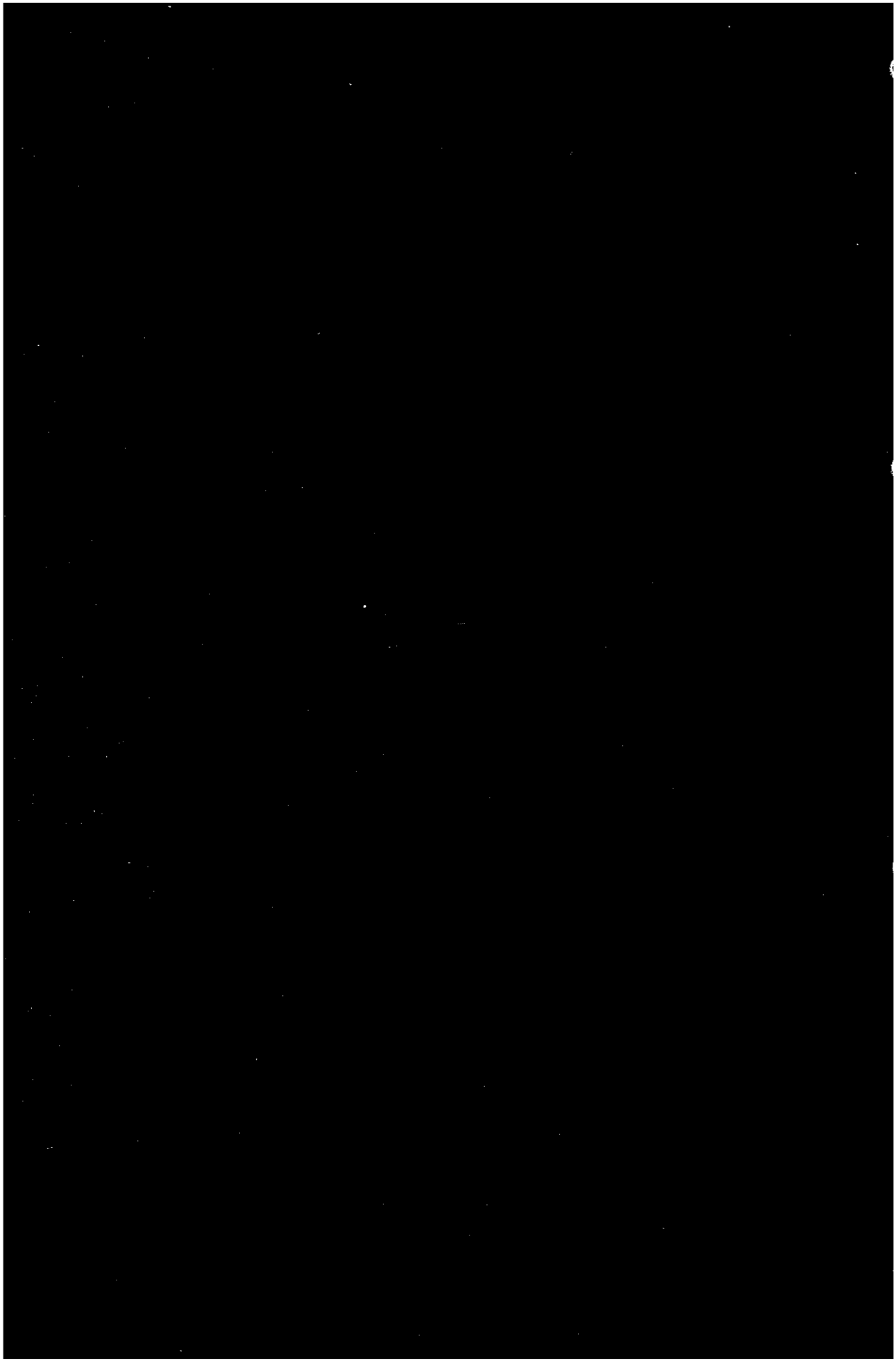
CHAPTER 3

OUTLINE OF BANGLADESH



CHAPTER 3 OUTLINE OF BANGLADESH

3-1 Territory and Geographical Conditions

The People's Republic of Bangladesh has an area of 1,411,122 km^2. It is a young country having become independent on December 16th 1971. It is assumed to have a population of the order of 76,398,000 persons (according to census of 1974) which is growing at a high rate of approximately 3% per year. Approximately 85% of the nation's population lives in rural areas. The country is typically agricultural, with approximately 57% of the GNP depending upon agriculture. Most of the land is flat; belonging to the delta of the Ganges and Brahmaputra rivers. With the exception of the south-east extremity of the country, close to the border with Burma, where is located the plateau of the Chittagong Hill Tracts, and the northern part of the country, close to the border with India, most of the territory of the country is composed of endlessly uniform flats. From the climatic point of view, the year can be divided into a rainy season and a dry season. During the rainy season (June - October/November) the increase in the water level of the rivers causes inundation of large areas of the country, which remain underwater for a long period. During the dry season (November - February) the climate becomes very mild, but the shortage of rain affects growth of cereal grains and irrigation is required.

3-2 Climate Conditions (Refer to Annex I)

(1) Temperature:

According to data collected over the past 15 years, the maximum temperature occurs in May, reaching 43.4°C (110°F), and the minimum temperature occurs in November, with 5°C (41°F). The average year round temperature is 26°C (78.8°F).

(2) Humidity:

In the months of November through March the humidity is of the order of 35%-45%, being, therefore, a relatively comfortable season. During the monsoon season from June through October it exceeds 80%.

(3) Pluviometry:

Bangladesh is a country with a typically monsoon type climate and the rainfall has an evident difference according to the season. During the monsoon season occurs 80% of the annual rainfall, and the remaining 20% occurs from March through May, accompanied by strong thunder. In the north-west region, close to the border with India, the annual rainfall is of the order of 50 inches, while in the north-east region, in Sylhet, it reaches 200 inches.

(4) Wind:

The wind occurring in Bangladesh is generally mild with the exception of the thunderstorms and during the cyclone season.

(5) Cyclone:

From five (5) to 15 cyclones occur each year in the Bay of Bengel. Approximately 1/3 of these have a direct influence on the territory of Bangladesh. 50% of the total occur during the month of October and the remaining 50% are distributed throughout the months of May, September and November.

