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Regional Hydro-power Resources: Status of Development and Barriers

Bangladesh

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Bangladesh

For

United States Agency for International Development

Under

South Asia Regional Initiative for Energy

Prepared by

Nexant SARI / Energy

List of Abbreviations

ADB	Asian Development Bank
BCR	Benefit Cost Ratio
BMPP	Barge Mounted Power Plant
BPBD	Bangladesh Power Development Board
BUET	Bangladesh University of Engineering and Technology
BWDB	Bangladesh Water Development Board
EIRR	Economic Internal Rate of Return
FY	Financial Year
GDP	Gross Domestic Product
GWh	Giga Watt Hour
IECO	International Engineering Co. Inc., USA
IPP	Independent Power Producer(s)
IRR	Internal Rate of Return
JBIC	Japan Bank for International Co-operation
JETRO	Japan External Trade Organization
JICA	Japan International Co-operation Agency
kV	Kilo Volt
kWH	Kilo Watt Hour
LFS	Labour Force Survey
MEMR	Ministry of Energy & Mineral Resources
MkWh	Million Kilo Watt Hour
MSL	Mean Sea Level
MW	Mega Watt
OECF	Overseas Economic Co-operation Fund, Japan
OTCA	Overseas Technical Co-operation Agency, Japan
PSMP	Power System Master Plan
TCF	Trillion Cubic Feet
TEPSCO	Tokyo Electric Power Services Company, Japan
WAPDA	Water and Power Development Authority

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Executive Summary

General

Bangladesh with a current population of about 130 million is one of the densely populated countries of the world. The country is bounded by India on the west, the north and north-east and the Bay of Bengal in the south. The topography of the country is rather flat except in the Hill Tracts region lying in the south-east. Bangladesh has quite large natural gas resources. Power generation in the country is still at a lower level, meeting the load demand of only 3,218 MW and only **30%** of the country's population has access to electricity.

Purpose of this Study

The main purpose of the present study is to provide to SARI/Energy a comprehensive and authentic reference document, compiling profile of the regional hydro-power resources development potential, the present status of the utilization of hydro-power resources, the future hydro-power development plan(s), policies currently followed for the hydro-power development and the problems and issues as perceived in the partner countries.

Assessment of Project Options

In Bangladesh, the hydro-power potential is rather limited. The only hydro-power plant is located at Kaptai, built in 1962 on the Karnafuli River, about 70 km upstream of Chittagong City. Kaptai Hydro has now an installed capacity of 230 MW with 5 units having vertical shaft Kaplan turbines. The power station has a maximum annual generation of over 1000 MkWh. Kaptai has a further potential of 100 MW. Bangladesh has other hydro-power potentials in the development of the Sangu and Matamuhuri River basins, with a combined capacity of 167 MW. In addition, the Brahmaputra Multi-purpose project and the barrage project may provide an electric power of 1,400 MW. Bangladesh needs to develop its energy resources at a quick pace for poverty alleviation, economic development and improved standard of living. The issues and barriers in the development of power sector, including hydro-power, have been listed. The power demand in Bangladesh is rising at a very fast rate. Bangladesh power Development Board (BPDB) with its installed capacity of 3,420 MW is unable to meet the maximum demand of 3,218 MW. Independent Power Producers (IPP) have come to rescue with their installed capacity of 810 MW.

Principal Results

In this background, Bangladesh should give priority to implementing the following projects.

- Kaptai Extension Project (6 & 7 Units) with a capacity of 100 MW
- The Sangu and Matamuhuri River Basins development project with a capacity of 167 MW

Subsequently, Bangladesh should make appropriate move for implementation of the Brahmaputra Multi-purpose and the Brahmaputra Barrage Projects.

Recommendations and Next Steps

Regional and international co-operation should be pursued by Bangladesh in mitigating the power crisis in the country. It is established that there is enormous hydro potential in the region, particularly, in Nepal and Bhutan. Thus with sincere co-operation and proper initiative from amongst the partner countries in the region, the power crisis in the region may be resolved for some future decades. India being the largest country in the region should come up with extra initiative and create trust amongst its neighbours for regional co-operation in development of hydro potential in the region. As a step toward achieving this goal, an immediate conference of the technocrats, academicians, retired bureaucrats in the partner countries may be convened under the auspices of SARI/Energy with a view to identifying the projects and to fixing the priorities in the implementation of the projects identified.

1.1 General

Bangladesh lies in the north eastern part of South Asia between $20^{0}34'$ and $26^{0}38'$ north latitude and $88^{0}01'$ and $92^{0}41'$ east longitude. The country is bounded by India on the west, the north, and the north-east and Burma on the south east and the Bay of Bengal on the south. The area of the country is about 147,570 sq km. Except the hilly regions in the north-east and the south-east and some areas of high lands in the north and north western part, the country consists of low, flat and alluvial land. A network of rivers crisscrosses the country, of which the Padma, the Jamuna, the Teesta, the Brahmaputra, the Surma, the Meghna and the Karnafuli are significant. These rivers and their tributaries numbering about 230 with a total length of about 24,140 km covering the country flow down to the Bay of Bengal. Dhaka is the capital and the largest metropolis of the country with a population of over eight million. Chittagong is the main port of Bangladesh. The port city has a population of about three million. The location of Bangladesh in the sub-continental region is shown in an attached map, Map-1, titled Map of the Region. Bangladesh is shown in green clour. A blown out view of Bangladesh showing its major river system and demarcation of administrative districts is attached hereto as Map-2, titled Map of Bangladesh.

1.2 Flora and Fauna

The total forest area in Bangladesh covers about **13.36%** of the land area. The country produces timber, bamboo and cane. Bamboos grow in almost all areas but quality timber grows mostly in the valleys. Among the timber sal, gamari, chaplish, telsu, jarul, teak, garjan, chandon and sundari are important. Sundari trees grow in the Sundarbans located in the south-western part of the country bordering the Bay of Bengal. Plantation of rubber in the hilly regions of the country was undertaken recently and extraction of rubber had already begun.

Varieties of wild animals are found in the forest areas. Sundarban is the home of the world famous 'Royal Bengal Tigers’. Of the other animals, elephants, bears, deer, monkeys, boars, leopards, and crocodiles are worth mentioning. A few hundred species and sub-species of birds are found in the country. Some of them are of seasonal and migratory types.

1.3 Climate and Hydrology

Bangladesh enjoys generally a sub-tropical monsoon climate. Climate in Bangladesh is distinctly characterized by three seasons, namely, a mild winter during the months from November to February; summer during the months from March to May and wet monsoon during the months from June to September/October. The mean maximum temperature is 35 degree Celsius occurring in summer while the mean low is 15 degree Celsius occurring in winter. Monsoon starts in June and stays sometimes upto October. This period accounts for **80%** of the total rainfall. The annual mean rainfall varies from 1,429 to 4,338 millimetre. The maximum rainfall is recorded in the coastal areas of Chittagong and northern part of Sylhet district, while the minimum is observed in the western and northern parts of the country. Very little rain is experienced during winter.

1.4 Topography

Most of the land in Bangladesh is a flat delta except Chittagong and the Hill Tracts Districts in the southeast region. Highest elevation to be found in the Hill Tracts is about 610m above the sea level. Except for the southeast region, rest of the land slopes gently from north to south. Northern district of greater Dinajpur has an elevation of about 90m above sea level. The bank elevation of the Ganges in Bangladesh varies between 15m and 10m.

1.5 River System

Numerous small rivers crisscross Bangladesh. Most of them are either tributaries or distributors of the three mighty rivers: the Ganges-Padma, the Brahmaputra-Jamuna, and the Meghna. There are some independent small rivers. But most of the rivers originate from outside Bangladesh. Annually they used to bring an estimated 1,070 million acre-foot of water from outside into Bangladesh to discharge into the Bay of Bengal. About 100 million acre-foot of runoff is generated by rainfall within the country. Now that water is being diverted in the upper reaches by the upper riparian countries, some reduction in annual average inflow is expected. As per Master Plan Report of 1964 (Ref: 1009-BAN/SARI), the maximum and minimum monthly average flow of the river Jamuna at Bahadurabad ghat were 55,500 cumsec and 3,400 cumsec respectively, the average maximum occurring in August, while the average minimum in February. The Padma at the Hardinge Bridge was reported to have a maximum average of 56,000 cumsec in the month of September, and the lowest monthly average flow of 1,260 cumsec in April. Due to unilateral diversion of Ganges water by India, daily flow came down to about 280 cumsec in the dry month of April in the recent past. After the water sharing treaty with India, the situation has improved. According to the treaty, Bangladesh will receive a guaranteed minimum of 990 cumsec during the critical period. There are some small independent rivers located in the southeast. These are the little Feni River, the Feni, the Sangu, the Matamuhuri, and the Karnafuli with some what high gradient as they flow down the hills.

1.6 River Development

A comprehensive program was taken on hand in the late fifties to develop water resources.

The Master Plan of 1964 (Ref: 1009-BAN/SARI) prepared by International Engineering Co. Inc (IECO), USA recommended a comprehensive flood control and irrigation plan in addition to what had been already under implementation at that time. Some of the noteworthy completed river projects are Karnafuli Hydro-electric Project, Dhaka-Narayanganj-Demra Flood Control & Irrigation Project, Ganges-Kobadak Irrigation Project, Meghna-Dhonagoda Project, Teesta Barrage Project for irrigation etc. Except for Karnafuli, no other project has had hydro-electric feature.

1.7 Population

The Bangladesh Bureau of Statistics conducted the Third decennial population census in the country on March 12 to 15, 1991. The population of the country stood at 111.4 million in 1991. The percentage of urban population was 20.1 while that of rural 79.9. The intercensal growth rate of population estimated by using adjusted population of 1991 census was 2.1 per annum. Assuming medium variant of declining fertility and mortality the country is expected to reach a population of 129.6 million by 2000 A.D. The country-wide intensive family planning measure is aimed at reducing the growth rate. The density of population was approximately 647 per sq. km. in 1981. It has increased to 755 per sq. km. in 1991. The sex ratio of the population 106 males per 100 females. The literacy rate of the country obtained from 1991 census was 32.4 percent for population 7 years and above. The percentage of Muslim population was 88.3 while that of Hindu, Buddhist and Christian was 10.5, 0.6 and

0.3 respectively. There were 19.9 million households in the country distributed over 59,990 mauzas (revenue villages).

According to the Population Census of 2001, the population in Bangladesh as on 22 January, 2001 (Population Census: Enumerated) stood at 123.1 million with male population of 62.7 million and female population of 60.4 million. The annual growth rate during 1991-2001 was found to be **1.47%.** This shows a positive improvement in the family planning efforts undertaken by the government.

1.8 Labour Force

According to 1995-96 Labour Force Survey (LFS), the total Civilian Labour Force of the country was estimated at 56.0 million of which 34.7 million are male and 21.3 million are female while it was 51.2 million for both sex; 31.1 million being for male and 20.1 million being for female in 1990-91 LFS as per extended definition. In extended definition the activities like care of poultry & livestock, processing, husking, preservation of food etc. are considered as economic activities which are usually performed by females in an out of the agriculturally based household rural areas.

The provisional figures published for 1999-2000 shows total Civilian Labour Force as 60.3 million, of which 37.5 million are male and 22.8 million are female.

1.9 Mineral Resources and Energy

Bangladesh has a few proven mineral resources. The country has quite large natural gas resources.

1.9.1 Natural Gas

So far, 22 (twenty two) gas fields have been discovered from which natural gas is available for power-generation, industrial and other uses. Total proven resources are estimated at 15.5 TCF. Table 1-1 below shows the primary recoverable reserves of the 22 (twenty two) gas fields.

