement, to strengthen the law leading to the sure implementation of regular inspections, to prepare a lucrative investment environment by the private sector, to impose levies for the plant and equipment investments, to create an investment environment for the private sector and to establish an effective and efficient power market.

- Organization for coal procurement

As Bangladesh has less experience in dealing with coal power station development, the MP Recommended that Bangladesh set up a new organization for coal procurement to smooth the way towards its realization. The following figure is an organizational example of domestic coal procurement.

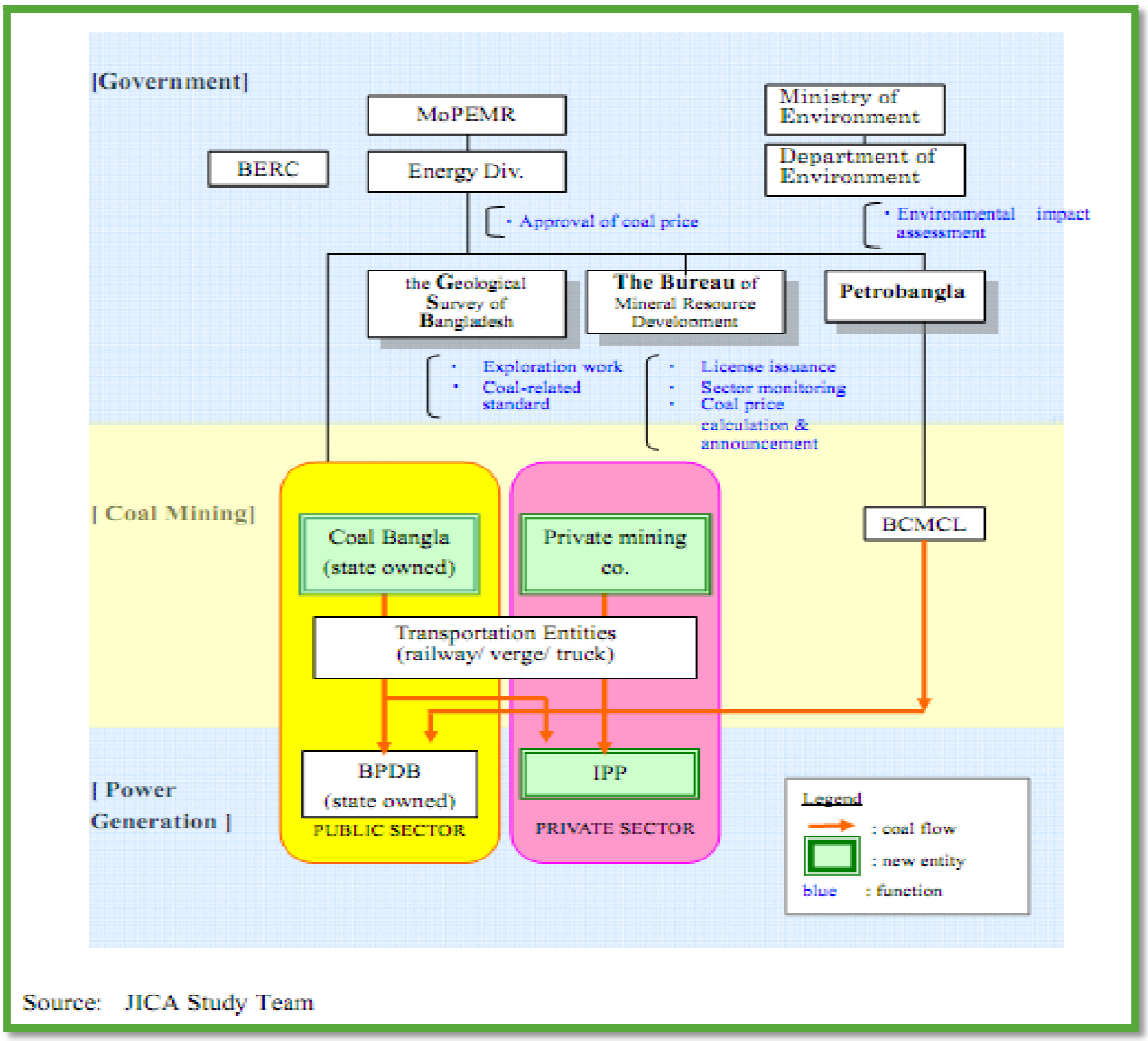


Fig: Fuel Procurement Implementation System Example of Coal Fired Power Plant

To revise the tariff structure to recover maintenance costs and future investment for plant and equipment

- Introduction of Power Development Surcharge into the power tariff the current tariff is politically constrained so that it does not envisage funding for neither appropriate maintenance nor future system expansion. While the prevailing tariff policy adheres to the cost reflection. The MP recommends that the tariff be revised to realize the cost for necessary maintenance to maintain the plant condition at an appropriate level. It is also recommended that the introduction of the power development surcharge into the power tariff be conducted for the purpose of funding the development of the power system and/or energy saving projects.
- Promotion of private investment to realize the Master Plan So far public funding has played a major role in establishing power system development, it is recommendable to promote private investment and develop an environment that allows private funding.
- To create an effective and efficient power market In order to make the power sector more effective and efficient, the MP recommends the introduction of a competitive market where the customer can select power providers.

Plan 6: <u>To Reduce The Poverty Through The Growth of Socio-Economy</u>**:**

Target: To change the organization toward the self-improvement

According to the Human Poverty Index (HPI-I) by UNDP, the 36.1% index value, Bangladesh ranks 112th among 135 countries in 2007, and is the third worst in the entire Asian region after Afghanistan and Timor-Leste. However, when looking at the HPI trend, the HPI-I for Bangladesh improved quickly over the last recent years. The present poverty index of Bangladesh is slightly higher than that of Indonesia and the Philippines 10 years ago. However, it is possible that Bangladesh could rank within the middle range of countries on the HPI within several years, if the present economic growth continues.

- To spread stable and sustainable power supply: Stable and sustainable power supply will be essential for Bangladesh to continue economic growth and switch the industry structure over to export processing. Power expansion planning and transmission planning shown in the MP should surely be implemented.
- To promote remote area electrification: Through power system expansion and power transmission development, the power system all over Bangladesh will be enhanced, as a result, local electrification will also be promoted.
- To promote the local industry, associated employment opportunities and income increases: An ample amount of stable power supply makes it possible to expand into local industries such as garments, developing industrial zones and free trade zones, which lead to massive long term employment opportunities for people in the region. This momentum contributes to economic growth with macro-economic improvements which ultimately enhances social and economic inclusion, integration of marginalized people and the reduction of poverty.

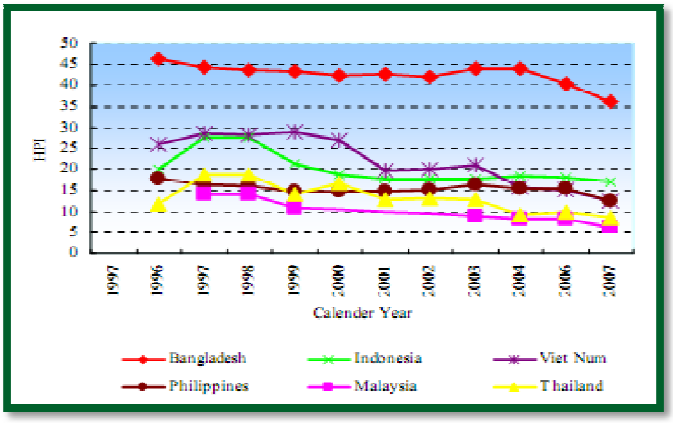


Fig: Human Poverty Index Trend

Electricity is an ingredient for poverty alleviation growth, infrastructure development, quality of living standard of the people & for overall development of the economy. Bangladesh government is trying to establish a sustainable development structure for many years but yet to accomplish such target due to shortage of electricity generation. At present only 53% of the people have access to electricity. Per capita generation is 232KWh (Grid) which is one of the lowest in the region. Every year the demand is increasing at a rate of 10%. Generation capacity could not be increased accordingly during past years which has resulted increasing power shortages in the country.

Power generation projects of immediate & short terms have been implemented in the year 2011& 2012. Under the midterm planning, generation capacity addition during 2012 to 2016 will be about 12,000 MW. In the long term planning, generation capacity requirement in 2021 and in 2030 will be 24,000 MW and 39,000 MW respectively.