According to recorded data, during a cyclone which occurred in November of 1970 the maximum speed of the wind reached 138mph in Chittagong.

As for the cyclone generated flood tides, in 1960 flood tides of 20'-30' occurred in Chittagong, and during the cyclone of November, 1970 tides of 12'46" in Niamapur, 5.56' in Bhola Ghat, 3.62' in Bakarganj, 1'7" in Barasal and 0.6' in Khulna were recorded.

(6) Thunder Storms:

Strong thunder storms occur during the months of March through June. A characteristic of these thunder storms is the affected area, which extends as a belt several miles in width. Duration is of one (1) or two (2) hours.

The winds of these thunder storms cause property damage in some cases. Rainfall is of the order of several inches.

In some cases these thunder storms are accompanied by hail, which causes crop damage. In general the storms are distributed throughout the entire country but the central region has a slightly higher incidence compared with other regions.

3-3 Population and Labour

(1) Population:

According to a 1974 census, the population of Bangladesh was estimated at approximately 76,398,000. Population growth is estimated as follows.

Population Growth

Year	1975	1976	1977	1978
Population (x 1,000)	78,200	80,400	82,700	85,400

The population is growing at a high annual rate of the order of 2.7-3.0%. According to estimates of The World Bank, it will reach 137,000,000 in the year 2003. The population has a low concentration rate in urban areas. Dacca, capital city of the country, has a population of 1,310,000 persons, Khulna 437,000 and Chittagong 416,000. The population of all urban areas totals 6,273,000 persons, corresponding to 8.8% of the nation's population.

(2) Labour:

The working population of Bangladesh is estimated to be of the order of 26 million (1973), corresponding to 35.4% of the population. Of this total, 77% are involved in agriculture related work (1978). Industry absorption of the working population is slow and since tertiary economic activity (commerce, services, etc.) also has difficulty in absorbing workers, the economy remains stagnant in rural areas and as a result there is a surplus of labour. As to population by age group, 48% are less than 15 years of age, implying that the same working population will exist in the future.

There is no statistical data available on unemployment but, according to the government, it is estimated to be of the order of 30-35%.

The "Approach Plan" (1978-1980) of the government of Bangladesh attributes special importance to economic development, employment and limitation of the population. Agriculture is being treated with special care in order to assure economic growth and to increase the chances of employment. In order to offer chances of employment to an expected 2.3 million persons entering the labour force, priority is being given to labour intensive sectors of the economy.