Table 1 - 1: Primary Recoverable Reserves of 22 Gas Fields in Bangladesh

S.No.	Gas Field	Year of Discovery	Initial Gas in Place (BCF)	Initial Explorable Reserve (BCF)	Accumulated Production (June-2000)	Rest of Explorable Reserve (July-2000) (BCF)
1	Bakhrabad	1969	1,432	867	580.27	286.73
2	Hobiganj	1963	3,669	1895	783.67	1111.33
3	Kailashtila	1962	3,657	2529	215.27	2313.73
4	Rashidpur	1960	2,242	1309	179.81	1129.19
5	Sylhet	1955	444	266	165.18	100.82
6	Titas	1962	4,138	2100	1721.18	378.82
7	Norshingdi	1990	194	126	26.03	99.97
8	Meghna	1990	159	104	20.11	83.89
9	Sangu	1996	1,031	848	69.27	778.73
10	Saldariver	1996	200	140	12.06	127.94
11	Jalalabad	1989	1,195	815	37.11	777.89
12	Bianibazar	1981	243	167	4.55	162.45
(i)	**Sub Total (1-12)**		**18,604**	**11,166**	**3,814.51**	**7,351.49**
13	Begumganj	1977	25	15	0	15
14	Fenchuganj	1988	350	210	0	210
15	Kutubdia	1977	780	468	0	468
16	Shahbazpur	1995	514	333	0	333
17	Semutung	1969	164	98	0	98
18	Bibiana	1998	3,150	2,401	0	2,401
19	Moulabibazar	1999	500	400	0	400
(ii)	**Sub-Total (13-19)**		**5,483**	**3,925**	**0**	**3,925**
20	Chattak	1959	447	268	26.46	241.536
21	Kamta	1981	33	23	21.1	1.9
22	Feni	1981	178	125	39.51	85.4905
(iii)	**Sub-Total (20-22)**		**658**	**416**	**87.07**	**328.9265**
	Total (i)+(ii)+(iii) BCF		**24,745.00**	**15,507.00**	**3,901.58**	**11,605.42**
	Total (i)+(ii)+(iii) TCF		**24.745**	**15.507**	**3.9**	**11.61**

Ref: Book on "Jalani Shamoshya-Bangladesh Preshkit" by Prof Muhammad Nurul Islam, December 2001 (ISBN: 984-8233-19-9)

1.9.2 Coal

Several coal deposits have been discovered in Bangladesh and efforts are under way to exploit them with international assistance. Of the deposits so far discovered, Jamalganj in the district of Bogra; Khalashpir in the district of Rangpur and Barapukuria in the district of Dinajpur are significant. The reserve in Jamalganj is estimated at 1000 million ton. The deposit lies at a depth of about 1000m. The reserve at Khalashpir is estimated at 450 million ton. The deposit lies at a depth of 200 - 450m. The deposit of Barapukaria lies at a depth of 150 - 350m. The reserve is estimated at 300 million ton. It is, however, learnt that only **23%** of this deposit is recoverable. At present, exploitation of coal from Barapukuria is under implementation with Chinese technical and financial assistance. A thermal power plant of 300 MW installed capacity near the location of the coal nine is now under implementation with the Chinese technical and financial assistance.

1.9.3 Electricity

Electricity is produced by both thermal and hydro-electric process. The total generation of electricity amounted to 16,754.20 MkWh in FY 2001. Hydro-electric potential that is technically feasible to develop is estimated at 7,000 GWh. Out of this, the Karnafuli River has been substantially exploited so far to the extent of more than 1,000 MkWh at Kaptai. The solitary hydro-electric project having installed capacity of producing 230 MW. electricity is located at Kaptai in the Chittagong Hill Tracts. Map-3, attached hereto shows the location of Hydro-electric potentials, namely, the basins of the river Karnafuli, the river Sangu and the river Matamuhuri.

1.9.4 Others

Limestone, the basic raw material for the production of cement, has been found in some places and cement factories are being set up for their utilization. Other minerals found include hardrock, lignite, silica sand, white clay, etc. There is possibility of oil deposit in the country and efforts are being made for its exploration. Salt is not mined but manufactured on small scale at several thousand evaporation sites in the coastal areas of Chittagong and Cox's Bazar.

Extensive radio-active sand deposits have been found all along the beaches from Kutubdia to Teknaf. A survey estimates the reserve to be of the order of 0.5 million tons of sand containing a significant amount of usable heavy minerals.

1.10 Industries

Although Bangladesh is predominantly an agricultural country, but a large number of large scale industries based on both indigenous and imported raw materials have been set up. Among them jute and cotton textile, paper and newsprint, sugar, cement, chemicals, fertilizers and tanneries are important. Other notable industries are engineering and ship building, iron and steel including re-rolling mills, oil refinery, paints, colors and varnishes; electric cables and wires, electric lamps, fluorescent tube lights, other electrical goods and accessories, matches, cigarettes, etc. Among the cottage industries, handlooms, carpet-making, shoe-making, coir, bamboo and cane products, earth-ware, brass and bell metal products, bidi and cheroots, small tools and implements, ornaments, etc. are important.

The industrial sector contributing about **11.5%** of the GDP, is dominated by Jute processing followed by cotton textiles, cigarettes and garment industry.

1.11 Power Generation

Bangladesh Power Development Board (BPDB) is the executing agency for implementation of power generation projects in the country. The total installed capacity of BPDB system as of FY 2002 is 3,420 MW excluding the generation by the Independent Power Producers (IPP). The total installed capacity of IPP system is 810 MW; thus the total installed capacity of Bangladesh system as of FY 2002 is 4,230 MW. Table 1-2 below shows the installed capacity by type of plants.

Table 1-2: Installed Capacity (FY2002)

Serial No.	Type of Plant	Installed Capacity of BPDB in MW	Percentage of Total (BPDB)	IPP's Installed Capacity in MW
1	Steam Turbine	2,228	65.15	--
2	Combined Cycle	236	6.90	360
3	Hydro	230	6.72	--
4	Diesel	18	0.53	220
5	Gas Turbine	708	20.70	230
	Total=	**3,420**	**100.00**	**810**

Table 1-3 at the following page shows the Plant-wise Installed Capacity of BPDB as well as IPP System in FY 2002 (ending June 2002).

Table 1-3: Plantwise Installed Capacity (FY 2002) of BPDB and IPP System

Sl. No.	Name of Power Plant	Installed Capacity (As of June, 2002) (MW)	Fuel Type
A.	**BPDB System:**		
1	Karnafuli Hydro (2×40 MW+3×50 MW	230.0	Hydro
2	Ashuganj 2×64 MW Steam Turbine	128.0	Gas
	Ashuganj 3×150 MW Steam Turbine	450.0	Gas
	Ashuganj Combined Cycle	146.0	Gas
3	Shahjibazar Gas Turbine (7 Units)	96.0	Gas
	Shahjibazar Gas Turbine (2 Units)	70.0	Gas
4	Sylhet 1×20 MW Gas Turbine	20.0	Gas
5	Fenchuganj Combined Cycle	90.0	Gas
6	Ghorasal 2×55 MW Steam Turbine	110.0	Gas
	Ghorasal 4×210 MW Steam Turbine	840.0	Gas
7	Siddhirganj 1×50 MW Steam Turbine	50.0	Gas
8	Haripur Gas Turbine (3 Units)	99.0	Gas
9	Sikhalbaha 1×60 MW Steam Turbine	60.0	Gas
	Sikhalbaha 2×28 MW Barge Mounted GT	56.0	Gas
10	Rauzan 2×210 MW S/T	420.0	Gas
11	Khulna 1×110 MW Steam Turbine	110.0	F. Oil
	Khulna 1×60 MW Steam Turbine	60.0	F. Oil
	Khulna 2×28 MW BMPP	56.0	SKO
12	Baghabari 71 MW Gas Turbine	71.0	Gas
13	Baghabari 100 MW Gas Turbine	100.0	Gas
14	Bheramara 3×20 MW Gas Turbine	60.0	HSD
15	Thakurgaon 4×1.5 MW Diesel	4.5	LDO
16	Saidpur 2×3.75 MW Diesel	3.5	F. Oil
	Saidpur 20 MW Gas Turbine	20.0	HSD
17	Barisal 2×20 MW Gas Turbine	40.0	HSD
	Barisal Diesel (9 units)	2.5	HSD
18	Rangpur 20 MW Gas Turbine	20.0	HSD
19	Bhola Diesel	7.5	F. Oil/HSD
	Total Installed Capacity of BPDB System	**3,420.0**	
B	**IPP System**		
1	Haripur BMPP	110.0	Diesel
2	Haripur Combined Cycle (AES)	360.0	Gas
3	Khulna Power Co Ltd.	110.0	Diesel
4	Baghabari (Westmont)	90.0	Gas
5	Rural Power Co., Mymensingh	140.0	Gas
	Total IPP System	**810.0**	

1.12 Load Demand

The country's generating plants have been chronically deficient to meet system demand over the past decade. With only around **30%** of the country's population having access to electricity and with power demand growing rapidly (**10%** annually from 1974-1994; **7%** annually from 1995-1997), Bangladesh's Power System Master Plan (PSMP) projects a required doubling of generating capacity by 2010. Total investment required for this increased capacity is estimated at $4.4 billion through 2005. In addition, Bangladesh may also need to replace **30%-40%** of its current generating capacity due to ageing infrastructure.

1.12.1 Maximum Demand of FY 2002

The maximum demand of 3,218 MW was met by Bangladesh system during FY 2002 on June 18, 2002 at 19:30 hrs.

1.12.2 Share of Generation in Meeting Maximum Demand of FY 2002

The share of generation in meeting the above demand of 3,218 MW during FY 2002 is shown below in Table 1-4.

Table 1-4 Share of Generation in Meeting Maximum Demand during FY 2002.

Serial No	Type of Plant	Total Installed capacity including IPP (MW)	Share of Generation in meeting Maximum Demand during FY 2002 (MW)	Share in Percentage in meeting Maximum Demand
1	Steam Turbine	2,228	1,789	55.59
2	Combined Cycle	596	469	14.57
3	Hydro	230	177	5.50
4	Diesel	238	222	6.90
5	Gas Turbine	938	561	17.43
	Total=	**4,230**	**3,218**	**100.00**