6.4. Mid Term Power Generation Expansion Plan Up to 2016:

Based on the primary fuel supply availability and Government's limited ability to finance capital – intensive power generation projects, an aggressive midterm generation expansion plan was growing demand of electricity to cope with accelerated economic growth under the present government. [14] Revised generation expansion plan prepared in 2012 targeting about 12,000 MW generation additions from 2012 to 2016 which is provided in the table below:

Year Wise Projects Completion (From 2012 to 2016)

Year	2012 (MW)	2013 (MW)	2014 (MW)	2015 (MW)	2016 (MW)	Total (MW)
Public	632	737	2426	934	700	5429
Private	344	1413	892	1707	2135	6491
Power Import	--	500	—	--	—	500
Total	976	2650	3318	2641	2835	12420

6.5. Annual Development Program for BPDB's Own Generation & Distribution Projects:

A total of 5 generation and 8 distribution projects were included in the revised annul development program (PADP) in the FY 2012. Original allocation revised allocation & expenditure incurred (Providian) in the FY 2012 are shown in the following table.

(Taka in lakh)

Sub-Sector	Original ADP FY 2011-12			RADP FY 2011-12			Expenditure incurred FY 2011-12			% change
	Local	Foreign	Total	Local	Foreign	Total	Local	Foreign	Total	
Generation	292122	100	292222	15.00	297060	297075	295894	0.00	295894	-11.98
Distribution	13600	37000	50600	13770	22020	35790	13691	22277	35968	83.54
Total	305722	37100	342822	310830	22035	332865	309585	22277	331863	6.76

6.6. Implementation Status of the power generation Expansion Plan:

Since January 2009, total 51 small and medium sized power plants of capacity 3595MW have been commissioned, 28 projects of capacity 5048 MW are now under construction. At present 28 projects of capacity 3744 MW are in the various stages of procurement process right from tender invitation to issuance of LOI.

Year wise implementation statuses of generation projects in power sector are follows:

Projects implemented in 2010

Sl. No.	Name of the Power Plant	Capacity (MW)	Ownership	Type of Fuel	Expected Commissioning Date
	Public Sector				
1	Sikalbaha 150 MW	150	BPDB		18.08.2010
2	Siddirganj 2x120 MW GT	105	EGCB		14.10.2011
	Sub Total	**255**			
	Private Sector				
3	Shikalbaha 55 MW Rental Power Plant	55	Rental (BPDB)	HFO	06.05.2010
4	Ashugonj Rental Power Plant	55	Rental (BPDB)	Gas	07.04.2010
5	Thakurgaon, 3 Years Rental	50	Rental (BPDB)	HFO	02.08.2010
6	Ghorashal Sponsor: Aggreko	145	Rental (BPDB)	Gas	10.08.2010 23.08.2010
7	Khulna Sponsor: Aggreko	55	Rental (BPDB)	Diesel	10.08.2010
8	Pagla, Narayaganj Sponsor: DPAPGL	50	Rental (BPDB)	Diesel	24.11.2010
9	Bheramara 3 Years Rental	110	Rental (BPDB)	Diesel	31.12.2010
	Sub Total	**520**			
	Total	**775**			

Projects implemented in 2011

Sl. No.	Name of the Power Plant	Capacity (MW)	Ownership	Type of Fuel	Expected Commissioning Date
	Public Sector				
1	Ashugonj 50 MW Power Plant	53	APSCL	Gas	30.04.2011
2	Baghabari 50 MW Peaking PP	52	BPDB	HFO	29.08.2011
3	Fenchuganj 90 MW CC	104	BPDB	Gas	26.10.2011
4	Bera 70 MW Peaking PP	71	BPDB	HFO	28.10. 2011
5	Titas, Doudkandi 50 MW Peaking PP	52	BPDB	HFO	29.10. 2011
6	Siddirganj 2x120 MW Peaking PP	105	EGCB	Gas	December ,2011
7	Faridpur 50 MW Peaking PP	54	BPDB	HFO	November, 2011
8	Gopanlgonj 100 MW Peaking PP	109	BPDB	HFO	29.09.2011
9	Sangu, Dohazari 100 MW Peaking PP	102	BPDB	HFO	30.12.2011
10	Hathazari 100 MW Peaking PP	98	BPDB	HFO	23.12.2011
	Sub Total	**800**			

Sl. No.	Name of the Power Plant	Capacity (MW)	Ownership	Type of Fuel	Expected Commissioning Date
	Private Sector (Rental & Quick Rental)				
1	Siddirganj, Sponsor: Desh Energy	100	Rental (BPDB)	HSD	17.02.2011
2	B.Baria, Sponsor: Aggreko	70	Rental (BPDB)	Gas	06.03.2011
3	Modanganj, Sponsor: Summit Power	102	Rental (BPDB)	FO	01.04.2011
4	Meghnagat, Sponsor: IEL	100	Rental (BPDB)	FO	08.05.2011
5	Ghorasal, Sponsor: Max Power	78	Rental (BPDB)	Gas	27.05.2011
6	Nowapara, Sponsor: Khan Jahan Ali	40	Rental (BPDB)	FO	28.05.2011
7	Ashugonj, Sponsor: Aggreko	80	Rental (BPDB)	Gas	31.05.2011
8	Khulna, Sponsor: KPCL	115	Rental (BPDB)	FO	01.06.2011
9	Ashugonj, Sponsor: United Ashugonj Power Ltd.	53	Rental (BPDB)	Gas	22.06.2011
10	Siddirganj Sponsor: Dutch Bangla Power	100	Rental (BPDB)	FO	21.07.2011
11	Noapara, Jessore, 5 Years Rental	105	Rental (BPDB)	FO	26.08.2011
12	Bogra 3 years Rental, Sponsor: Energy Prima	20	Rental (BPDB)	Gas	
	Sub-Total (Private)	**963**			
	Total (2011)	**1763**			

Projects being implemented in 2012

Sl. No	Name of the Power Plant	Capacity (MW)	Ownership	Type of Fuel	Expected Commissioning Date
	Public sector				
1	Sylhet 150 MW Power Plant	142	BPDB	Gas	28 March, 2012
2	Gazipur 50 MW PP	52	RPCL	Gas/HFO	July, 2012
3	Chandpur 150 MW CC Power Plant	163	BPDB	Gas	GT: March, 2012 CC: July, 2012
4	Raujan 25 MW PP	25	RPCL	Gas/HFO	November, 2012
5	Sirajganj 150 MW GT	150	NWPGC	Gas/HSD	November, 2012
6	Santahar 50 MW Peaking Power Plant	50	BPDB	HFO	December, 2012
7	Katakhali 50 MW Peaking Power Plant	50	BPDB	HFO	December, 2012
	Sub-Total (Public)	**632**			
	Private sector				
1	Amnura,Chapainawabganj Sponsor: Sinha Power	50	Rental (BPDB)	HFO	13 January, 2012
2	Fenchuganj 3 Years Rental Sponsor: Energy Prime Ltd.	44	Rental (BPDB)	Gas	15 February, 2012
3	Julda, Chittagong Sponsor: Acom Infrastructure Services	100	Rental (BPDB)	HFO	26 March, 2012
4	Keraniganj, Sponsor: Power Pac	100	Rental (BPDB)	HFO	27 March, 2012
5	Katakhali, Rajshahi Sponsor: NPSL	50	Rental (BPDB)	HFO	23 May, 2012
	Sub-Total (Private)	**344**			
	Total	**976**			