(3) Wages:

As described above, there is a surplus of labour, including unemployed and semi-unemployed populations. Consequently, the wages of industrial and agricultural workers are low and conditions of employment very unstable.

The following average daily wages paid in Dacca are given for reference in Table 3-1.

Table 3-1 Wage Level (Average Daily Wage in Dacca)

(unit: TK)

Kind of worker		1975.6	1976.6	1976.12	1977.6	1977.12	1978.6
Agricultural worker	Skilled	10.00	10.50	9.75	10.00	12.00	12.00
	Unskilled	9.30	8.00	8.25	8.50	8.00	10.00
Fishery worker	Skilled	11.33	10.75	13.50	11.00	10.00	13.00
	Unskilled	10.45	8.12	11.50	9.00	9.00	11.00
Industrial worker	Skilled	13.00	14.46	16.17	14.52	16.05	17.50
	Unskilled	9.75	10.93	11.35	10.98	10.29	11.48
Construction worker	Skilled	20.00	24.33	25.00	25.00	25.00	30.00
	Unskilled	12.00	12.00	12.00	12.67	14.00	15.00

Source: Economic Indicators of Bangladesh, Oct. 1977, Aug. 1978.

3-4 Outline of the Economy

In the economy of Bangladesh the agricultural sector, representing approximately 60% of the GDP (refer to Table 3-2), occupies a position of absolute importance, and is the core of the national economic activity.

The most important agricultural products are rice and jute. Rice, represents 97% of all cereal production in the country and occupies 78% of all land cultivated (89,720 km^2).

The industrial sector occupies a position of minor importance, representing approximately 8.0% of the GDP (7.3-8.4%). The most important industrial activities are jute processing and cotton textile manufacture. In 1977/78 the economy of Bangladesh showed a growth of 7.8% of GDP. The economy continues to progress favorably. This is a consequence of favorable climatic conditions contributing to the improvement of agricultural production, which showed growth of 7.8% over the preceeding year. As for industrial production, vigorous economic activity reflected in an increase in the rate of operation of the factories of state owned companies. The rate of growth compared with the preceeding year reached 10.4%, surpassing for the first time the level prevailing in East Pakistan before independence.

The sectors of electric power, construction and gas are also growing steadily. In the export sector, despite a reduction in the supply of raw jute in the jute industry, the main export industry of the country, soaring prices on the international market resulted in an increase of 40% in the value of exports and the export sector as a whole showed an increase of 14%.

On the other hand, in the import sector an increase of 52.8% for import of foodstuffs pushed the value of all imports up by 43% compared with the preceeding year.

As a result of these figures the balance of international trade is still in deficit. The Government of Bangladesh is presently executing the two-year "Approach Plan" as a basis for the next quennial plan commencing in 1980/81. The allotment of investments of the 1978/79 ADP (Annual Development Plan) allows 28% to the rural development program comprised of agriculture, rural development, flood control and irrigation, evidence of the importance attributed to the rural sector by the

government. Next following agricultural projects are listed the transportation and communication sector with approximately 18% and power development with 9%, together totalling 27%. Investments in the industrial sector correspond to 17% of the total.

As described above, Bangladesh is a typically monocultural agriculture country, with trends in agriculture having a decisive influence upon the national economy as a whole. Stabilization of agriculture, self-sufficiency in foods and the development of the rural economy can be considered the most important goals facing the nation. Another important item is the development and utilization of the abundant supplies of natural gas existing in the country. The utilization of natural gas to replace imported petroleum will contribute to remarkable improvement in the international balance of payments of the country.