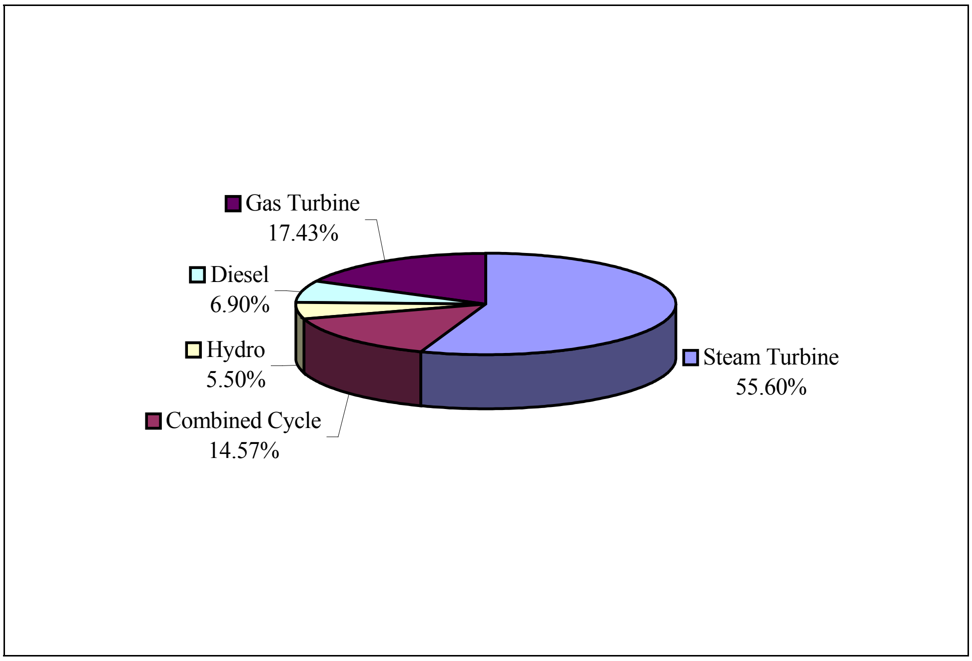
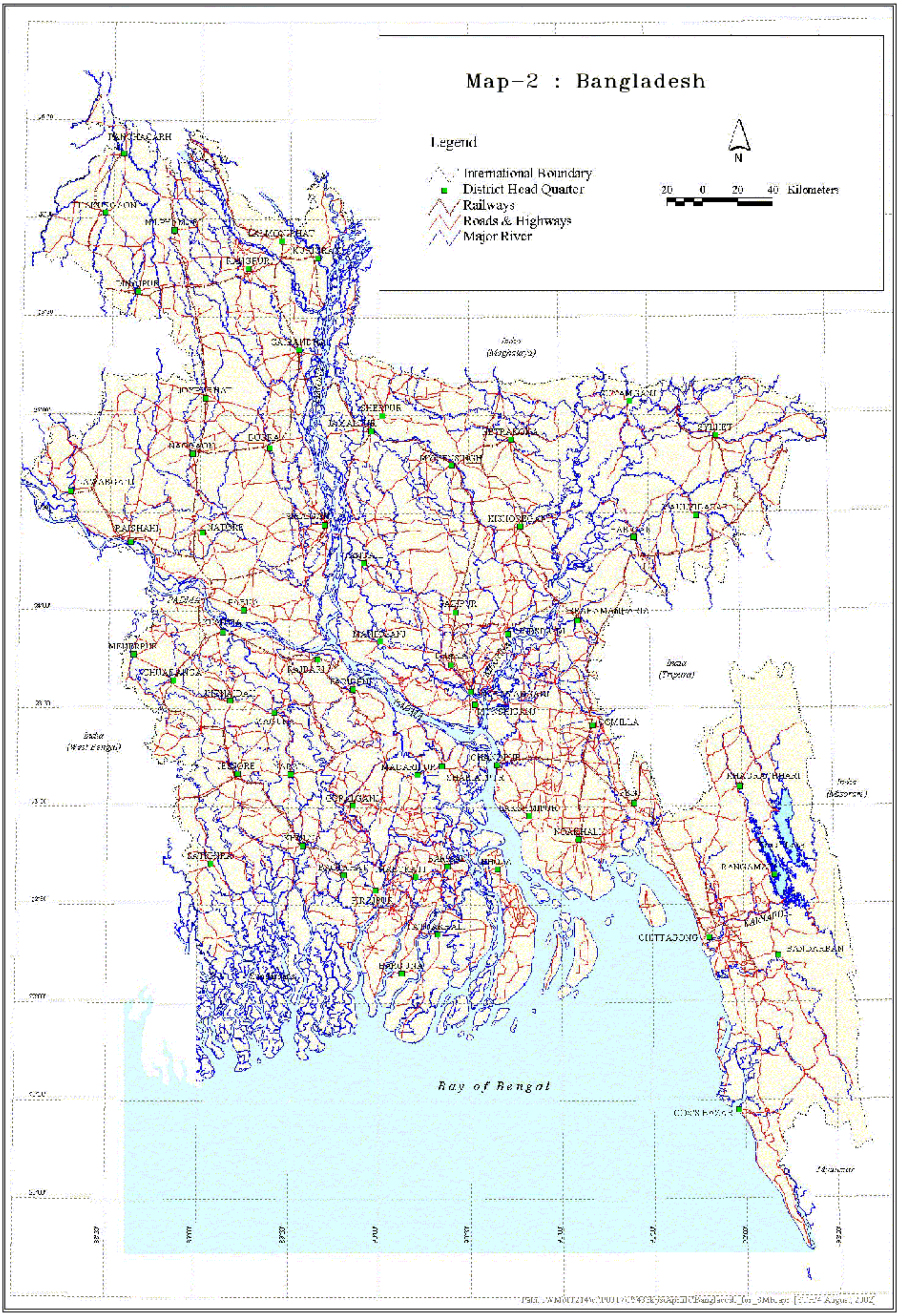


Figure 1-1: Sharing of Generation in meeting Maximum Demand of FY 2002


Map-1 : Map of the Region
Showing Bangladesh
in green color
JAMMU &
KASHMIR
PAKISTAN
HIMACHAL PRADESH
PUNJAB
CHINA
HARYANA
Delhi
NEPAL
RAJASTHAN
UTTAR
PRADESH
SIKKIM
BHUTAN
ASSAM
NAGALAND
BIHAR
MEGHALAYA
BANGLADESH
MANIPUR
JHARKHAND
TRIPURA
GUJARAT
MADHYA PRADESH
WEST
BENGAL
MIZORAM
CHHATTIS-
GARH
ORISSA
MYANMAR
MAHARASTRA
ARABIAN
SEA
BAY OF BENGAL
ANDHRA
PRADESH
GOA
KARNATAKA
PONDICHERRY
LAKSHADWEEP
SRI
LANKA


Map–2 : Bangladesh
Legend
International Boundary
District Head Quarter
Railways
Roads & Highways
Major River
20 0 20 40 Kilometers
N
Bay of Bengal

The Advisory Meeting on Hydro-power Rehabilitation of Hydro Plants in SARI region held in Sri Lanka has recommended a list of prioritized issues needing to be addressed in regional context. In order to address the issues raised in the workshop, particularly (i) evaluation of unique economic and other benefits of a hydro-power project from the regional perspective and develop a pricing mechanism of hydro-power (ii) develop a Regional Master Plan for exploitation of hydro-power resources and (iii) a Regional Least Cost Generation Expansion Plan, a comprehensive and authentic documentation of Regional Hydro-power Resources, the present status of its development, hydro-power development policies adopted and issues and barriers perceived by the partner countries in the development of hydro-power will be needed.

Section 3 Objective of the Report

The main objective of the current report relating to the Study on Hydro-power Resources, its status of development and barriers in the Region is to provide to SARI/Energy a Comprehensive and Authentic Reference Document, compiling profile of the regional hydro-power resource development potential (including parameters of all the identified projects), the present status of the utilization of hydro-power resources, the future hydro-power development plan(s), policies currently followed for the hydro-power development and the problems and issues as perceived in the partner countries.

In order to achieve the above objective, the following tasks need to be accomplished.

(i) Collection of all the relevant published information ("Secondary Data") from the partner countries.

(ii) Completion and analysis of the data and normalization for consistency. It is recognized that published information originates from various sources and is often conflicting. Hence a thorough check is needed to authenticate the information.

(iii) Development of a common system to present the entire database regarding the potential, status of present utilization and future development plans of hydro-power resources of the partner countries.

(iv) Compile Summary of the current hydro-power development policies of the partner countries.

(v) Identification of the issues and barriers for the development of hydro-power in the partner countries.

4.1 General

The following Reference Codes have been used in the report for identification of the Selected Secondary Data (SD).

- Bangladesh is designated as : 1 - BAN / SARI
- Bhutan is designated as : 2 - BHU / SARI
- India is designated as : 3 - IN / SARI
- Nepal is designated as : 4 - NEP / SARI
- Sri Lanka is designated as : 5 - SL / SARI

Further, the "Country Code and Report Reference" has been designated by a 4-digit number. The first digit denotes the Country; for example: 1 represents Bangladesh; 2 represents Bhutan; 3 represents India; 4 represents Nepal; and 5 represents Sri Lanka. The last three digits represent the Serial Number of the Report. The "Status" of each Report has been designated either as "draft", or "published" or "internal" as the case may be.

4.2 Data for Bangladesh

In accordance with the above criteria, the Resources Data Base are listed below:

Serial No	Country Code and Report Reference	Title	Author	Agency	Year	Status
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1	1001-BAN/ SARI	Bangladesh Gazette on Policy Guideline for Small Power Plant (SPP) in Private Sector	Govt of Bangladesh	MEMR	December, 2000	Published
2	1002-BAN/SARI	The Feasibility Study on Kaptai Hydro-electric Power Extension (Unit No 6&7) Project	Japan External Trade Organization (JETRO)	Ministry of International Trade & Industry, japan	March, 2000	Internal
3	1003-BAN/SARI	Proceedings Workshop on Prospects of Small Hydropower Generation in Bangladesh	Centre for Energy Studies, BUET	Bangladesh University of Engineering & Technology (BUET) Dhaka	May, 1998	Published
4	1004-BAN/SARI	Bangladesh Gazette on Private Sector Power Generation of Bangladesh	Govt of Bangladesh	Ministry of Energy & Mineral Resources (MEMR)	December, 1996	Published
5	1005-BAN/SARI	Bangladesh Gazette on National Energy Policy	Govt of Bangladesh	Ministry of Energy & Mineral Resources (MEMR)	January, 1996	Published
6	1006-BAN/SARI	Power System Master Plan Bangladesh Main Report	Directorate of System Planning BPDB and Acres Int'l Limited	Bangladesh Power Development Board (BPDB)	August, 1995	Internal
7	1007-BAN/SARI	Power System Master Plan (1985-2000) Main Report	BPDB Power System Master Plan cell and Acres Int'l Limited.	Bangladesh Power Development Board (BPDB)	February, 1985	Internal
8	1008-BAN/SARI	Sangu Multi-Purpose Project Feasibility Report.	Sandwell and Co. Canada	Govt. of Canada	January, 1965	Internal
9	1009-BAN/SARI	Master Plan, Supplement D, (POWER)	International Engineering Co, Inc, USA	East Pakistan Water and Power Development Authority	December, 1964	Internal

5.1 Background

The Karnafuli Project, popularly known as Kaptai Project is the only hydro-power station commissioned and operating in Bangladesh. The Hydro Station is located on the river Karnafuli, about 70 km upstream of Chittagong City.

Records show that studies of hydro-electric developments at various dam sites on the Karnafuli River had been made since 1906. In 1954, International Engineering Co Inc. (IECO) of USA entered into a contract for providing engineering services in the development of a hydro-power plant in the Karnafuli River Basin. Field investigations by IECO examined and verified all previous studies, records and drawings and found out that the Kaptai site was the most logical location for the project, both from economic as well as from design points of view. On finalization of the project design by IECO, the construction of the project was started from October 1957. Messrs. Utah International of USA was engaged as the construction and installation contractor. The project comprised 2 × 40 MW vertical shaft hydro turbine-generators (Kaplan turbine) with all appurtenances, an earth-filled dam, a concrete spillway, intake structures for 3 units including the steel-lined penstock for the future 3rd unit, 132 kV switchyard, an overhead cargo transfer system, a permanent diversion tunnel, 132 kV transmission lines etc. The project was completed by end of December 1961 and the two 40 MW hydro-turbine-generating units were commissioned in January and February 1962 respectively. The third unit (1 × 50 MW) also of Kaplan type was commissioned in January 1982.

5.2 Further Potential of Karnafuli River Basin

After completion of the first phase of the project, namely Unit No. 1 & 2 and during early years of operation, it was observed that (i) submergence of the lake was larger than expected, and that (ii) the draw-down of reservoir water level due to operation of power station was lower. This prompted the authorities concerned to start investigations toward addition of further units. At the request of the then Government of Pakistan, the Japanese Government granted a technical assistance against OTCA program in 1969 to conduct a reservoir survey. On the basis of this survey and also LANDSAT report later on, it was ascertained that the reservoir capacity was at least **25%** more than originally computed by Messrs. IECO during first phase of construction. Subsequently, upon request from the Government of Bangladesh, Japan International Co-operation Agency, JICA (formerly OTCA) conducted a study on the same aspect in 1980 and updated the feasibility study of 1969. The latest study indicated that by utilizing the high reservoir capacity and inflow, more generation could be achieved. It was computed that by utilizing **90%** of inflow in an average year, about 1089 million kWh could be generated yearly. Based on these studies it was recommended that two (2) additional units (No. 4 & 5) be installed which, in addition to incremental energy, would add to peaking capacity of the plant.

Messrs. Tokyo Electric Power Services Co. Ltd (TEPSCO), Japan was engaged as the consultant for this third phase of construction of Kaptai Hydro. They made additional studies on unit size and head and on the basis of their findings, BPDB decided in 1982 to install 2 × 50 MW Kaplan type adjustable blade water turbines having a design head of 25.908 m.

The site selected for installation of the turbines is about 150 meters upstream of unit 1,2 & 3 power plant. Intake structure was located adjacent to the old intake structure but separately and at almost 90^0 alignment to the previous one. A new 132 kV switchyard was constructed near the old one and both the bays were interconnected. Two 132 kV transmission lines were constructed between Kaptai and Hathazari to transfer the additional power from the new units. Along with the units, a new cargo transfer system was constructed to replace the old one which became obsolete and unworthy of future use. Along with these units, a microwave monitoring system of daily rainfall from several monitoring stations over the lake area was also installed and commissioned.

The work of construction of Unit No. 4 & 5 started in 1984. Total erection, testing and commissioning of the two units were completed by December, 1987. Unit No. 4 was commissioned on January 11, 1988 and Unit No. 5 on February 11, 1988. On completion and commissioning of these two units the total generating capacity of Kaptai Hydro-electric power plant rose to 230 MW.