Projects to be implemented in 2013

Sl. No	Name of the Power Plant	Capacity (MW)	Ownership	Type of Fuel	Expected Commissioning Date
	Public Sector				
1.	Haripur 360 MW CCPP: GT Unit	273	EGCB	Gas	February, 2013
2.	Khulna 150 MW GT	150	NWPGC	Gas/HSD	May, 2013
3.	Haripur 360 MW CCPP: ST Unit	139	EGCB	Gas	July, 2013
4.	Ashuganj 200+ - 10% MW Modular Power Plant	175	APSCL	Gas	November, 2013
	Sub-Total (Public)	**737**			
1.	Chittagong (Mohra) 50 MW PP	50	IPP	HFO	May, 2013
2.	Jamalpur Peaking	95	IPP	HFO/Gas	June, 2013
3.	Munshiganj (Kathpotti) 50 MW PP	52.5	IPP	HFO	June, 2013
4.	Chittagong (Patenga) 100 MW PP	108	IPP	HFO	July, 2013
5.	Bosila, Keraniganj	108	IPP	HFO/Gas	August, 2013
6.	Regional Import	500	Import		August, 2013
7.	Dhaka (Gaptoli) 108 MW PP	108	IPP	HFO	October, 2013
8.	Narayanganj (Gogonnagar) 100 MW PP	102	IPP	HFO	October, 2013
9.	Meghnaghat 300-450 MW CCPP (2^{nd} Unit) Duel Fuel: SC GT Unit	220	IPP	HFO/Gas	October, 2013
10.	Ghorasal, Narsindi 100 MW PP	108	IPP	HFO/Gas	October, 2013
11.	Ashuganj 50 MW PP	51	IPP	HFO/Gas	October, 2013
12.	Khulna Peaking	100	IPP	HFO	December, 2013
13.	Keraniganj (Basila) 108 MW PP	108	IPP	HFO/Gas	December, 2013
14.	Comilla (Homna) 50 MW PP	52.5	IPP	HFO/Gas	December, 2013
15.	Nababganj 50 MW PP	50	IPP (RE8)	HFO	December, 2013
16.	Munshiganj 50 MW PP	50	IPP (RE8)	HFO	December, 2013
17.	Manikganj 50 MW PP	50	IPP (RE8)	HFO	December, 2013
	Sub-Total (Private)	**1913**			
	Total	**2650**			

Projects to be implemented in 2014

Sl. No	Name of the Power Plant	Capacity (MW)	Ownership	Type of Fuel	Expected Commissioning Date
	Public Sector				
1.	Siddirganj 450 MW CCPP ; SC GT Unit	200	EGCB	Gas	February, 2014
2.	Ashuganj 200 + -10% MW Modular PP	20	IPP	APSCL	February, 2014
3.	Kodda, Gazipur 150 MW PP	150	BPDB-RPCL Powergen	HFO/Gas	March, 2014
4.	Chapai nababganj	100	BPDB	HFO	May, 2014
5.	Sylhet 150 MW PP Conversion	75	BPDB	Gas	May, 2014
6.	Ashuganj 225 CCPP: SC GT Unit	150	APSCL	HFO	June, 2014
7.	Baghabari 100 MW PP Conversion	50	BPDB	Gas	August, 2014
8.	Shahjibazar 70 MW PP Conversion	35	BPDB	Gas	August, 2014
9.	Sirajganj 150 MW PP Conversion	75	NWPGC	Gas	August, 2014
10.	Kaptai Solar	5	BPDB	Solar	September, 2014
11.	Bibiana #3 CCPP: SC GT Unit	300	BPDB	Gas	September, 2014
12.	Bhola 225 MW CCPP: SC GT Unit	131	BPDB	Gas	September, 2014
13.	Sikalbaha 150-225 MW CCPP: SC GT Unit	150	BPDB	Gas/HFO	September, 2014
14.	Shahjibazar CCPP: SC GT Unit	200	BPDB	Gas	December, 2014
15.	Ghorasal 300-450 MW CCPP: SC GT Unit	200	BPDB	Gas	December, 2014
16.	Ashuganj (South) 450 MW CCPP	450	APSCL	Gas	December, 2014
17.	Siddirganj 450 MW CCPP ; ST Unit	135	EGCB	Gas	December, 2014
	Sub-Total (Public)	**2426**			
	Private Sector				
1.	Kliakair Peaking Plant, Gazipur	149	IPP	Gas/HFO	March, 2014
2.	Bhairab, Kishoregonj 50 MW PP	50	IPP	HFO	March, 2014
3.	Sathkfira 50 MW PP	50	IPP	HFO	March, 2014
4.	Keraniganj 150 MW PP	150	IPP	Gas/HFO	May, 2014
5.	Fenchuganj 100-150 MW CCPP	163	IPP	Gas/HFO	June, 2014
6.	Tangail 20 MW	20	IPP(REB)	Gas/HFO	June, 2014

Sl. No	Name of the Power Plant	Capacity (MW)	Ownership	Type of Fuel	Expected Commissioning Date
7.	Narayanganj 50 MW	50	IPP(REB)	HFO	June, 2014
8.	Meghnaghat 300-450 MW CCPP (2nd Unit): ST Unit	115	IPP	Gas/HFO	July, 2014
9.	Bhola 150-225 CCPP (2nd unit): SC GT Unit	145	IPP	Gas	August, 2014
	Sub-Total (Private)	**892**			
	Total	**3318**			

Projects to be implemented in 2015

Sl. No	Name of the Power Plant	Capacity (MW)	Ownership	Type of Fuel	Expected Commissioning Date
	Public Sector				
1.	AQshuganj 225 CCPP: ST Unit	75	APSCL	Gas	March, 2015
2.	Bibiana #3 CCPP: ST Unit	150	BPDB	Gas	June, 2015
3.	Bheramara 360 MW CCPP	360	NWPGC	Gas	June, 2015
4.	Shahjibazar225 MW CCPP: ST Unit	75	BPDB	Gas/HFO	June, 2015
5.	Bhola 225 MW CCPP : ST Unit	74	IPP	Gas	August, 2015
6.	Shahjibazar CCPP: ST Unit	100	BPDB	Gas	October, 2015
7.	Ghorasal 300-450 MW CCPP: ST Unit	100	BPDB	Gas	October, 2015
	Sub-Total (Public)	**934**			
	Private Sector				
1.	Solar	7	IPP	Solar	January, 2015
2.	Sirajganj 300-450 MW CCPP (1st Unit): SC GT Unit	249	IPP	Gas/HSD	January, 2015
3.	Bibiana 300-450 MW CCPP (1st Unit): SC GT Unit	222	IPP	Gas	March, 2015
4.	Bibiana 300-450 MW CCPP (2nd Unit): SC GT Unit	222	IPP	Gas	March, 2015
5.	LNG Based 200-850 MW CCPP: ST Unit	150	IPP	LNG	March, 2015
6.	Wind	100	IPP(BPDB)	Wind	March, 2015
7.	Bhola 150-225 CCPP (2nd Unit): ST Unit	73	IPP	Gas	June, 2015
8.	Chittagong 150-300 MW Coal fired Power Project	283	IPP	Imp. Coal	June, 2015
9.	Khulna 150-300 MW Coal fired Power Projec	283	IPP	Imp. Coal	June, 2015
10.	Sirajganj 300-450 MW CCPP: ST Unit	118	IPP	Gas/HSD	October, 2015
	Sub-Total (Private)	**1707**			
	Total	**2641**			

Projects to be implemented in 2016

Sl. No	Name of the Power Plant	Capacity (MW)	Ownership	Type of Fuel	Expected Commissioning Date
	Public Sector				
1.	Barapukuria 250-300 MW (3rd Unit)	250	BPDB	Coal	January , 2016
2.	Ashuganj (North) CCPP	450	APSCL	Gas	January, 2016
	Sub-Total (Public)	**700**			
	Private Sector				
1.	Bibiana 300-450 MW CCPP (1st Unit)	119	IPP	Gas	January, 2016
2.	Bibiana 300-450 MW CCPP (2nd Unit): ST Unit	119	IPP	Gas	January, 2016
3.	Maowa, Munshiganj 300-650 MW Coal Fired Power Project	522	IPP	Imp. Coal	February, 2016
4.	LNG Based 200-850 MW CCPP: ST Unit	75	IPP	LNG	March, 2016
5.	Khulna 1300 MW Large Coal	1300	PPP (Joint Vent.)/IPP	Imp.Coal	June, 2016
	Sub-Total (Private)	**2135**			
	Total	**2835**			

6.7. On Going Distribution Project of FY 2011 – 2012:

With the aim of renovation and expansion of existing distribution network for reduction of distribution line loss, electrification new areas and improved customer satisfaction, BPDB has undertaken various distribution projects. The under construction distribution projects are as follows:

Sl. no.	Name of the Projects	Projects costs			Completion Period	Cumu. progress (%)
		Local (Lakh Tk)	Foreign (Lakh Tk)	Total (Lakh Tk)		
1.	10-Town power system dev. project (Rajshahi, Pabna, Shirajgonj, Bogora, Joypurhat, Gaibandah, Nilfamari, Dinajpur, Thakurgaon & Rongpur)	25893.80	35231.46	61125.26	2003-04 to 2013-14	92.00
2.	Emergency rehabilitation & expansion of urban areas power dist. system under Ctg. zone.	18012.61	-	18012.61	2008-09 to 2012-13	62.00
3.	Emergency rehabilitation & expansion of urban areas power dist. system under Rajshahi (northern) zone.	11001.48	-	11001.48	2008-09 to 2012-13	79.46
4.	Prepayment metering project for dist. southern zone, Ctg. (Phase-I)	13736.00	-	13736.00	Jan' 2009 to June' 2014	0.42
5.	Greater Ctg. power dist. project, SCADA rehabilitation	1816.57	8588.91	10405.48	Jan' 2009 to June' 2013	90.00
6.	Central zone power dist. project, Mymenshing	23902.55	74019.89	97922.44	Dec' 2009 to June' 2013	62.00
7.	Renovation & augmentation of dist. lines & 11/.4 kv s/ss under six zones of BPDB	17348.00	-	17348.00	2010-11 to 2011-12	100.00
8.	Ctg. hill-tracts power dist. dev. project, Rangamati	16447.00	-	16447.00	Jan' 2011 to June' 2013	13.87

6.8. Future Distribution Projects Up To 2016:

From the view point of continuous improvement in retain sales performance and consumer's service & satisfaction, BPDB has under taken the following distribution projects that are at the various stages of approval and procurement process:

Sl. no.	Name of the Projects	Projects costs		Total (Lakh Tk)
		Local (Lakh Tk)	Foreign (Lakh Tk)	
1.	Power system development project, Rajshahi zone	76545.06	-	76545.06
2.	Power system development project, Rangpur zone	74354.66	-	74354.66
3.	Power system development project, Chittagong zone	69123.06	-	69123.06
4.	Power system development project, Comilla zone	118557.90	-	118557.90
5.	Prepayment metering project for distribution, northern zone, Rajshahi (Phase-I)	24880.81	12240.59	37121.39
6.	Prepayment metering project for distribution zone, Mymenshing (Phase-I)	-	-	-
7.	Prepayment metering project for distribution zone, Comilla (Phase-I)	-	-	-

Chapter 7

Variable Power Project for Future

7.1. Nuclear Energy:

Since 1960s, a plan has been taken to establish a nuclear power plant in the country. [15] But no effective action had taken in the last 50 years except land selection and acquisition for the nuclear power plant. Present Government, with the technical assistance of Russia, has made effective arrangement to establish a nuclear power plant with a capacity of 1000 MW in the pre-determined location at Rooppur. In this respect, Bangladesh government has signed a framework agreement with the Russian National Nuclear Institute. It is expected that the country will be able to enter into nuclear age through the establishment of nuclear power plant by 2016.

7.2. Development of Nuclear Power:

The pursuit of nuclear energy for electricity generation began soon after the discovery in the early 20th century that radioactive elements, such as radium, released immense amounts of energy, according to the principle of mass–energy equivalence. However, means of harnessing such energy was impractical, because intensely radioactive elements were, by their very nature, short-lived (high-energy release is correlated with short half-lives). However, the dream of harnessing "atomic energy" was quite strong, even though it was dismissed by such fathers of nuclear physics like Ernest Rutherford as "moonshine." This situation, however, changed in the late 1930s, with the discovery of nuclear fission. In 1932, James Chadwick discovered the neutron, which was immediately recognized as a potential tool for nuclear experimentation because of its lack of an electric charge. Afterwards the development of Nuclear energy begins. Installed nuclear capacity initially rose relatively quickly, rising from less than 1 giga watt (GW) in 1960 to 100 GW in the late 1970s, and 300 GW in the late 1980s. Since the late 1980s worldwide capacity has risen much more slowly, reaching 366 GW in 2005. Between around 1970 and 1990, more than 50 GW of capacity was under construction (peaking at over 150 GW in the late 70s and early 80s) — in 2005, around 25 GW of new capacity was planned. During the 1970s and 1980s rising economic costs (related to extended construction times largely due to regulatory changes and pressure-group litigation) and falling fossil fuel prices made nuclear power plants then under construction less attractive. In the 1980s (U.S.) and 1990s (Europe), flat load growth and electricity liberalization also made the addition of large new base load capacity unattractive. The 1973 oil crisis had a significant effect on countries, such as France and Japan, which had relied more heavily on oil for electric generation (39% and 73% respectively) to invest in nuclear power. Some local opposition to nuclear power emerged in the early 1960s, and in the late 1960s some members of the scientific community began to express their concerns. These concerns related to nuclear accidents, nuclear proliferation, and high cost of nuclear power plants, nuclear terrorism and radioactive waste disposal. In the early 1970s, there were large protests about a proposed nuclear power plant in Wyhl, Germany. The project was cancelled in 1975 and anti-nuclear success at Wyhl inspired opposition to nuclear power in other parts of Europe and North America. By the mid-1970s, anti-nuclear activist had moved beyond local protests and politics to gain a wider appeal and influence, and nuclear power became an issue of major public protest. Although it lacked a single coordinating organization, and did not have uniform goals, the movement's efforts gained a great deal of attention.

7.3. Producing Electricity Using Nuclear Power:

Just as many conventional thermal power stations generate electricity by harnessing the thermal energy released from burning fossil fuels, nuclear power plants convert the energy released from the nucleus of an atom via nuclear fission that takes place in a nuclear reactor. The heat is removed from the reactor core by a cooling system that uses the heat to generate steam, which drives a steam turbine connected to a generator producing electricity. And the energy comes from the nuclear fission chain reaction. While typical chemical reactions release energies on the order of a few eVs (e.g. the binding energy of the electron to hydrogen is 13.6 eV), nuclear fission reactions typically release energies on the order of hundreds of millions of eVs. Two typical fission reactions are shown below with average values of energy released and number of neutrons ejected:

- 235 U+ neutron fission → fragments +2.4 neutrons+192.9 MeV ..... (1)
- 239 Pu+ neutron fission →fragments +2.9 neutrons+198.5 MeV..... (2)

Chain reactions naturally give rise to reaction rates that grow (or shrink) exponentially, whereas a nuclear power reactor needs to be able to hold the reaction rate reasonably constant. To maintain this control, the chain reaction criticality must have a slow enough time-scale to permit intervention by additional effects (e.g., mechanical control rods or thermal expansion). Consequently, all nuclear power reactors (even fast-neutron reactors) rely on delayed neutrons for their criticality. An operating nuclear power reactor fluctuates between being slightly subcritical and slightly delayed-supercritical, but must always remain below prompt-critical. Uranium is a fairly common element in the Earth's crust. A nuclear reactor is only part of the life-cycle for nuclear power. The process starts with mining (see Uranium mining). Uranium mines are underground, open-pit, or in-situ leach mines. In any case, the uranium ore is extracted, usually converted into a stable and compact form such as yellowcake, and then transported to a processing facility. Here, the yellowcake is converted to uranium hexafluoride, which is then enriched using various techniques. At this point, the enriched uranium, containing more than the natural 0.7% U-235, is used to make rods of the proper composition and geometry for the particular reactor that the fuel is destined for. The fuel rods will spend about 3 operational cycles (typically 6 years total now) inside the reactor, generally until about 3% of their uranium has been fission, then they will be moved to a spent fuel pool where the short lived isotopes generated by fission can decay away. After about 5 years in a spent fuel pool the spent fuel is radioactively and thermally cool enough to handle and it can be moved to dry storage casks or reprocessed

7.4. Present Condition of Nuclear Power in World:

Currently, nuclear energy produces slightly less than 14% of the world's electricity supplies and 5.7% of total primary energy used worldwide. The global energy supply and energy use per capita are increasing. The total energy requirements of the world rose by a factor of 2.5 between 1970 and 2010, from 4.64 billion tons of oil equivalent (toe) to 11.9 billion toe (195 to 499 exajoules (EJ)) 1. Over the past few decades, the share of electricity in total energy use has steadily increased energy mix over this period. The share of nuclear grew from just below 0.5%in 1970 to above 7% in the 1990s and declined to 5.7% by 2008. Fossil fuels remain the dominant energy source. 1 EJ = 1018 J or 2.78 ×105 GWh (th) or 31.7 GW·a.4 Nuclear power has been used to produce electricity for public distribution since 1954. Since that time, nuclear power plants have been operated in 32 countries2. Currently,