Table 3-2 The GNP and its Composition*

10^6 Taka	1973/74 Total Production	1974/75 Total Production	1975/76 Total Production	1976/77 Total Production	1977/78** Total Production	Percentage	Growth Rate
Agriculture	30,307	29,701	32,627	32,161	34,542	56.8	7.4
Manufacturing	3,784	3,735	4,216	4,650	5,133	8.4	10.4
Large Scale	2,429	2,380	2,712	3,056	3,444	5.7	12.7
Small Scale	1,355	1,355	1,504	1,594	1,689	2.7	6.0
Construction	744	1,756	1,954	2,306	2,663	4.4	15.5
Power/Gas	258	265	316	360	411	0.6	14.0
Transportation	2,615	2,615	2,955	3,191	3,235	5.3	7.0
International Trade	3,924	3,924	4,289	4,203	4,497	7.4	7.0
Housing Services	2,426	2,494	2,594	2,698	2,806	4.6	4.0
Public Administration	1,945	2,462	2,757	3,033	3,331	5.5	9.8
Bank/Insurance	338	349	392	431	470	0.7	9.0
Profession and Miscellaneous Services	3,264	3,297	3,403	3,607	3,752	6.3	5.0
GDP	49,607	50,598	55,503	56,640	60,840	100.0	7.8
Income per Capita (Taka)	651	645	686	680	714		5.0

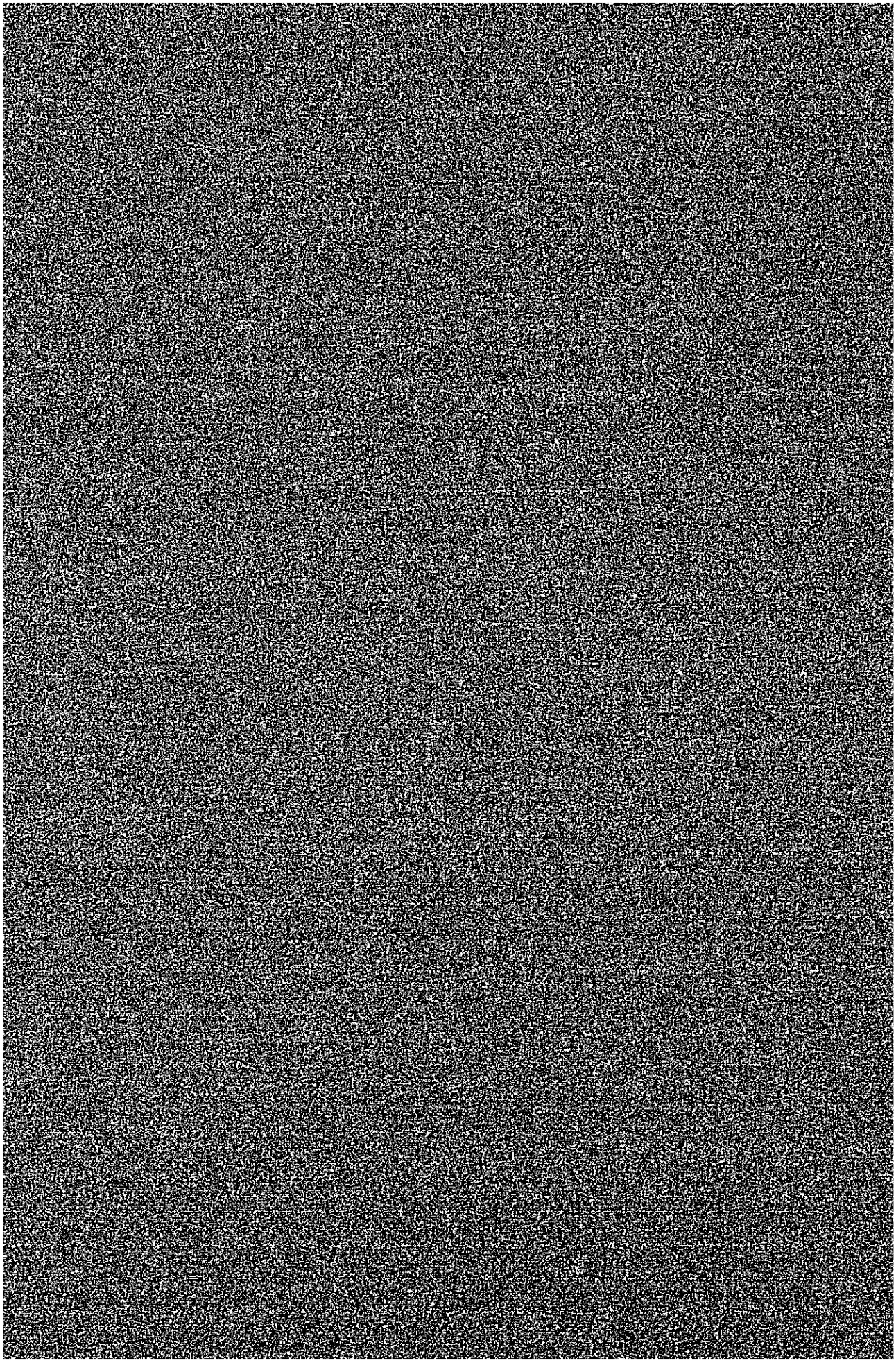
Notes: * According to fixed price of 1972/73.