5.2.1 Change of Maximum Reservoir Level

While the first phase of Kaptai Hydro (Unit No. 1 & 2) was under construction, then Government of Pakistan decided in May 1960 to incorporate design changes in the project, which would permit raising the reservoir level by 13.0 ft. (3.962 m.) at some future date. After a study of the physical limitations of the project site and the adaptability of the major equipment which, had, at that time, already been purchased, it was determined that the normal maximum reservoir height should not be greater than Elevation 122.0 ft. (EL.37.186 m MSL). The required engineering investigations were performed and some of the structures and equipment modified accordingly. The dam height was not, however, raised but necessary design was provided so that if decision is taken at a future date the dam height could be raised to match the reservoir operation at Elevation 122.0 ft. (EL.37.196 m MSL).

5.2.2 Previous Study and Work

It is already stated that studies of hydro-electric developments at the Karnafuli River Basin dated back to 1906. The earliest study was conducted in 1906-07 but the results were inconclusive. The next study was made in 1922-23. A development of Barkal Dam site upto an Elevation of 122.8 ft. (37.429 m MSL) was recommended but this was not accepted by the concerned authorities. In 1946, while the British was still in power in India, Mr. E. A. Moore, Superintending Engineer prepared a report on a multipurpose development at Barkal Rapids, 18 miles from the present Indian border, for the generation of hydro-electric power, flood control and river improvement with respect to navigation between Barkal and Chittagong.

5.2.2.1 Investigation Subsequent to 1947

Merz Rendel Vatten (Pakistan), Consulting and Designing Engineers, issued a report in 1950 which presented the results of investigations of the Barkal Rapids and Chilardak Damsites. The latter site is situated about nine miles upstream from Rangamati.

The Barkal site was not adopted due to the small storage available with the maximum reservoir elevation limited by considerations of back-water on lands in India.

A plan was presented for the development of the Chilardak site, which was investigated in considerable detail. This proposed scheme included a concrete buttress dam with a maximum height of about 160 ft, a four unit powerhouse with an ultimate installed capacity of 40,000 kW, and an outdoor switching station. The average output of the plant was estimated to be

20,000 kW during the dry season of a dry year. At an assumed load factor of 0.50, the plant was estimated to generate 175,000,000 kWh in an average year and 270,000,000 kWh in a maximum power year. The plan, as presented for the development of the Chilardak site, was not, however, adopted by the Government of Pakistan.

After the issue of the Merx Rendel Vatten (Pakistan) 1950 report, the Government of Pakistan, through its Irrigation Branch of the Communication, Building and Irrigation Department, undertook a study to determine the best plan suited to the optimum development of the Karnafuli River. As a result of this study, it was concluded that such a plan should involve the development of a site in the farthest downstream location with an acceptable foundation, and where the topography would allow the economical development of the total storage volume available at a maximum reservoir elevation permissible with respect to backwater at the international boundary. In addition, the site topography should be adaptable to the location of the major features such as the dam, powerhouse and spillway and should be reasonably close to a source of construction materials.

Due to its flat gradient, it was apparent that there could be only one economical project development on the Karnafuli River. The portion of the river downstream of any site selected, would have an insufficient drop to justify the development of second hydro-electric project. Thus, the importance of the selection of a site farthest downstream became apparent.

Consequently, the Chitmaran site was investigated in 1950-1951 by the Government engineers. It is located between the towns of Chitmaran and Chandraghona, near the village of Silchari. Although the location of the site was satisfactory with respect to river control and reservoir development, there were several undesirable aspects which eliminated its further consideration. The site topography did not permit a favorable location of the main project features; foundation conditions were unfavourable, and the reservoir would flood valuable teak wood forests, tea gardens and a Buddhist Temple. This temple and its adjoining shrine are of special religious significance to the peoples of the Chittagong Hill Tracts, the Lushai Hills in India, and areas in Burma. In consideration of the above conditions, the Chitmaran site was not adopted by the Government engineers.

The next investigations, which were made in 1951 under the supervision of Mr. K. Azeemuddin, Chief Engineer, Irrigation Branch, Communication, Building and Irrigation Department, centered on the Kaptai site. This is located in the Silchari range about 3.2 miles upstream of the village of Kaptai. It is far enough upstream of the Chitmaran site to eliminate flooding of the teakwood forest, tea gardens and the temple.

A favourable report was issued in December 1951, based on a tentative layout of the site. Although one less tributary enters the Karnafuli River at this site than at the Chitmaran site, other features, as discussed below, proved the suitability of the Kaptai site.

The Karnafuli River travels in a long hairpin curve at the Kaptai site, and thereby forms a peninsula. The topography on this peninsula permits both an economical and a flexible arrangement of the main features. Although the foundation conditions at the site are only fair, proper design of the project will ensure safe and stable structure at an economical cost. Materials for use in the construction of an earth dam are available in ample quantities at the site.

Mr. A.V. Karpov, Consulting Engineer representing the United Nations Mission of Technical Assistance to Pakistan, reviewed the Kaptai development in the spring of 1952, and in June of the same year issued a report on the generation of power and an independent layout of the main features. He suggested a project which included the normal maximum reservoir at EL 106 ft. (EL. 32.309 m MSL), a powerhouse with a total installed capacity of 160,000 kW in four units, and an earth dam flanked on each side by a spillway. As a result of this report, construction of the main dam at the Kaptai site was started under the supervision of Mr. K. Azeemuddin.

Field investigations and design studies were also continued and were in progress when International Engineering Company Inc. personnel arrived at the project site in April, 1954.

5.2.2.2 Investigation by IECO, USA

On March 24, 1954, International Engineering Company Inc. (IECO) entered into a contract with the United States (represented by the Foreign Operations Administration) for the purpose of giving technical aid to the Government of Pakistan, now Bangladesh.

In broad terms, this contract included the collection of data, field investigation and surveys, engineering designs, estimates of costs and economic benefits, and an analysis of power requirements and markets in the region of East Pakistan, now Bangladesh.

Pursuant to the contract, a group of specialized engineers from International Engineering Company Inc., USA, made field visits to the Kaptai project site from April 5 to June 13, 1954, for the express purpose of making comprehensive investigations and studies.

Field investigations by International Engineering Company Inc. engineers verified the Kaptai site as being the most logical location for the project, both from economic and design points of view. However, a project layout different from what was proposed by other agencies was developed. The Project Circle Engineers had developed a layout which considered essentially of a main earth fill dam, a power house in the left abutment of the dam, a gated spillway to the left of the power house, an uncontrolled spillway to the right of the dam, and a flight of navigation locks downstream from the power house.

As a result of more extensive field investigations, which resulted in a better understanding of foundation conditions, International Engineering Company Inc. adopted the following preliminary layout.

The main dam and the gated spillway remained in the same location as before. The power house, however, was shifted to the right of the dam and the uncontrolled spillway eliminated. A gate-controlled diversion tunnel was added through the right abutment of the dam. The orientation of the navigation locks was slightly changed.

Preliminary studies presented in the Reconnaissance Report were concluded and finalized in the Master Report prepared by International Engineering Company Inc. in March 1955. The latter report consists of the following three volumes:

Volume-I “The Karnafuli Project and Power Survey with Economic Analysis”.

Volume-II “Karnafuli Project Specifications”.

Volume-III "Karnafuli Project Drawings".

Foundation investigations were continued. As additional information became available, it was found that changes in the details of the structures would be advantageous. Thus, the structures vary in the following respects from those shown in the Master Report:

(1) Main Dam- Location of axis was revised

(2) Spillway- Minor revisions were made to outlet channel and chute

(3) Powerhouse- The integral powerhouse and intake structure was changed to a powerhouse connected to a separate intake by penstocks.

(4) Outlet Works- The access shaft was relocated from the upstream end of the tunnel to a point about midway of the tunnel length.

(5) Navigation Locks- The navigation locks were eliminated for economic reasons and a monorail cargo transfer plant was substituted.

5.2.2.3 Study by OTCA, Japan

After completion of Kaptai Project (Unit No. 1 & 2) and upon commencement of reservoir operation, various facts came to the notice of the concerned authorities in charge of power plant operation, which brought into question the accuracy of the reservoir storage capacity used in planning the project. The authorities concerned, namely, Water and Power Development Authority (WAPDA) desired to check the Kaptai reservoir capacity and to undertake a Feasibility Study on extension of Kaptai Power Plant. On receiving an appropriate request through relevant government channel, the Government of Japan assigned the Overseas Technical Co-operation Agency (OTCA), Japan. OTCA entrusted Nippon Koei Co. Ltd, Consulting Engineers, Tokyo, Japan with the execution of the above job. OTCA also dispatched in 1969 an expert on aerial photo mapping in order to assist in the new mapping work. The first survey by the Japanese Team, consisting of topographical survey and geological survey and collection of data, was carried out from October 1967 to February 1968 and the second survey, comprising discussion with the concerned personnel in WAPDA and collection of new contour maps and other upto-date data, was carried out from August through September 1969. Based on the survey and collection of data during the study as mentioned above, OTCA submitted a formal report in March, 1970 with the following observations and recommendations.

The Kaptai reservoir is about **23%** larger than previously estimated. That means the storage of 4.25 million Acre-ft at EL 109.0 ft. (EL. 33.223 m MSL) shall be corrected to read 5.235 million Acre-ft.

By a study of the reservoir operation based on the new storage curve and a study of power market, it is concluded that the installation of additional 100 MW (Unit No. 4 & 5, namely, 2x50 MW) generating equipment is justified and that it is economically feasible. After the extension, the total installed capacity will become 230 MW (in 5 units) producing 907.6 GWh annually.

5.2.2.4 Study by JICA, Japan

Bangladesh emerged as a sovereign, independent country on 16 December 1971. So what was East Pakistan during OTCA study above (March 1970) became Bangladesh. In 1978 the Government of the People's Republic of Bangladesh requested the Government of Japan to review afresh the extension project recommended by OTCA, Japan (March 1970). Japan International Co-operation Agency was assigned to carry out the study on the following basis.

(i) Hydrologic analysis on available reservoir capacity

(ii) Power demand forecast

(iii) Power supply area from the hydro-power station

(iv) Optimum operation method of the reservoir

(v) Preliminary design structures

(vi) Approximation of construction cost

(vii) Outline of construction schedule

(viii) Economic and financial analysis

JICA entrusted Tokyo Electric Power Services Co. Ltd. (TEPSCO), Consulting Engineers, Tokyo, Japan with the execution of the above job.

This study is an extension of the study carried out by OTCA in 1969-70. JICA Team carried out field investigations in March 1980, carried out further studies and analysis in Japan and developed a plan for the project. The JICA Team again visited Bangladesh in August 1980 and held discussion with concerned personnel of Bangladesh Power Development Board (BPDB). Finally, the formal Feasibility Study Report was submitted in September 1980. The Report recommended implementation of 2 × 50 MW (Unit No. 4 & 5) in scale as indicated in OTCA's report (March 1970). The Units No. 4 & 5 were ultimately constructed and commissioned in 1988.

5.2.2.5 Preliminary Study by TEPSCO in 1986 for Further Extension of Karnafuli Hydro

TEPSCO in its Preliminary Study Report referred to the observations made in the First Power System Master Plan (1985) about the possibility of adding two more units each of 50 MW in rolling sequence with Unit No. 4 & 5 then under construction and stated that this Preliminary Study was aimed at confirming its economic feasibleness based on updated data available. During this study, the record generation data including the spilt water through the spillway during rainy season were collected for the period from 1980 through 1985. The economic feasibility was studied comprising the most competitive alternative power plant, say the gas-turbine power plant, in consideration of suitable peaking power plant. This study observed that after addition of Unit No. 4 & 5, the plant factor at Kaptai Hydro-power Plant became 0.54 during rainy season and 0.33 during dry season. It was stated in the study that after implementation of Units No. 6 & 7, 5.8 hour peaking operation at Kaptai in dry season could be ensured. The addition of Units No. 6 & 7 (2 × 50 MW) was hydrologically confirmed in terms of water resources of Kaptai reservoir.

5.2.2.6 Feasibility Study by TEPSCO in 1998 for Kaptai 6TH & 7TH Units Extension Project

In the above background, TEPSCO received BPDB's invitation letter dated 11-08-98 to permit to survey Kaptai existing power station for the proposed Feasibility Study of additional units (6th & 7th Units).