29 countries operate 441 plants, with a total capacity of 375 GW (e). A further 60 units, totaling 58.6 GW (e), are under construction3. During 2009, nuclear power produced 2558 billion kWh of electricity. The industry now has more than 14 000 reactor years of experience. The contribution of nuclear energy to total electricity generation varies considerably by region. In Western Europe, nuclear generated electricity accounts for almost 27% of total electricity. In North America and Eastern Europe, it is approximately 18%, whereas in Africa and Latin America it is 2.1% and 2.4%, respectively. In the Far East, nuclear energy accounts for 10% of electricity generation; in the Middle East and South Asia it accounts for 1.4% Nuclear energy use is concentrated in technologically advanced countries. Over the past two years the contribution of nuclear generation to world electricity production has declined from 15% to less than 14%, largely due to a rise in total electricity generation worldwide without an increase of nuclear generation. The number of reactors under construction increased from 33 with a total capacity of 27 193 MW (e) at the end of 2007 to 60 with a total capacity of 58 584 MW (e) on 26 August 2010. In many countries with existing nuclear power programs, there are significant increases in investment in future nuclear power plants. Of these 60 plants, 11 have been under construction since before 1990, and of the 11 possibly only three are predicted to be commissioned in the next three years. There are a few reactors which have been under construction for over 20 years and which currently have little progress and activity. In 2008, there were 10 construction starts and in 2009, there were 12, extending a continuous upward trend that started in 2003. All 22 of the construction starts in 2008 and 2009 were pressurized water reactors (PWRs) in three countries: China, Republic of Korea and Russian Federation. Since the accident at Chernobyl in 1986, industry safety records have improved significantly. Unplanned automatic scrams continue at the low level of 0.5 per 7000 hours critical. The improved availability and safety records are, in part, attributable to increased information sharing of best practices and lessons.

7.5. Accidents and Safety of Nuclear Power Plants: [16]

- Accidents

Some serious nuclear and radiation accidents have occurred. Nuclear power plant accidents include the Chernobyl disaster (1986), Fukushima Daiichi nuclear disaster (2011), and the Three Mile Island accident (1979). Nuclear-powered submarine mishaps include the K-19 reactor accident (1961), the K-27 reactor accident (1968), and the K-431 reactor accident (1985). International research is continuing into safety improvements such as passively safe plants, and the possible future use of nuclear fusion. Nuclear power has caused far fewer accidental deaths per unit of energy generated than other major forms of power generation. Energy production from coal, natural gas, and hydropower has caused far more deaths due to accidents. In comparison, nuclear power plant accidents rank first in terms of their economic cost, accounting for 41 percent of all property damage attributed to energy accidents.

- Safety

In the 1990s, performance and safety records improved significantly, and they have remained high. Well run nuclear power plants have proven quite profitable. The improvement in the global average energy availability factor and reduction in the number of unplanned reactor trips reflect this improvement. The good safety and performance records over the past two decades, the resulting increased profitability, and the expectation

of further improvements all contribute to rising expectations for nuclear power. The main issue of Nuclear Power safety is the waste disposal. Disposal of nuclear waste is often said to be the Achilles' heel of the industry. Presently, waste is mainly stored at individual reactor sites, and there are over 430 locations around the world where radioactive material continues to accumulate. Some experts suggest that centralized underground repositories which are well-managed, guarded, and monitored, would be a vast improvement There is an "international consensus on the advisability of storing nuclear waste in Deep geological repository", with much confidence in the safety of the method coming from the analysis of the lack of movement of nuclear waste in the numerous 2 billion year old Natural nuclear fission reactors in Oklo Gabon.

7.6. Challenges of Nuclear Energy Sector:

In order to remove energy deficit and build up energy security in the country, the probable challenges are:

- Necessary fund provision.
- Ensure safety of the population and environment.
- Build up the trained and efficient manpower in order to administer and maintain the nuclear plant.
- Build up awareness among general people regarding the risk and prevention of nuclear power centre.

7.7. Production, Usage and Promotion of Renewable energy and Energy Saving Activities**:**

In order to reduce the reliance on natural gas and import-dependent oil the government has taken a number of steps to spread and develop environment-friendly, renewable energy. **[17]**

Benefits to use renewable energy are as follows:

- Supply of raw materials for power generation is infinite
- Management cost is minimum though initial investment is comparatively high
- Technology used is easy and portable
- People living separately in places away from the main land can have access to power and energy facilities
- Future energy security is ensured
- Environment Friendly
- To ensure future energy security

Actions taken up on priority basis for implementation of energy saving programme's are as follows:

- Formation of Sustainable Energy Development Authority
- Preparation of Energy Conservation Act
- Expansion and development of renewable energy

- Implementation of cost effective energy procedure
- Ensuring of efficient use of energy
- Standardization of energy saving electronic machineries

It is necessary to encourage the production and use of such energy from a source which is not harmful to environment in order to ensure safe energy supply along with habitable surroundings.

7.8. Steps taken to produce and extend use of renewable energy:

- Setting up 14 thousand solar home system by REB
- Setting up a solar panel having capacity of 21.2 kilowatt for Prime Minister's Office
- Installation of around 5.30 lakh solar home system in rural areas with the aid of IDCOL (Infrastructure Development Company Limited) through NGOs
- Power generation by setting up wind-mill run power plants in coastal region of Kutubdia and Feni
- Establishing of a wind-mill run power plant of 100 MW(off-shore) capacity in Anowara of Chittagong and 4 solar power plants of 10-15 MW capacity (connected to grid)
- Actions are underway to implement pilot project as IPP to produce power from waste Setting up several solar panel factory by IDCOL

7.9. Pubic Effort:

In order to encourage people to use renewable energy, some of the significant steps taken by the Government are:

- The use of Solar Panel in all large public buildings to be mandatory within 3 years
- Solar Panel import made duty-free

7.10. Immediate Steps To Be Taken:

- Providing policy-strategic and financial support to wind-mill power generation
- Encouraging setting up of Bio-digester Plant
- Encouraging the establishing of solar panel producing industry
- Providing adequate investment in power sector enterprises
- Fixing maritime boundary with India and Myanmar
- Reducing the tendency of quick withdrawal of invested money of international oil companies under Production Sharing Contract (PSC)
- Determining rational price to ensure sustainable development of energy sector
- Developing and sustaining skilled professionals with knowledge on various sources of energy
- Finalizing of Coal Policy
- Expediting the import of LNG
- Expedite onshore bidding process

7.11. Future Plans:

Bangladesh plans to have two 1000 MWe Russian nuclear power reactors in operation from 2018.[18] This is to meet rapidly increasing demand and reduce dependence on natural gas. Bangladesh produced 38 billion kWh gross in 2009 from some 6.1 GWe of plant, giving per capita consumption of 250 kWh/yr. About 88% of electricity comes from natural gas. Electricity demand is raising rapidly, with peak demand 7.5 GWe, and the government aims to increase capacity to at least 7 GWe by 2014, meanwhile importing some 250 MWe from India. New small coal-fired plants are envisaged for 2 GWe of that and for 3 GWe more by 2016. However, about half the population remains without electricity, and the other half experience frequent power cuts. Some 5.0% of government expenditure is being allocated to 'power and energy'. The capacity target for 2021 is 20 GWe. Building a nuclear power plant in the west of the country was proposed in 1961. Since then a number of reports have affirmed the technical and economic feasibility. The Rooppur site in Pabna district about 200 km north of Dhaka was selected in 1963 and land was acquired. The government gave formal approval for a succession of plant proposals, then after independence a 125 MWe nuclear power plant proposal was approved in 1980 but not built. With growth in demand and grid capacity since then, a much larger plant looked feasible, and the government in 1999 expressed its firm commitment to build this Rooppur plant. In 2001, it adopted a national Nuclear Power Action Plan and in 2005, it signed a nuclear cooperation agreement with China. In 2007 the Bangladesh Atomic Energy Commission proposed two 500 MWe nuclear reactors for Rooppur by 2015, quoting likely costs of US$ 0.9-1.2 billion for a 600 MWe unit and US$ 1.5-2.0 billion for 1000 MWe. In April 2008 the government reiterated its intention to work with China in building the Rooppur plant and China offered funding for the project. The International Atomic Energy Agency (IAEA) approved a Technical Assistance Project for Rooppur Nuclear Power Plant to be initiated between 2009 and 2011, and it then appeared that an 1100 MWe plant was envisaged. Russia, China and South Korea had earlier offered financial and technical help to establish nuclear power, and in March 2009 Russia made a formal proposal to build a nuclear power plant in the country. In May 2009 a bilateral nuclear cooperation agreement was signed with Russia. In April 2009 the government approved the Russian proposal to build a 1000 MWe nuclear plant at Rooppur for about $2 billion, and a year later this had become two such reactors by 2017. A nuclear energy bill was introduced into parliament in May 2012, with work to begin in 2013, and setting up a Bangladesh Atomic Energy Regulatory Authority. Parliament was told that 5000 MWe of nuclear capacity was envisaged by 2030, and a second plant would be built in the south once Rooppur was operating. In May 2010 an intergovernmental agreement was signed with Russia, providing a legal basis for nuclear cooperation in areas such as sitting, design, construction and operation of power and research nuclear reactors, water desalination plants, and elementary particle accelerators. Other areas covered included fuel supply and wastes. An agreement with Rosatom was signed in February 2011 for two 1000 MWe-class reactors to be built at Rooppur for the Bangladesh Atomic Energy Commission. In line with standard Russian practice this included fuel supply and return of used fuel to Russia. Another intergovernmental agreement was signed in November 2011. In February 2012 the Ministry of Science and Technology signed an agreement with Russia's Rostechnadzor related to regulation and safety "and the provision of advisory support to the Bangladesh Nuclear Regulatory Commission on regulation, licensing and supervision". Staff will be