** Provisional estimation.

Source: Planning Commission, Govt. of Bangladesh

CHAPTER 4

OUTLINE OF POWER SYSTEM



CHAPTER 4 OUTLINE OF POWER SYSTEM

4-1 Current Status of Power Stations, Transmission Lines and Transformation Facilities

Electric power is an indispensable energy source for development of the country. Electric power supply at low cost and with high reliability is directly related to the development of the national economy and to the improvement of the living level.

The supply of power to the nation is the responsibility and duty of the government and the government has entrusted this job to the Bangladesh Power Development Board (BPDB).

Generally speaking, the power system of Bangladesh is divided into an eastern grid and a western grid by the Brahmaputra-Jamuna river crossing the country in the north-south direction.

The power system is composed of 132kV and 66kV trunk lines and 33kV and 11kV distribution lines.

The eastern zone has an installed capacity of 525MW, produced chiefly by power plants utilizing natural gas, and hydroelectric power plants. Available capacity is 408MW out of installed capacity in 1977 - 1978.

Comparatively speaking, in the western zone the development of power resources is behind development in the eastern zone and only eight (8) out of the eleven (11) districts in the region are connected to the power system. The main grid in the western zone is composed chiefly of steam power plants and gas turbine power plants, and in the areas not connected to the main grid, diesel engine power generation is indispensable. As a whole the western zone has an installed capacity of 226MW, but the available capacity is only 148MW in 1977 - 1978.

Compared with the eastern zone, the western zone is insufficiently equipped with power generation, transmission and distribution facilities and is therefore unable to cope with demand. Consequently, power is being supplied under load shedding conditions.

There are places in this region where power is supplied only two (2) or three (3) days a week, and the available power supply capacity is of the order of 50% compared with the actual loads. Statistic data on the occurrence of power failures in the western and eastern grids in

1976/77 and 1977/78 is given in the following table. The data shows a high incidence of failure in the western grid compared with the eastern grid.

Occurrence of power failures

Western grid	Total number	Total Duration		Number of faults by type					Others
		Hour	Minutes	Generation trouble	Transformer trouble	Fault in trans. line	Lightning	Planned maintenance/ repair-work	
1976/1977									
1. Partial grid failure									
2. Partial grid failure (both 132 & 66 kV)	32	08	20	1	2	26	1	1	1
3. Partial grid failure (132 kV only)	16	62	24	-	-	7	1	4	4
4. Partial grid failure (66 kV only)	12	56	54	-	-	8	1	3	-
5. Total	60	127	38	1	2	41	3	8	5
6. Total grid failure	24	08	47	14	-	9	-	-	1
1977/1978									
1. Partial and grid failure									
2. Partial grid failure (both 132 & 66 kV)	79	90	21	52	-	26	-	-	1
3. Partial grid failure (132 kV only)	46	179	29	23	1	14	-	8	-
4. Partial grid failure (66 kV only)	13	30	34	7	-	2	1	3	-
5. Total	138	300	24	82	1	42	1	11	1
6. Total grid failure	16	86	03	12	-	3	-	-	1

Eastern grid	number	Total Duration		Number of faults by type					Others
		Hour	Minutes	Generation trouble	Transformer breaker trouble	Fault in tran. line	Lightning	Planned maintenance/ repair work	
1976/1977									
1.0 Partial grid failure	7	01	39	-	-	5	2	-	-
2.0 Total grid failures	2	0	42	-	-	-	2	-	-
1977/1978									
1.0 Partial grid failure	3	10	19	-	-	2	-	-	1
2.0 Total grid failure	2	1	28	-	1	-	-	-	1

In addition to the aspects described above, power system loss is a very high 34%. (Refer to Table 4-1). The chief causes of power losses in the system are as follows:

- Inefficient operation of the power plants, due to underloading
- Pilferage of electricity
- Defective metering
- Under billing
- Unmetered energy consumption at the premises of the employees
- Overloaded distribution facilities in urban areas, underloaded long distribution lines in rural areas.