TEPSCO sent a team of engineers to carry out detailed field investigations. Finally, a formal report was prepared and submitted to BPDB in October 1999. TEPSCO subsequently supplemented the Report and furnished additional/revised data to BPDB in March 2000. Following the above FS Report, BPDB moved through the Government channel to the Government of Japan seeking project finance. At this stage, discussions were held between BPDB and OECF (JBIC) as to how the implementation schedule could be shortened. Loan Agreement for implementation of the extension project is awaited.

5.3 Potential of Sangu River Basin

The three major river systems in Chittagong Hill Tracts, namely, the Karnafuli, the Sangu and the Matamuhuri Rivers drain the Hill Tracts and in the case of the Karnafuli River, part of India. (Ref: Map-3, Chittagong & Hill Tracts; Hydro-power Potential in Bangladesh). The Sangu and Matamuhuri Rivers, illustrated in above-stated Map-3 are the only major river systems which have their entire drainage basin within the boundaries of Bangladesh. All the above-mentioned three rivers flow out of the Hill Tracts and across the coastal plain to empty into the bay of Bengal.

5.3.1 Sangu River Valley

The Sangu River drains an area of 955 square miles almost entirely within the Chittagong Hills. The river, whose location is shown in Map-3 flows from the hills then across an alluvial coastal plain and empties into the Bay of Bengal about 14 miles south of the port of Chittagong.

The river provides the most convenient access route for the inhabitants of the drainage basin; but navigation during the lowest river stages becomes restricted by the numerous sandbars to local shallow draft boats and during the highest river stages it is again restricted by the floating debris of the monsoon flood water. Two roads shown in Map-4 (Blow out of the Sangu River Basin) lead to Bandarban, the major village of the Sangu Valley about 25 miles inland from the Bay of Bengal. These roads are passable, preferably with four-wheel drive vehicles, in the dry season and then only following annual repairs to the roadbed made necessary by the destructive monsoon rains. One road branches eastward from the Arakan Road at Kerani Bazar and follows the south side of the River. The other crosses the divide between the Sangu and the Karnafuli Rivers, commencing on the south bank of the Karnafuli River at Chandraghona and terminating on the north bank of the Sangu River opposite Bandarban.

The inhabitants of the Sangu Valley and its tributaries are the tribal people of the Chittagong Hill Tracts; the principal tribes being the Chakmas, the Moghs and the Tipperas. Their settlements are mostly along the river valleys and consist of clusters of typical bamboo house, each raised on stilts, a few feet above the ground. The village of Bandarban is the largest in the area and the tribal centre or seat of the Bomon Rajah, Chief of the Mogh Tribe.

The hills and mountains of the Hill Tracts are of geologically recent origin, consisting of soft sandstone, siltstone and shale of lower to Middle Miocene periods, overlaid by residual fine-grained soils. They form a maze of sharp, razor-backed ridges and intervening, "V" shaped ravines creating an intricate pinnate or demdritic drainage system.

The Sangu Valley, of course, is subject to the same weather systems of distinct wet and dry seasons as experienced generally across Bangladesh. The Hills, however, cause a local variation in the dry season when the valleys become filled with heavy, early morning mists. Earthquakes have been recorded in the Chittagong Hills and the area is considered moderately seismically active.

The resources of the Sangu Valley are the agricultural land, the forests and the river. The fields on the alluvial land along the river are cultivated in rice, tobacco, cotton and melons. The oldest and most extensive mode of agriculture, however, is Jhuming. The system involves the burning of all vegetation from the hillside during March and April, the end of the dry season. Then mixed seeds are planted on the burnt off area to sprout with the subsequent monsoon rains which also wash the ashes into the ground to act as a fertilizer for the plants. Once jhumed, a hillside must remain fallow for a period of at least seven years before its growing properties are restored. The forests contain bamboo, a variety of timber trees and tall grasses. At present bamboo, primarily for the construction industry, and grasses for thatching the houses of the Hills people are being harvested to some extent, but, with the construction of the Sangu Reservoir, the forests will become more extensively and economically productive. The river, an important resource is the chief transportation route; it supplies water for domestic purposes and is a source of fish.

5.3.2 Feasibility Study by Sandwell and Company, Canada

The Sangu Multipurpose Project Feasibility Study, authorized by the External Aid Office of the Government of Canada, under the auspices of the Colombo Plan, was carried out through investigation in the field and extensive engineering studies in the head office of Sandwell and Co., Canada, the Consultants. Sandwell called upon the professional services of a number of eminent consultants for collaboration as well as co-ordination of the various aspects of the study. Also, in the case of the study of the Irrigation works and Agricultural benefits, the services of Associated Consulting Engineers Ltd. were engaged, thus obtaining local impressions of a socio-economic problem. The study was carried out during 1962 to 1964. The results are summarized below:

The Sangu River drains a catchment area in the southeast region of Bangladesh. It flows from the Chittagong Hill Tracts across the alluvial coastal plain just south of the city and sea port of Chittagong. The proposed scheme of development envisages a 190-foot dam and power generation facility in the vicinity of Bandarban, a village in the Chittagong Hill Tracts, 28 miles southeast of Chittagong; a barrage with irrigation canal headgates, near Dohazari, a village on the coastal plain, 20 miles southeast of Chittagong; and an irrigation system commanding 100,000 acres of arable land on the coastal plain. This project will provide hydro-electric power, irrigation, flood control and improved navigation, as well as open extensive areas of forests within the Chittagong Hills.

The scope of the Sangu River Feasibility Study encompassed;

a. An extensive review of the hydrologic, geologic and topographic data; collection and interpretation, through surveys and exploration, of additional data; and investigation through engineering studies of the feasibility of hydro-electric power generation with irrigation and agricultural development and the economic alternatives to such schemes;

b. An extensive study into the quantity of water available in the Sangu drainage basin, its regulation and optimum use for power and irrigation;

c. A study of the possible additional supplies of water from adjacent drainage basins and whether diversion from these, the Rankhiang and the Matamuhari, is economic;

d. An extensive investigation into the requirements for an irrigation canal system which would command a maximum section of the arable coastal plain, and the location and size of major canals and structures;

e. An extensive sample study into the conditions existing in the agricultural and sociological life of the coastal plain, evaluation of the probable limitations to the agronomic and humanistic elements, and prediction of an increased productivity through improved culture, technology and methods of farming coupled with the controlled application of water made possible by the Irrigation System ; and

f. An appraisal of the benefits derived through flood control and improved drainage in the areas of the Coastal Plain which comes within the influence of the Sangu River.

This study, based on the data available, indicated that at a dam site on the Sangu River, four miles upstream of the village of Bandarban, in the vicinity of its confluence with the Terasa Chara, it is technically feasible and economically practicable to construct a Storage Dam and Hydro-electric Power Development. The only element of uncertainty that exists for the above development is that additional records must be obtained to substantiate the estimated life expectancy of the proposed storage reservoir; at present estimated to be not less than one hundred and fifty years. A brief description of the proposed system is given in the following paragraphs.

The proposed Tarasa Chara Powerhouse contains three Francis-type reaction turbines of 45, 600 HP design capacity (full gate, design head) coupled to conventional generators of 27.5 megawatts (rated capacity) having 85 percent power factor, 32,400 kVA and 13.8 kV which provide annual primary peaking energy of 228. 6×10^6 kilowatt-hours at a 33.3 percent Plant Factor with an additional annual secondary energy of 124.4×10^6 kilowatt-hours. This energy is carried by nominal 132 kV transmission lines and tied to the Dhaka-Karnafuli grid at Madanhat.

The regulated water then flows from the Tarasa Chara Development downstream and is retained in the tailwater pond by the Dohazari Barrage, two miles upstream of the village of Dohazari in the vicinity of the confluence of Lalutia Chara, where a portion of the flow is diverted to the Irrigation System while the surplus water is passed through the Dohazari Powerhouse. This powerhouse contains two 2.2 megawatt bulb-type propeller turbine-generator units which provide 18.7×10^6 kilowatt-hours of annual primary energy with an additional 7.1 $\times 10^6$ kilowatt-hours of annual secondary energy. This energy is tied to the same transmission lines and thus applied to the Dhaka-Karnafuli Grid.

The indicated Benefit-Cost relationship for hydro-electric peaking power of the Sangu Multipurpose Project when the net annual cost is compared with the value of the equivalent block of power for the most economic alternative is 2.11 to 1.

The waters diverted to the Irrigation System enter three primary canals which regulate the flow, pass it to the secondary channels and eventually distribute it to the cultivable portion of a 114,900 acre Command Area. The Command Area, divided by the Sangu River, contains to the north 56,120 acres and to the south 23,880 acres of cultivable land fully protected from flood waters and the sea. An additional 11,910 acres lie between the Sangu River and the protective embankments of the irrigation canals and, therefore, will be subjected to periodic inundations by the flood waters of the river. The natural khals of the area are widened, deepened and embanked to form a greatly improved drainage system to move the storm water off the land as rapidly as practicable.

The agricultural aspects of the Command Area were assessed and a pattern of systematic development established. This development included consolidation of the small land holdings, addition of fertilizers and lime to the land, rotation of the crops, change from monocultural to multicultural cropping, improvements in farm implements and utilization of labour, development of better seeds and utilization of insecticides.

The indicated Benefit-Cost relationships for the combined Irrigation System and Agricultural Development are: for the "Optimum" program 3.79 to 1 and for the "Practical" program 1.35 to 1.

Although full flood protection was not provided, it is extensive enough to establish a Benefit-Cost relationship of 2.43 to 1.

In addition, the project provided improved navigation on the Sangu River from the Bay of Bengal to a point 130 miles inland. This waterway opened to development the untapped forests of the Sangu drainage basin by providing convenient access. New industries might be expected to move into the area; i.e. sawmills, logging operations, bamboo harvesting, fruit orchards, farming, ranching, canning, packing, etc.

The vast lake covering some 60 square miles, stocked with fish, would support a very large commercial fishing industry and with power nearby, a small cannery and packing house might also be economic. In addition, private fishing by the local inhabitants as a source of food, as well as sport fishing by the tourist and vacationing public would develop.

Other small secondary industries would be located near the source of power, raw materials and economic transportation. Also, the hill country would be opened to improved agriculture with the result that orchards and a fruit canning industry will be feasible.

The Sangu Multipurpose Project is considered a very worthwhile project and will provide needed peaking power, increased agricultural produce, protection of the coastal plain from flood waters, improved navigation and many additional benefits. The scheme is, therefore, considered desirable. It is also considered economically attractive and technically feasible.

5.3.3 Development Since Creation of Bangladesh

Bangladesh came into existence after a 9-month's armed liberation war in 1971. There had been socio-politico events in mid-70's, which did not provide a congenial climate for pushing this project. The situation still remains unchanged.

5.4 Potential of Matamuhari River Basin

Sandwell and Company, Canada during their Feasibility Study of Sangu River Basin during 1962 to 1964 carried out preliminary study on possible diversion from the Matamuhari River. Sandwell thought that diversion of the water from one drainage basin to the other would be desirable if one of the proposed reservoirs had a storage capacity in excess of the average inflow.

Comprehensive investigations into the hydrology, drainage basin, reservoir area-volume relationship and possible damsites were performed; but, because topographic mapping was not available in the critical areas of the proposed control-structure sites, it was impossible to perform a feasibility study comparable to that of the Sangu Multipurpose Project. Considerable work and investigation, though, was done which resulted in the establishment of a number of qualified conclusions. These are:

a. Further investigation of the Matamuhari River for the generation of hydro-electric power is justified,

b. Hydro-electric peaking power appears to be economic,

c. Additional hydrologic and geologic data is required, and

d. Adequate topographic mapping is not available and therefore, must be obtained before further investigations are commenced.

It is indicated that the Matamuhari Reservoir may be considerably larger than the Sangu Reservoir resulting in the possibility that water could be diverted to storage from the Sangu to the Matamuhari reservoirs during monsoon periods. If this proves economic it would result in smaller water wastage and a consequent increase in generated energy.