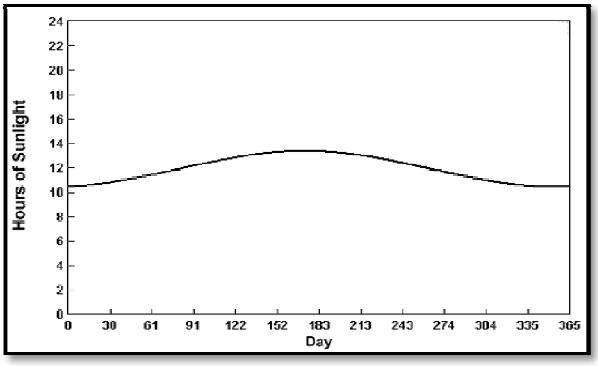
trained in Russia. A further agreement will be for Russian finance. Construction of the first unit is expected from 2013, with operation in about 2018. In August 2012 a financing agreement was finalized under which Bangladesh would borrow $500 million for a 2-year technical and economic study together with design, documentation and training, at not less than 4% interest. Russia will then fund 85% of the estimated $1.5 billion for the first unit's construction. The $500 million loan will be repaid in 12 years with five years grace period, and the final construction cost will be repaid in 28 years with 10 years grace period. The IAEA continues its close involvement with the project.

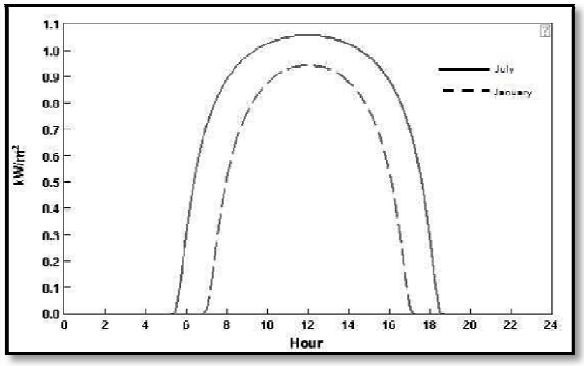
7.12. Renewable Energy Development Program**:**

Development of renewable energy id one of the important strategies adopted by Government for going green. Under the existing generation scenario of Bangladesh, renewable energy has very small to the total generation. The present share of renewable energy is about .05%. BPDB has taken steps for the last few years in the development of renewable energy implementation of energy efficiency measures to achieve the target of renewable energy policy 2008 of the Government.

7.13. Solar Power Project**:**

Solar Energy can be a great source for solving power crisis in Bangladesh. Bangladesh is situated between 20.30 and 26.38 degrees north latitude and 88.04 and 92.44 degrees east which is an ideal location for solar energy utilization. **[19]** At this position the amount of hours of sunlight each day throughout a year is shown in the following graph in the Figure 1.The highest and the lowest intensity of direct radiation in W/m² are also shown in the Figure 2.

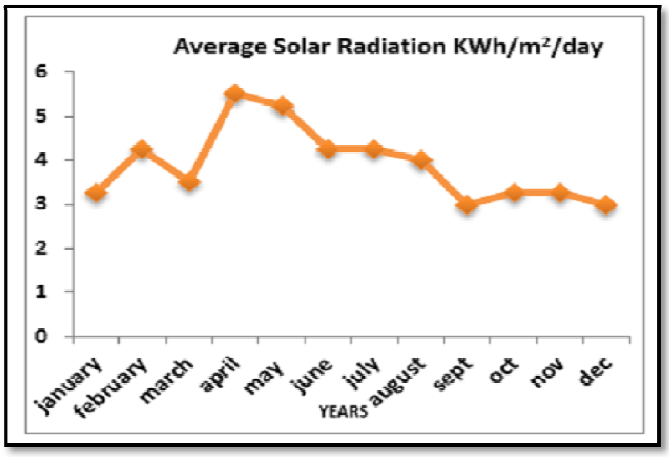




In a recent study conducted by Renewable Energy Research Centre, it is found that average solar radiation varies between4 to 6.5 kWhm day and maximum amounts of radiation are available in the month of March8April and minimum in December-January. So from the above figure and discussion we can say that there is a good prospect of harnessing solar power in Bangladesh.

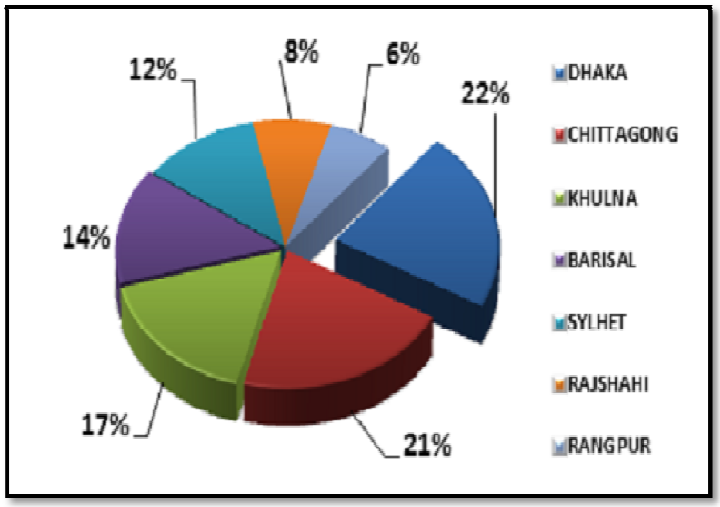
Solar panels are the medium to convert solar power into the electrical power. Sun beam is absorbed with the panel material and electrons are emitted from the atoms that they are bounded. This releases current thus solar power is converted into electrical power. When PV cells are joined physically and electrically and placed into a frame they form a solar panel or PV module. Panels joined together form a solar array.

The sunlight impinging on panels, i.e. irradiance or insolation (incoming solar radiation), is measured in units of watts per square meter (W/m2).We can use only 25% of sunlight radiation for PV module. The PV system power output (DC) has approximately a linear relationship to the insolation. Using the solar radiation available on the tilted surface the hourly energy output of the PV generator can be calculated according to following equation:



$$P = A x2 + B x + C \text{ (in Watts)}$$

Where, x= solar radiation, P=power generation, and A, B, C are constants, which can be derived from measured data. By using above formula, we can predict solar power generation at any solar radiation.



Moreover, in the rural areas where there is no electricity connection, photovoltaic technology can be a blessing. Although, the installment cost of solar systems in the house is very much costly, but once installed it can give service up to 20825 years with proper maintenance. Moreover, in then northern territories of Bangladesh where the solar intensity is very high, solar thermal power plant can be installed. For both photovoltaic technology and solar thermal technology, Bangladesh is at a perfect location. In fact, Bangladesh government has recently taken many steps to encourage people to use photovoltaic energy. Almost every newly built apartment building is now using solar panels along with the grid connection to get support during the load shedding period. Even in the rural areas, some NGO's have been working to provide solar panels to the villagers in a cheap price.

Though Bangladesh is among the countries of the world which has substantial volume of natural gas resource, the reserve is degrading day by day as mentioned in the previous section because of our continuous dependence on natural gas for cooking purpose, electricity generation and industrial work. So if we can minimize the use of natural gas as a fuel in our house hold replacing it with solar cooker we can increase the production of electricity. Solar cooker is a device that uses the energy of sunlight to cook food. Solar cooker is mainly advantageous because they do not use fuel and cost nothing to operate. There are

many more advantages of solar cooker. For example, as it does not require any fuel, it reduces fuel costs for low8income people, it does not create air pollution, minimize deforestation and desertification which are caused by the use of firewood for cooking. An ideal solar cooker is cheap and simple to construct. It can be made using the normal day to day materials. As solar cooker can compensate the use of natural gas to some extent, these amount of natural gas can be used in the steam based power plants of Bangladesh to produce electricity. Finally, we can say that adoption of solar cooker for the cooking purpose will reduce the power crisis of our country as the pressure on natural gas will be reduced which we can be used for power generation.