The BPDB is at present seriously studying measures intended to reduce the losses in the power system caused by the above factors.

4-2 Power Transmission System

(1) The power transmission network of the BPDB is shown in Figure 4-1. Generally speaking, the western zone is divided into grid areas served by 132kV, 66kV, 33kV and 11kV, and isolated areas not connected to the grid.

The 132kV lines cover the region of Thakurgoan, in the north and down to the Saidpur, Rangpur, Bogra, Ishurdi, Jessore and Khulna areas.

The Barisal area is entirely isolated from the 132kV grid but a single circuit 132kV transmission line, from Khulna to Barisal via Bagerhat, is presently under construction, with completion expected by 1980.

An additional one (1) circuit 132kV transmission line from Ishurdi to Khulna passing through Bheramara is also under construction, with completion expected by 1980.

The Barisal-Madaripur-Faridpur-Bheramara area, subject of the present project, is now served by a 33kV (partially 11kV) transmission line connected to the 132kV Bottail Substation and is equipped with Diesel engine power generators of several hundred kW capacity, intended to cope with emergency situations and peak load. These are derated plants however and are able to supply only 50-60% of the rated output, due to a shortage of spare parts and other factors.

(2) The power system of Bangladesh is not unified, due to the presence of the gigantic Brahmaputra-Jamuna river.

A comparison of the unit costs for power generation in the eastern and western zone shows that in the eastern zone, where power is generated chiefly by using natural resources (natural gas, hydroelectric resources), in 1978 the unit cost of fuel was 4.2 paisa/kWh.

On the other hand, in the western zone power is generated using mainly imported petroleum and consequently the unit cost soars to 70.89 paisa/kWh, i.e., approximately 17 times the figure for the eastern zone. (Refer to Table 4-2).

The BPDB considers as a matter of top priority the interconnection of the eastern and the western grids in order to send economical power to the western zone and attain a reduction in the unit price of power generation in the country as a whole. This interconnection (East-West interconnector) will also make possible the supply of surplus power of the eastern zone to the western zone, solving as a consequence the power shortage problem. Construction of a 230kV double circuit transmission line, with an extension of approximately 110 miles, between

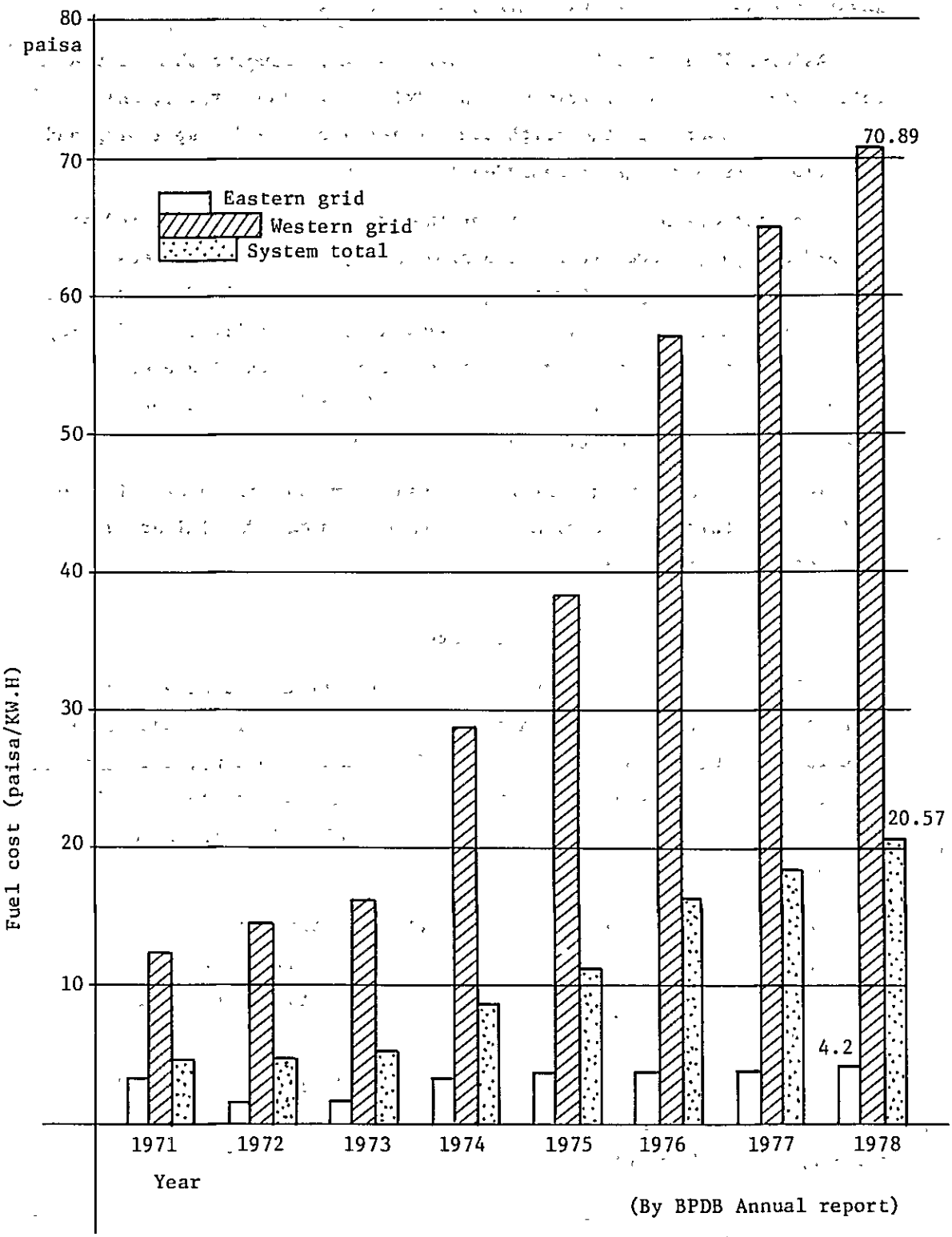
Ghorasal in the eastern grid and Ishurdi in the western grid is presently in progress.