5.5 Potential of the Brahmaputra River

The proposed Old Brahmaputra Multi-Purpose Project, located in the Mymensingh District, was investigated by IECO, USA while formulating the Master Plan in 1964(Ref: 1009-BAN/SARI) and found to be economically feasible. Plans included construction of a hydroelectric plant having five 8 MW units about 10 miles northwest of Mymensingh. Development of the project was divided into three consecutive phases. For each phase, the report shows total annual energy production of 277.7, 266.9, and 234.0 MkWh respectively. Maximum power development for each phase is estimated as 34.1, 33.3, and 32.2 MW, respectively. Similarly minimum power output is shown as 27.9, 25.8, and 21.4 MW, respectively. Since the tailwater is high in the summer period, minimum power output would occur during this time, Maximum output would be available in the winter period.

The only other hydroelectric power installation site considered in the Master Plan of 1964 (Ref: 1009-BAN/SARI) was in connection with the Brahmaputra Barrage Project, tentatively located just upstream from Bahadurabad in the Mymensingh District. A very preliminary investigation had developed the following scheme.

Phase one contemplated four hundred 2.5 MW tubular seperating units installed in the spillway, aggregating 1,000 MW power output. The ultimate installation would add 300 MW. The firm continuous power for the ultimate installation would amount to 400 MW or 3,500 MkWh per year. Annual secondary power would amount to 2,700 MkWh for phase one and 800 MkWh for future additions, totaling 3,500 MkWh for the ultimate installation. These tentative figures are provided to indicate the large size of the project.

5.6 Further Study Since Creation of Bangladesh

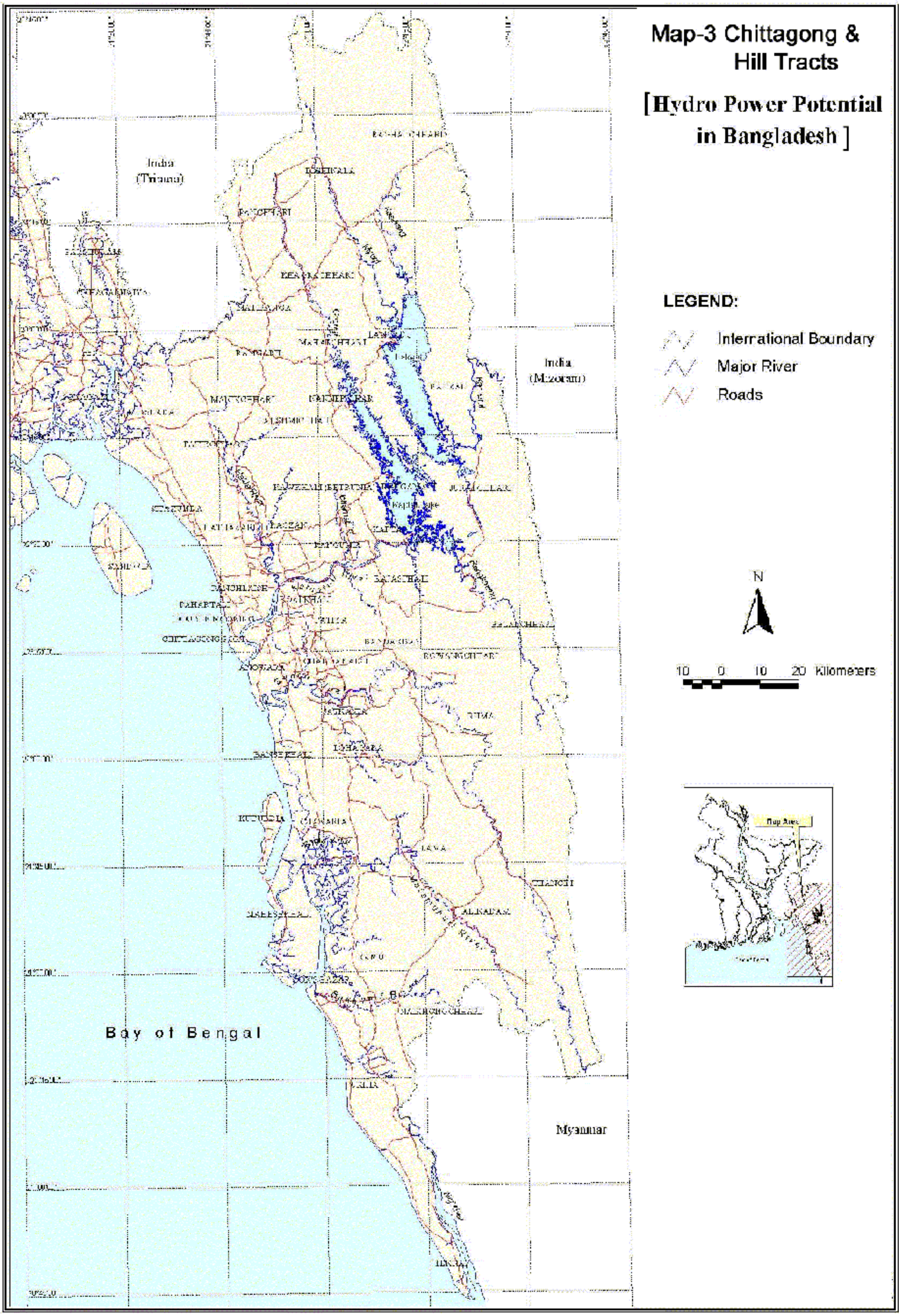
No further study has been carried out since liberation of Bangladesh in 1971. In view of increasing demand for power in the country, it is considered necessary that hydro-power potential of the Sangu and the Matamuhari as well as the Brahmaputra River Basins, being sources of renewable energy, be given priority for their development.

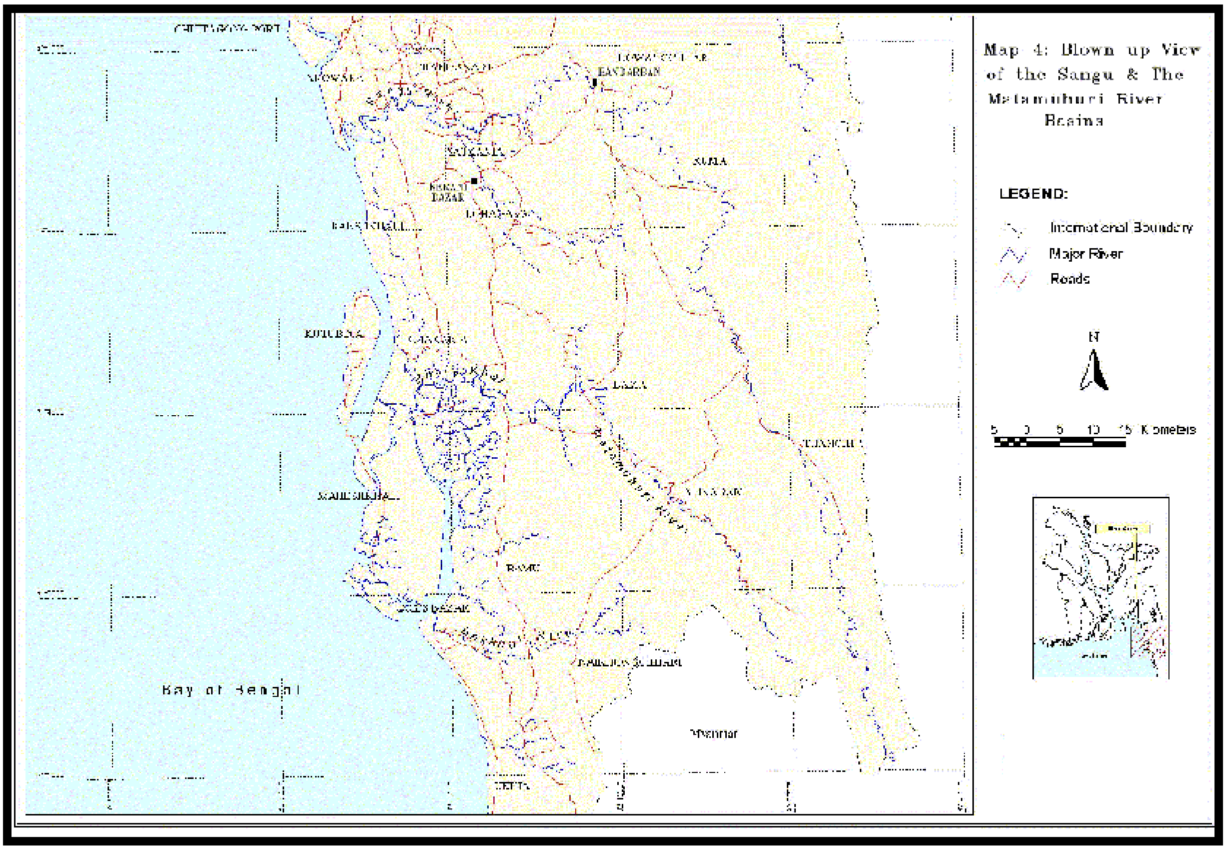
5.7 Total Hydro-power Potential in Bangladesh

Based on the foregoing descriptions, the total hydro-power potential may be summarized below in Table 5-1: Hydro-power Potential in Bangladesh.

Table 5-1: Hydro-power Potential in Bangladesh

Serial No.	Description	Potential in MW	Already Harnessed in MW	Balance MW
(1)	(2)	(3)	(4)	(5)
1	The Karnafuli River Basin	330	230	100
2	The Sangu River Basin	87	-	87
3	The Matamuhuri River Basin	80	-	80
4	The Brahmaputra River Basin (a) Multi-purpose Project (b) Barrage Project	 100 1,300	 - -	 100 1,300
	Total=	**1,897**	**230**	**1,667**


Map-3 Chittagong & Hill Tracts
[Hydro Power Potential in Bangladesh]
LEGEND:
International Boundary
Major River
Roads
N
10 0 10 20 Kilometers
India
India (Mizoram)
Myanmar
Bay of Bengal


Map 4: Blown up View of the Sangu & The Matamuhuri River Basins
LEGEND:
Major River
Roads
N
Bay of Bengal
BANDARBAN
RAMU
LAMA

6.1 General

It is stated in foregoing Section-5 of this Report that the Karnafuli Project, popularly known as Kaptai Project, is the only hydro-electric power plant in Bangladesh. A brief description of Kaptai Hydro is given in foregoing Section-5.

6.2 Karnafuli Project

The relevant data on current hydro-power utilization in Bangladesh, namely, Karnafuli Project are furnished below in an approved format.

Table 6-1: Relevant Data on Current Hydro-power Utilization

Sl No.	Project Name	Owner	Year of Install-ation	Out put		Reservoir		Type	Possible Reno-vation, Moder-nization and up-grading
				MW [State Unit size and No of Units]	Annual Energy In MU (Million kWh)	Capacity (MCM)	AREA (Km^2)		
1	2	3	4	5	6	7	8	9	10
1.	Karnafuli Project	Bangladesh Power Develop-Ment Board (BPDB)	1962 1982 1988 1988	Unit # 1: 40 MW Unit # 2: 40 MW Unit # 3: 50 MW Unit # 4: 50 MW Unit # 5: 50 MW	Please See Section 6.1.1	6,460.0	780	Pondage	Please See Sections 6.2 & 6.2.1

6.2.1 Annual Generation Figures

The year-wise generation figures of the 5 units, now in operation are given below. It may be recalled that Unit Nos. 1 & 2 came into operation in early 1962 while Unit No 3 was commissioned in early 1982. Unit Nos. 4 & 5 was commissioned in early 1988.