7.14. Ongoing Solar Projects:

- BPDB has taken steps to install 5MW grid connected solar PV power plant at Kaptai Hydro Power Station
- 1MW solar PV power plant (off grid solar – Wind – Diesel based hybrid system) at Hatiya Island, Noakhali.
- 650KWp (400KW load) solar mini grid power plant at remote haor area of sulla upazila at Sunamganj district under climate change trust fund (CCFT)
- 1000KM of street lightning based on solar PV & Led Based technology in seven City Corporation of the country.
- BPDB is installed solar power system in all offices of BPDB across the country to run the light and fan load.

7.15. Solar project Under Planning:

- BPDB has planned to install 10MW grid connected solar PV plants on basis at Jamalpur and Rajshahi.
- BPDB has planned to install 1MW solar mini grid power plant under climate change trust fund (CCFT) at remote and inaccessible areas of Chittagong and Bandarban District.
- BPDB has planned to implement solar park projects on BOO basic under the roadmap of ADB's 500 MW solar power mission.
- BPDB has planned to install 1 MW solar PV plant (off grid solar – diesel based hybrid system) at kutubdia Island.

7.16. Micro Hydro:

Because of the geographic position, Bangladesh is a riverine country which is a huge advantage for the country. [20] This huge amount of river currents and sources of low head of waterfalls can be used for generating microhydro8power. Micro hydro means generating up to 58300 KW of electricity through hydroelectric power [10]. It is a simple technology that converts hydropower to mechanical power. Micro8Hydro technology is very much suitable for a developing country like Bangladesh because it is a special source of energy which can generate energy without of fuel and the technology is very cheap. Because of the presence of many canals and tributaries of main river Karnafuli, Shangu, Matamuhuri which have very good potentials for setting up micro hydropower unit in Chittagong Hill Tracts region [10], recently Sustainable Rural Energy (SRE) under LGED has successfully demonstrated first micro8hydro power unit at Bamerchara, Chittagong. Although the installed capacity of the unit was 10 kW but due to insufficient water head only 4kW power was generated.

7.17. Potential of Micro hydro power in Bangladesh:

In 1981, Bangladesh Water Development Board and Bangladesh Power Development Board explored potential sites which are suitable for micro8hydro power generation which are listed in Table 2. Sustainable Rural Energy (SRE) has explored some potential micro8hydro sites in Chittagong region in 2004 which is listed in Table 3. From the Tables 2 and 3 and the related discussions, it is clear that there is massive possibility of extracting electricity from the micro hydro energy.

Serial No	District	Name River/Chara/Stream	Potential of Electrical Energy KW
1	Chittagong	Foy's lake	4
2	Chittagong	ChotoKumira	15
3	Chittagong	HinguliChara	12
4	Chittagong Hill Track	Sealock	81
5	Chittagong	Lungichara	10
6	Chittagong	Budiachara	10
7	Sylhet	NikhariChara	26
8	Sylhet	Madhab Chara1500ft. from fall	78
9	Sylhet	Rangapani Gung	616
10	Jamalpur	Bhugai8Kongsa at 2 miles U/S. of Nalitabari P.S	69 KW for 10months48 KW for 2 months
11	Jamalpur	Marisi at Dukabad nearJhinaigati Thana HeadQuarter	35 KW for 10months20 KW for 2 months
12	Dinajpur	Dahuk at Burabari	24
13	Dinajpur	Chawai at U/S. of ChawaiL.L.P	32
14	Dinajpur	Talam at U/S. of Talam L.L.P	24
15	Dinajpur	Pathraj at Fulbari	32
16	Dinajpur	Tangon at D/S of Nargun L.L.P	48
17	Dinajpur	Punarbhaba at Singraban	11
18	Rangpur	BuriKhoraChikli at Nizbari	32
19	Rangpur	Fulkumar at Raiganj Bazar	48

Table: Potential Small Hydro Sites Identified By BPDB and BWDB.

7.18. Wind Energy:

There are many hilly and coastal areas in Bangladesh which have huge potential for wind energy generation. [21] Wind energy is a technique which converts the air flow into mechanical energy which is eventually converted into electricity without generating pollutants. Bangladesh has a 724 km long coast line and many small islands in the Bay of Bengal, where strong south- westerly trade wind and sea8breeze blow in the summer months and there is gentle north-easterly trade wind and land breeze in winter months. Along the coastal area of Bangladesh, the annual average wind speed at 30m height is more than 5 m/s. Wind speed in northeastern parts in Bangladesh is above 4.5 m/s while for the other parts of the country wind speed is around 3.5 m/s. Coastal locations of Bangladesh such as Chittagong, Kutubdia and Cox's Bazaar have immense potential to produce electricity from wind energy.

By using one year data of Bangladesh Centre for Advanced Studies, it has been found that at 50 meter height in these areas the wind speed varies from 4.1 to 5.8 meter/second with a power density of 1008250 w/m2. An analysis of wind energy measurement done by RISOE shows locations with power density above 200 w/m2 over 2000 km2 which is very good to set up wind turbines and expand wind energy in Bangladesh. To check whether wind energy can be a potential renewable source of electricity, small8scale wind turbines can be installed in areas in Bangladesh such as St. Martins Island, Patenga, Bhola, Barguna, Dinajpur, Thakurgaon and Panchagar. So from the above discussion we see that there is a huge possibility of extracting electrical or mechanical energy from the wind in Bangladesh.Wind power involves converting wind energy into electricity by using wind turbines. A wind turbine is a machine that converts the kinetic energy in wind into mechanical energy. A wind turbine is composed of three propellers-like blades called a rotor. The rotor is attached to an all tower which is 20m high. Wind comes from atmospheric changes, changes in temperature and pressure makes the air move around the surface of

Organization name	Type of Application	Installed Capacity(Watt)	Location	Present Status
Grameen Shakti	3 Hybrid	4,500	Grameen Offices in the Coastal Region	Functioning
	Hybrid	7,500	Cyclone Shelter in the Coastal Region	Functioning
BRAC	Stand-alone	900	Coastal Region	Functioning
	Hybrid	4,320	Coastal Region	Functioning
Bangladesh Army	Stand-alone	400	Chittagong Hill Tracts	Functioning
IFDR	Stand-alone	1,100	Teknaf	Functioning
	Stand-alone	600	Meghnaghat	Functioning
LGED	Wind-PV Hybrid	400	Kuakata	Functioning
	Total	19,720		

the earth all of which is triggered by the sun. The power output of a turbine is a function of the cube of the wind speed, so as wind speed increases, power output increases dramatically. Areas where winds are stronger and more constant, such as offshore and high altitude sites are preferred locations for wind farms. We cannot convert all the wind energy into electricity: we can convert only 59%, according to Betz limit. The output equation for a wind generator is given by:

$P = .5 \times \rho \times A \times v3$ (in Watts)

Where, A=area perpendicular to the direction of flow (inm2), v=wind velocity (ms-1), ρ =density of air (in Kgm-3) and P=power generation.

7.19. Ocean Wave Energy:

Ocean wave energy is generated directly from the waves of the oceans. [22] It is another special type of renewable energy which helps to decrease the harmful emissions of

greenhouse gases associated with the generation of power. It can be potentially a significant source of electricity for Bangladesh. Though the main purpose of ocean wave energy is electricity generation, it can also be used for the pumping of water, water desalination etc."The Oscillating Water Column method is technically feasible and becoming economically attractive in this purpose. This type of wave energy harnessing device is being commissioned by several countries such as the United Kingdom (500 kW), Ireland (3.5 MW), Norway (100 kW), India (150 kW), etc. Bangladesh has potential for harnessing ocean wave energy from the BAY OF BENGAL.

7.20. Tidal Power:

Tidal power or tidal energy is a form of hydropower that converts the energy of tides into electrical power. [23] As tides are more predictable than wind and sunlight, tidal energy can easily be generated from the changing sea levels. The coastal area of Bangladesh has a tidal rise and fall of between 2 to 5 meters. Among these coastal areas, with 5 meter tides experienced, Sandip has the best prospect to generate tidal energy. Moreover, Bangladesh can generate tidal power from these coastal tidal resources by applying Low head tidal movements and Medium head tidal movements, low head tidal movements which uses tides of height within 2m to 5m can be used in areas like Khulna, Barisal, Bagerhat, Satkhira and Cox's Bazaar regions and the height tidal movements which use more than 5m of tides can be mainly used in Sandip. So we can say that with suitable tidal height available, this can be a great source of energy for Bangladesh.

7.21. Geothermal Energy:

The thermal energy which is generated and stored inside the earth surface is called geothermal energy. [24] It is very much cost effective and environmentally friendly. With this technology, we can use the steam and hot water produced inside the earth surface to generate electricity. Geothermal energy is generated about 4,000 miles below the surface, in the earth's core. The process takes place due to the slow decay of radioactive particles, the high temperature produced inside the earth and it happens in all rocks. About 10,715 megawatts (MW) of geothermal energy is generated in 24 countries worldwide. The northern districts of Bangladesh show the prospect to explore the geothermal resources. The demand of electricity in urban as well as in the rural areas are increasing, but our production of electricity is not increasing. The rural demand for electricity can be covered by the production of electricity through geothermal energy. The electricity demand of urban areas can be met then by this saved electricity which is supposed to be provided in the rural areas. Geothermal energy can balance the electricity consumption in these two areas. Dhaka based private company namely Anglo MGH Energy has initiated a project to setup the country's first geothermal power plant with a capacity to produce 200 MW of electricity close to Saland in Thakurgaon district. They have planned to set up 28 deep tube wells to lift hot steam and the lifted steam

Production Averages for Common Oil Crops		
Plant	lb. oil/acre	Gallons of Biodiesel/acre
Algae	6757	700
Coconut	2070	285
Jatropha	1460	201
Rapeseed	915	126
Peanut	715	112
Sunflower	720	99
Soybean	415	62

will be used to run a turbine and the turbine is connected to the generator to generate electricity. From the above discussion it is clear that geothermal energy can also be a great source of harnessing electrical energy in Bangladesh.

7.22. Bio Diesel:

In recent years fossil fuel depletion and global warming issues are the point of concern around the world. [25] To reduce Carbon emissions and decreasing reserves of fossil fuels, Bio fuel can be an attractive source of energy. In comparison to fossil fuels, bio fuel can reduce the emission of CO2. Next generation bio8fuels can be a great solution to the global warming and the crying need of fossil fuels. Bio fuel or Biodiesel is clean burning oil produced by transesterification of oils with short chain alcohols. Now8a8days, researchers are turning their attention into the production of biodiesel from algae because of their higher productivity, abundance in the nature, high triacylglycerides and they can be a major source for biodiesel production. Production of biodiesel from algae is less time consuming and cheaper than the petroleum diesel. So rather using petroleum diesel in the diesel generators in the power plants, we can use biodiesel which will both save our money and reduce our dependence on the diminishing fossil fuel reserves. This biodiesel can be used in the diesel generator to produce electricity. This will be cost efficient and as well as environment friendly. Algae grow in abundant in Bangladesh. So we can produce biodiesel from algae which we can use in the power plants to generate electricity. Biodiesel can be a great source of power generation for Bangladesh. Microalgae can take waste from CO2 and convert it into natural oil. Table1. Below shows a comparison of oil yield of various oil seed crops.

The climate of Bangladesh is perfect for the production of algae. It has plenty of ponds and canals which are perfect for the algae growth. With these huge amounts of algae we can easily produce biodiesel which are relatively cheaper than the petroleum diesel. The conventional petroleum diesel we are using in the diesel generators is costly. We can reduce the cost by using bio fuel in Bangladesh in these diesel generators to produce more electricity with lesser cost. So with favorable algae growth, cheaper production cost than the conventional diesel and more eco8friendly nature biodiesel can be a great source of renewable energy in Bangladesh.

7.23. Bio Gas:

Natural resources in the form of fossil fuels are the raw materials from which electrical energy is generated and the day to day life of the people of today's world is solely dependent on the electrical energy in this present world. [26] Scientists around the world have already indicated that our natural reserve of gas is decreasing day by day and the time is not too far when we will have no natural gas resource. Although previously it was believed that Bangladesh has plenty amount of gas, but recent study has shown that natural gas reserve of Bangladesh is not sufficient to meet the daily cooking purpose of the people for next few decades, let alone generation of electricity. However, waste materials produced from natural day to day life usage and also from animal wastes, can be good sources of energy in this purpose and can help to meet the electricity demand by generating electricity through biogas. Many countries around the world are now paying their attention to biogas because of its environment friendly technology and as a supplement for the gradually decreasing fossil fuel reserves. Many countries now8a8days are producing electricity from

biogas. Some of them are using biogas technology in mass production of electricity rather than using it in a distributed ways around the country.

In Bangladesh biogas is still a relatively new technology. In most of the places it is used to generate electricity to meet the household demands. But an agro8based country like Bangladesh produces huge amount of waste materials. Converting these waste materials into energy is economically advantageous as well as helpful to solve the issue of power crisis. In Bangladesh, recycling industry wastes raises a total of 436 t/d of material recovery. Moreover, 3,054 t/d of wastes is expected to be collected in 2015 and cumulative disposal volume is estimated at about 9 million tons by the end of 2015. This huge amount of waste, most of which are compostable and have very good fermentation property can be easily used to produce electricity as well as the generated gas can be used for the cooking purpose. Waste to energy technology can be a huge asset for a developing country like Bangladesh. Although some small farms and houses in the rural areas are using wastes produced from their livestock to produce electricity for daily purposes, it should be used commercially to produce electricity in the areas where there is still no electricity from the national grid. It will help the people of these areas to meet their demand of electricity and the government and the companies related to this technology can earn money which is also beneficial.

Bangladesh is an agricultural country so biomass is available in huge amount. Cattle dung, agricultural residue, poultry dropping, water hyacinth, rice husk etc. used for biomass power generation are available in Bangladesh. Below indicates that the amount of rice production in Bangladesh has been increased in recent years and this amount of production has made us more optimistic in using the rice husk as a biomass fuel which is nevertheless a perfect source of renewable energy in the context of Bangladesh.

Chapter 8

Conclusions

Conclusions:

Inefficient organizational management of the Power Division of the Ministry of Power, Energy, and Mineral Resources (MPEMR) as well as the BPDB has partially created current electricity crisis in Bangladesh. The influences of the three other major factors, i.e., financial resources, adequate generation capacity, private investment are also important for electricity generation along with the organizations efficiency and effective policy. Even the private sector participation and reformation processes have not been succeeded to overcome this crisis. Political interference and corruption in private investment and in bureaucracy as well as the conflicts between ruling party and opposition have more aggravated this crisis. Ineffective Parliamentary supervision, centralized organizational structure, bureaucratic culture and weak strategies to increase electricity productions are also criticized. Current crisis in electricity sector can be considerably overcome by increasing the efficiency of the 'Power Division' and 'BPDB' as well as by stopping the political interference in decision making and in bureaucracy. This study is completely a theoretical framework. From this, the result is obtained that it is high time that Bangladesh should use alternative source of energy. In addition, nuclear Power is the best way. The initial cost of the plant is high but it will sustain for long time. Moreover, the total amount of electricity production is high than renewable sources. Bangladesh is mainly using natural gas for electricity production, and natural gas is using for other purposes. By using this way the natural gas will finish one day, so nuclear power should be introduced in Bangladesh. Moreover, Nuclear Power has an exclusively important advantage of no creating carbon dioxide and, therefore, no consuming oxygen. Therefore, it does not disturb the equilibrium of the echo-system of our planet. Nuclear power possess considerable potential possibilities, far to be exhausted till now, which will be set in motion as the necessary results of investigation in the field of applied nuclear physics, radiation material physics and radiation chemistry are accumulated. Nevertheless it is now almost certain that the future nuclear arrangements based on splitting nuclear reactions will be in the form of systems of fast reactors operating in deeply subcritical regime fuelling and driven by spoliation neutrons produced in heavy extended targets by relativistic proton beams from accelerator (ADS). Such arrangements are able to burn up practically all-natural uranium in the closed nuclear cycle and, in addition, to transmute and incinerate the radioactive waste from other sources used in medicine, industry, scientific research and military applications. The main problem of thinking Nuclear power was radioactive disposal but now it can be used and dangerous to people. So, analyzing all perspectives Nuclear Power should be introduced in Bangladesh.

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