Table 6.2: Year-Wise Generation Figures of the 5 Units

Year	Generation in MkWh					
	Unit No 1 (40/46 MW)	Unit No 2 (40/46 MW)	Unit No 3 (50 MW)	Unit No 4 (50 MW)	Unit No 5 (50 MW)	Total
1	2	3	4	5	6	7
1962	✓	✓	-	-	-	176.434
1963	✓	✓	-	-	-	222.244
1964	✓	✓	-	-	-	337.024
1965	✓	✓	-	-	-	403.192
1966	✓	✓	-	-	-	450.946
1967	✓	✓	-	-	-	509.644
1968	✓	✓	-	-	-	604.934
1969	✓	✓	-	-	-	552.501
1970	✓	✓	-	-	-	394.687
1971	✓	✓	-	-	-	184.331
1972	✓	✓	-	-	-	299.973
1973	✓	✓	-	-	-	262.525
1974	✓	✓	-	-	-	351.674
1975	✓	✓	-	-	-	472.029
1976	✓	✓	-	-	-	446.760
1977	✓	✓	-	-	-	483.227
1978	✓	✓	-	-	-	568.313
1979	✓	✓	-	-	-	563.106
1980	✓	✓	-	-	-	557.399
1981	✓	✓	-	-	-	654.557
1982	✓	✓	✓	-	-	487.062
1983	✓	✓	✓	-	-	928.760
1984	✓	✓	✓	-	-	818.645
1985	✓	✓	✓	-	-	618.371
1986	✓	✓	✓	-	-	383.385
1987	✓	✓	✓	-	-	554.416
1988	✓	✓	✓	✓	✓	1001.786
1989	✓	✓	✓	✓	✓	738.879
1990	✓	✓	✓	✓	✓	822.683
1991	✓	✓	✓	✓	✓	935.516
1992	✓	✓	✓	✓	✓	582.972
1993	✓	✓	✓	✓	✓	867.575
1994	✓	✓	✓	✓	✓	491.750
1995	✓	✓	✓	✓	✓	607.389
1996	✓	✓	✓	✓	✓	679.967
1997	✓	✓	✓	✓	✓	722.901
1998	✓	✓	✓	✓	✓	864.621
1999	✓	✓	✓	✓	✓	832.850
1999-2000	✓	✓	✓	✓	✓	1,027.397
2000-2001	✓	✓	✓	✓	✓	971.096

2001-2002	✔	✔	✔	✔	✔	687.790

6.3 Possible Renovation, Modernization and Upgrading

Unit No. 1 and Unit No. 2 of Karnafuli Hydro Plant which were commissioned in 1962 were subjected to rehabilitation/renovation under a loan agreement reached between the World Bank and Bangladesh with relending terms to Bangladesh Power Development Board (BPDB), the owner of the Plant. An Engineering Services Agreement was signed on May 16, 1990 between BPDB and Messrs Lahmeyer International, Germany for detailed site investigations, preparation of scope of rehabilitation work, site supervision etc. Lahmeyer submitted the Final Report (Engineering Report) on Rehabilitation of Unit Nos 1 and 2 of Karnafuli Hydro in May 1992. The engineering services supervision contract was signed between BPDB and Lahmeyer on 23-9-93. Tender for Rehabilitation of Kaptai Unit Nos 1 & 2 was floated on 04 April 1993. Contract was signed with ABB, Italy and Voest Alpine on June 25, 1994. The Unit No 1 was shut down for the rehabilitation work from September 28, 1996 to October 24, 1997 while the Unit No 2 was shut down from June 15, 1995 to February 02, 1997 as well as from April 21, 1997 to July 16, 1997. After necessary rehabilitation, the Unit No 1 and 2 were commissioned on December 17, 1997.

A picture of the Rehabilitation Work carried out on Unit Nos. 1 and 2 is given at Annexure 6-1 (2-page), attached hereto. Following benefits were received as a result of the Rehabilitation Work.

(i) Restored (loss of) generating capacity
(ii) Achieved extended plant life
(iii) Achieved improved efficiency
(iv) Achieved operational reliability

6.3.1 Renovation of Kaptai Unit no 3

It is stated in the foregoing paragraph 6.2.1 that Unit No 3 was commissioned in early 1982. This unit was intended to be erected and commissioned in 1971; but due to liberation war, the work was stopped. Some of the goods were off-loaded in Myammar and India.

After liberation of Bangladesh, the old contract was revived and finally the unit was commissioned in early 1982. A proposal for its rehabilitation is under active consideration of BPDB.

Table 6.3: Power Plant Rehabi;itation Project - Karnafuli Hydro Power Station

POWER PLANT REHABILITATION PROJECT
KARNAFULI HYDRO POWER STATION
1994 - 1997

ABB SAE SADELMI PORTION

CONTRACT REF CODE	DESCRIPTION OF ITEMS	CONTRACT PRICE	
		US$	TAKA
	TOTAL AMOUNT	2,420,000.00	509,000,000.00
HM-1001	**MECHANICAL EQUIPMENT & CIVIL WORDS**	**1080000.00**	**44000000.00**
5.1.1	SPIRAL CASE	28363.59	712181.00
5.1.2	STAY RING	16363.61	397711.00
5.1.4	DISCHARGE RING	123272.51	1646340.00
5.2.1	RAW WATER DISTRIBUTION SYSTEM	39272.66	416210.00
5.2.1.1	COOLING WATER SYSTEM	93272.56	1054399.00
5.2.1.2	TREATED WATER SYSTEM	40909.02	485578.00
5.2.2	STATION SERVICE COMPRESSED AIR	23454.00	462456.00
5.2.3	VENTILATION AND AIR CONDITION SYSTEM	27272.68	342271.00
5.2.4	FIRE FIGHTING SYSTEM	63545.34	818546.00
5.2.5	EMERGENCY DIESEL GENERATOR SET	8727.26	101740.00
5.2.6	POWER HOUSE BRIDGE CRANE	23454.50	305221.00
5.2.7	PRESSURE OIL UNIT AT PLATFORM OF DIVERSION	17454.51	231227.00
5.2.8	SEWAGE EJECT POWER HOUSE	17454.51	166484.00
5.2.9	CORROSION PROT /PAINT OF WATERIMM. PARTS		
5.2.10	MECHANICAL WORKSHOP EQUIPMENT	10909.07	101740.00
5.3.1	PENSTOCK	146727.01	3579405.00
5.3.2	DRAFT TUBE	38181.75	730680.00
5.3.3	TRASHRACKS	37090.86	462456.00
5.3.4	STOPLOGS	94908.92	1350370.00
5.3.5	FIXED WHEEL INTAKE GATES	137181.57	2349274.00
5.3.6	DRAFT TUBE BULKHEADS	19090.88	282098.00
5.3.7	PENSTOCK PILLING VALVE	28363.59	240477.00
5.3.8	DTAFT TUBE DRAIN VALVE	30545.40	258975.00
5.6.1	SLOPE PROTECTION		4243500.00
5.6.2	BLOCKAGE OF FLOOR DRAINAGE SYSTEM	14183.70	138732.00
5.6.3	FIRE SEPARATION WALL		848700.00
5.6.4	WORKSHOP FACILITIES FOR MECH & ELECT MAT		20368800.00
5.6.5	PAINTING OF POWER HOUSE & WATER INT. BLD.		207083.00
5.6.6	SURVEY OF WATER RESERVOIR AREA		1697400.00
HE-2100	**ELECTRICAL EQUIPMENT**	**1000000.00**	**5500000.00**
HE-2101	132 KV EQUIPMENT	114873.03	1737200.00
HE-2102	11 KV OUTDOOR EQUIPMENT	32648.12	358693.00
HE-2103	LV DISTRIBUTION	14510.26	84399.00
HE-2104	LIGHTING BOARD VOLTAGE REGULATOR	9673.52	56265.00
HE-2105	DC SYSTEM 225 V BATTERY CHARGERS	33857.32	365726.00
HE-2107	GENERATOR, STATOR/ROTOR	500000.04	
HE-2108	GENERATOR, EXCITATION SYSTEM/AVR	140266.02	1153445.00
HE-2109	GENERATOR, PROTECTION SYSTEM	38694.07	225062.00
HE-2110	GENERATOR, SYNCHRONIZING	14510.28	84437.00
HE-2111	CABLES	17533.25	450125.00
HE-2112	LIGHTING TURBINE HALL	41112.45	414959.00
HE-2113	AUXILIARY BRIDGE CRANE	42321.64	569689.00
HI-3054	**INSTRUMENT AND CONTROL**	**80000.00**	**1200000.00**
HI-3054/2	PANEL SECTION	27500.00	425000.00
HI-3054/3	DATALOGGING SYSTEM	20000.00	250000.00
HI-3054/5	WATER ENERGY SYSTEM	13750.00	262500.00
HI-3054/6	WORKSHOP EQUIPMENT	6250.00	87500.00
HI-3054/7	SPARE PARTS MANAG.SYSTEM	6250.00	87500.00
HI-3054/8	MISCELLANEOUS I&c	6250.00	87500.00
HM-1003	TRAINING OF EMPLOYER'S PERSONNEL	260000.00	

Table 6-3: (Continued)

VOEST ALPINE PORTION		**ATS**	**TAKA**
	TOTAL AMOUNT	10352000.00	7261000.00
HM-1001	MECHANICAL EQUIPMENT &CIVIL WORKS	6307000.00	7086000.00
5.1.1	SPIRAL CASE	119000.00	140000.00
5.1.2	STAY RING	59000.00	84000.00
5.1.3	RUNNER, HUB, LINKAGE BEARING	654000.00	1499000.00
5.1.4	DISCHARGE RING	476000.00	558000.00
5.1.5	OUTER HEADCOVER	238000.00	278000.00
5.1.6	HEADCOVER	238000.00	223000.00
5.1.7	BOTTOM RING	357000.00	333000.00
5.1.8	SHAFT SEAL	119000.00	82000.00
5.1.9	MAIN GUIDE BEARING	119000.00	62000.00
5.1.10	WICKET GATES	802000.00	1015000.00
5.1.11	WICKET GATE MECHANISM	357000.00	332000.00
5.1.12	GATE OPERATING RING	238000.00	223000.00
5.1.13	GATE SERVOMOTOR	445000.00	334000.00
5.1.14	SHAFT, SHAFT SERVOMOTOR & OIL HEAD	595000.00	556000.00
5.1.15	GREASE LUBRICATION SYSTEM	120000.00	62000.00
5.1.16	INSPECTION & MAINTENANCE PLATFORM	119000.00	84000.00
5.1.17	MISCELLANEOUS MATERIALS	60000.00	14000.00
5.2.7	PRESSURE OIL UNIT AT PLATFORM OF DIVERS	238000.00	223000.00
5.2.8	SEWAGE EJECT OF POWER HOUSE	63000.00	106000.00
5.2.9	CORROSION PROT/PAINT.OF WATER IMM. PARTS	59000.00	13000.00
5.2.12	SERVICE	118000.00	28000.00
5.5.5.1	REHABILITATION GOVERNOR	714000.00	837000.00
HI-3054	**INSTRUMENT AND CONTROL**		
HI-3054/5	WATER ENERGY SYSTEM	193000.00	175000.00
HM-1003	**TRAINING OF EMPLOYER'S PERSONNEL**	**3852000.00**	

Section 7 Projects Under Construction

As of June 2002, there is no hydro-power development project under construction in Bangladesh. It is already stated in foregoing Section-5 that proposed extension of Karnafuli Hydro by way of installing additional two (2) units (6^{th} and 7^{th}), each of 50 MW capacity is already approved by the Govt. of Bangladesh. Government of Japan through the Japan Bank of International Co-operation (JBIC) is expected to finance the Project. Prior to pledge of the project fund and formal signing of the Loan Agreement, JBIC asked the Executive Agency, namely, Bangladesh Power Development Board (BPDB) to carry out Social Impact Assessment (SIA) Study and submit the Report. Subsequently, Atlanta Enterprise Ltd., Consulting Engineers, Dhaka entered into a Contract with BPDB on June 19, 2002 for carrying out the SIA Study and submit the Report. The SIA Study is in progress.

Section 8 Potential Upgrade of Existing Projects

It is stated in foregoing paragraph 6.3.1 in Section 6 that BPDB is actively considering Rehabilitation Work of Kaptai Unit No 3 (50 MW). The work could not proceed due to lack of finance.

Section 9 Future Plan

Except for extension of Karnafuli Hydro by way of installing 6^{th} and 7^{th} Units, each of 50 MW, Bangladesh does not have any immediate future plan on hydro development. Even though there is good prospects of developing the Sangu and the Matamuhuri River basin, the environmental and social impacts due to possible inundation of land and consequent rehabilitation and resettlement of the affected population seem to be the greatest barrier in initiating the hydro-power development in the country. The Brahmaputra multipurpose and the Brahmaputra Barrage Projects are still in consideration of the government but because of huge investment involved and dearth of foreign finance, no headway has yet been made.

5.2 General

There has not been any government policy on hydro-power as yet, even though the National Water Policy (NWP_0) has been formulated to ensure progress towards fulfilling national goals of economic development, poverty alleviation, food security, public health and safety, a decent standard of living for the people and protection of the natural environment. The broad objectives of the NWP_0 are enumerated below.

(i) To address issues related to the harnessing and development of all forms of surface water and groundwater and management of these resources in an efficient and equitable manner.

(ii) To ensure the availability of water to all elements of society inlcuding the poor and the underprivileged, and to take into account the particular needs of women and children.

(iii) To accelerate the development of sustainable public and private water delivery systems with appropriate legal and financial measures and incentives, including delineation of water rights and water pricing.

(iv) To bring institutional changes that will help decentralize the management of water resources and enhance the role of women in water management.

(v) To develop a legal and regulatory environment that will help the process of decentralization, and sound environmental management, and will improve the investment climate for the private sector in water development and management.

(vi) To develop a state of knowledge and capability that will enable the country to design future water resources management plans by itself with economic efficiency, gender equality, social justice and environmental awareness to facilitate achievement of the water management objectives through broad public participation.

The Government's Development Strategy acknowledges that to achieve these objectives will require a comprehensive implementation package involving:

- New legislation and regulations, particularly a Water Resources Act and a regulatory framework for private sector participation;
- Institutional development and strengthening at central and local levels;
- Consultation and participation with the direct beneficiaries in the hand-over and development of water schemes;
- Decentralization and devolution of responsibility for management and operation of water schemes to local government and local water groups; and
- Private sector participation in the development, financing, management and operation of water schemes at the local and regional levels, as well as in the major cities. This could involve companies with the appropriate qualifications, financial backing and expertise.

Further, with implementation of a range of structural and non-structural measures shall be designed to:

- Improve efficiency of resource utilization through conjunctive use of all forms of surface water and groundwater for irrigation and urban water supply.
- Facilitate availability of safe and affordable drinking water supplies
- Comprehensively develop and manage the main rivers for multipurpose use
- De-silt watercourses to maintain navigation channels and proper drainage
- Develop flood-proofing systems to manage natural disasters
- Provide desired levels of protection in designated flood risk zones
- Implement river training and erosion control works for preservation of scarce land and prevention of landlessness and pauperization.
- Reclaim land from the sea and rivers
- Develop mini-hydro-power and recreational facilities at or around water bodies.
- Implement environmental protection, restoration and enhancement measures consistent with the National Environmental Management Action Plan.

10.2 Policy on Hydro-power Development

Even though the government has not yet formulated any specific policy on hydro-power development, the government emphasizes that any hydro-power project must be subjected to thorough environmental and social impact assessment.

10.3 Project Approval Procedure

A hydro-power development project in Bangladesh is conceived either by the Bangladesh Water Development Board (BWDB) or by the Bangladesh Power Development Board (BPDB).

From the stage of planning concept to the stage of project approval, there are 19 definite steps which are described below in Flow Chart 10-1: Project Approval Procedure.

Flow Chart 10-1: Project Approval Procedure

1	Project Concept Paper (PCP) is prepared by the Project Planning Directorate of Board as per guide line of Master Plan/System Planning of the Board.
2	Submitted to the Administrative Ministry M/O Energy & Mineral Resources (MEMR) for comment and scrutiny of physical quantity and financial involvement.
3	MEMR sends back to the Board with comments.
4	After incorporating the Ministry’s comment send to the MEMR for submission to the Planning Commission.
5	Planning Commission examines the justification of the Project, both physical and financial aspects, BCR, EIRR, IRR and also sends to Inter Ministerial Evaluation Division (IMED). Planning commission with the comments of IMED and their comments sends to MEMR.
6	MEMR sends to the Board to recast the PCP as per comments of Planning Commission & IMED.
7	Board after recasting sends to MEMR
8	MEMR sends to Planning Commission.
9	Planning Commission places it to Pre-ECNEC headed by the Member, Planning Commission, Power & Industry.
10	Member, Planning Commission holds a meeting with the representatives of different concerned Ministries and obtain their opinion and examines the justification of the Project. If he is satisfied, he recommends and sends it to Planning Commission for in corporation of the comments/views of pre-ECNEC meeting.
11	Planning Commission sends to MEMR to incorporate the comments of Pre-ECNEC meeting.
12	MEMR sends to BPDB to prepare the PCP as per decision of the Pre-ECNEC meeting incorporating their comments.
13	BPDB incorporating the comments of Pre-ECNEC meeting sends to MEMR.
14	MEMR sends to Planning Commission for Executive Committee for National Economic Council (ECNEC).
15	ECNEC approves the PCP.
16	ECNEC sends to Planning Commission.
17	Planning Commission sends to MEMR.
18	MEMR sends to BPDB. BPDB – incorporating the decision of the ECNEC prepares Project Paper (PP) and submits to the Secretary, MEMR for DPEC (Divisional Project Evaluation Committee).
19	DPEC examines the PP in the light of ECNEC approval and approves the PP

N.B : PCP may be disapproved at stage 2, 5, 10 & 15

Section 11 Issues and Barriers

11.1 General

Hydro-power development and regional co-operation seem to be very much interlinked. It is mentioned in Section-5, para 5.1.1, that the maximum reservoir height of Kaptai Hydro could be raised by 13.0 ft at a future date, but this would require co-operation of India as back water of Kaptai reservoir would inundate Indian land. Implementation of the Brahmaputra Barrage Project also would require co-operation of the upper riparian countries.

11.2 Issues

Bangladesh being one of the densely populated countries in the world needs to develop its energy resources at a quick pace for poverty alleviation, economic development and improved standard of living of its people. At present, only about **30%** of country's population has access to electricity. Therefore, lots of efforts have to be made for making electricity available to most of the population within the shortest possible time. Hydro-power potential in Bangladesh is rather limited. At present, only **5.5%** of the maximum demand is met from Hydro. However, in developing hydro-power potential, and for that matter, for development of any power development projects, the following issues need to be examined.

11.2.1 Demand Forecast

The methodology of forecasting, linking to electricity with socioeconomic goals of the country, should be used for projecting demands for electricity.

11.2.2 Long Term Planning & Project Implementation

Long term planning for development of the power sector should be drawn up on the basis of the projection on demand, cost of supply, reliability and quality of supply and adequate transmission and distribution facilities.

11.2.3 Investment

Development of the power sector shall be such that the utilities can function economically and reliably and their financial situation permits generation of resources internally for financing at least a part of their development activities.

11.2.4 Fuel

Efforts shall be made to maximize use of indigenous fuels, namely, natural gas, coal, hydro-electricity etc in the future generation mix of the country.

A mix of fuel for power generation shall be evolved so as to reduce reliance on any particular fuel type. Least cost fuel option for generation of electricity should be chosen.

11.2.5 Technology

Criteria for selection of a technology shall include its provenness, maintainability, reliability, adaptability, and efficiency and environmental compatibility.

11.2.6 Tariff

The tariff shall be reviewed and fixed in such a way that the utilities can be financially viable, can generate internal resources and at the same time the consumers can get electricity at a reasonable cost.

Long run marginal cost shall form the basis for tariff formulation.

11.2.7 Captive and Stand-by Generation

Permission to install captive generation facilities shall be accorded by the regulatory authority.

11.2.8 System Loss Reduction

Total system loss shall be brought down to a level typical to the successful utilities of the developing countries in the region, subject to cost effectiveness of such reduction in loss.

11.2.9 Load Management and Conservation

Measures shall be taken to reduce peak hour load. The possible areas where policy intervention can help implement such measures are as follows:

- Restriction of commercial activities during peak load hours.
- Restriction of ceremonial illumination during peak load hours.
- Staggering holidays for industries

For conservation of energy, use of power factor improvement plants shall be made mandatory.

11.2.10 Reliability of Supply

Adequate generation capacity shall be installed on an emergency basis to overcome the existing power crisis in the country.

Adequate reserve margin shall be provided by installing capacities in excess of peak demand (say **25%**), so that the system can reliably accommodate planned maintenance and forced outage.

Planning of major maintenance including overhauling, retrofitting and rehabilitation shall be done meticulously and ahead of time so that necessary spares, experts and logistics are available in time.

11.2.11 System Stability

Adequate transmission links between generating stations and major load centers shall be provided to enhance system stability.

Fast acting relays and breakers, auto reclosing of transmission line, co-ordination among protective devices, quick acting governors and excitation system along with automatic load shedding scheme shall be provided.

11.2.12 Load Dispatching

Load dispatching center shall ensure co-ordination among the power stations and load centers for economic, efficient and reliable operation of the power system through continuous control of load flows, regulation of voltage and reactive powers, and reduction of transmission losses.

11.2.13 Private Sector Participation

Local and expatriate entrepreneurs shall be allowed to participate in development of the power sector.

11.1.14 Project Finance

Line up of project finance is a very significant issue. Most of the international financing agencies, namely, the World Bank, the Asian Development Bank (ADB), the Japanese Bank for International Co-operation seem to impose difficult conditions to be fulfilled prior to approving the loan agreements for project implementation.

11.1.15 Environment and Social Impact

In implementing any hydro-power development project, the country as well as the donor agencies are putting up emphasis on carrying out environmental and social impact assessment studies prior to commencement of implementation of the project (s). Compensation and rehabilitation of displaced persons become a big issue in approving a project.

11.1.16 Regional and International Co-operation

Possibility of importing/exporting electricity from/to the neighboring countries may be examined.

Attempts may be made to include inter-utility co-operation in the region.
Linkages of local utilities with those in other countries in the region may be established to form a basis for exchange of experience in power development and training of human resources.

11.3 Barriers

Hydro-power development projects are highly capital intensive with long gestation period. For evacuation of power, costly transmission lines have to be built. This would require resolving the right-of-way problem. The main barriers are listed below:

11.3.1 Finance

Lining of finance for implementation of a project is considered to be the most significant barrier; as it is very difficult on the part of Bangladesh to mobilize internal resources for meeting the necessary investment and securing foreign finance has become extremely difficult now-a-days.

11.3.2 Environmental and Social Impact

Now-a-days, people have become quite conscious about effect of environment and social impact on account of implementing a hydro-power project. People's reaction toward rehabilitation/resettlement is not regarded as friendly. Further, this adds to the cost of the project.

Section 12 Conclusion

12.1 General

Bangladesh is one of the densely populated countries of the world with a current population of about 130 million. The per capita income is one of the lowest in the world. The country's generating capability is unable to meet the rising power demand. Only **30%** of country's population has access to electricity. Power sector development in the country should, therefore, be given high priority with a view to achieving poverty alleviation, economic development and improved standard of living of the people of Bangladesh.

Power sector development in general and hydro-power development in particular is highly capital intensive. Bangladesh alone is unable to mobilize its internal resources for power sector development. As such, the country has to depend on foreign finance. Recently, Bangladesh has allowed, as a government policy, the Independent Power Producers (IPP), to supplement the country's generation capability.

12.2 Hydro-power Potential

Bangladesh has limited hydro-power potential. The only hydro-power plant in the country is located at Kaptai on the Karnafuli River producing 230 MW power. There is a plan for adding 100 MW at Kaptai. The Japanese Government which is expected to finance the project is insisting that environmental and social impact assessment must be carried out and satisfactory results obtained prior to signing the loan agreement for project finance.

There is potential in the Sangu and the Matamuhuri river basins (167 MW). There is also potential in the Brahmaputra river basin (1,400 MW). Development of these hydro potentials with require huge investments. It is not easy to secure foreign finance now-a-days. In the circumstances, the need for regional co-operation has assumed great importance.

12.3 Regional and International Co-operation

There is enormous hydro potential in neighboring Nepal and Bhutan. With active and sincere co-operation of India, Nepal, Bhutan and Bangladesh, it may be possible to develop the hydro potentials in the region. If developed, the power requirements of all the four(4) countries will be met for decades to come. If the countries in the region reach an agreement for such co-operation, international co-operation in matters of expert services, training, choice of technology, selection of equipment etc. would be available on easier terms. Securing foreign finance for project implementation may also be easier.

12.4 Conclusion

From the foregoing discussions, it may be safely concluded that regional and international co-operation is the only way of harnessing the enormous hydro potential in Nepal and Bhutan with a view to meeting the power requirements of the countries in the region. When such a co-operation is put into implementation, other avenues will be opened up and the people in general will be benefited by way of reliable supply of electricity, increase of economic activities and improved standard of living. Bangladesh may then venture to harness the available hydro potential in the country for the benefit of the region.