The completion of this 230kV, 795MCM double circuit east-west interconnection line will make possible the supply of approximately 306MW capacity from the eastern grid to the western grid by 1990, operating at 132kV. After 1990 this interconnection line is expected to operate at 230kV, and will transmit approximate 532MW capacity. (Refer to Item 6.2.1 (4)).

Table 4-1 Electric Power Statistics in Western Zone

	Fiscal year	1970-1971	1971-1972	1972-1973	1973-1974	1974-1975	1975-1976	1976-1977	1977-1978
1	Installed Capacity in MW	101.555	101.555	156.055	165.794	174.734	225.027	225.153	226.563
2	Available Capacity in MW	87.438	74.614	136.965	122.791	129.959	155.077	101.197	148.582
3	Max. Demand in MW	53.022	42.172	47.170	65.262	67.257	81.417	88.303	108.638
4	Gross Generation in M.Kwh	203.726	135.369	228.781	282.950	300.100	344.370	394.189	468.499
5	Station Service & Own Use in M.Kwh	12.236	11.256	15.120	21.832	21.405	25.555	21.421	19.937
6	Net Generation in M.Kwh	191.492	124.113	213.661	261.118	278.614	318.815	372.776	448.562
7	Energy Sales in M.Kwh	151.944	88.560	126.533	165.609	164.255	219.057	254.023	295.661
8	Energy Losses in M.Kwh	39.548	35.553	87.128	95.509	114.359	99.758	118.753	152.901
9	Energy loss in Percentage of Net Generation	20.65	28.65	40.78	36.58	41.05	31.29	31.86	34.08

Fig. 4-2 Transition of Fuel cost/KW.H



4-3 Load Dispatching System

4-3-1 Current Status of Load Dispatching System

As described previously, the power system of Bangladesh is divided into eastern and western grids by the Brahmaputra-Jumna river, which crosses the country in the north-south direction. Load dispatching and operations are performed independently in each zone.

The load dispatching center for the eastern system is located at the Siddhiraganji power station, approximately 40kM east of Dacca. This load dispatching center is equipped with a simple load dispatching board but is not equipped with S.V. (supervision) facilities to display the on-off status of the circuit breakers nor with T.M. (telemetery) equipment for metering display. All load dispatching operations are done by means of a power line carrier telephone.

The load dispatching center of the western grid is located in the Goalpara substation close to Khulna, and operations are similar to those of the eastern grid.

4-3-2 Future of Load Dispatching System

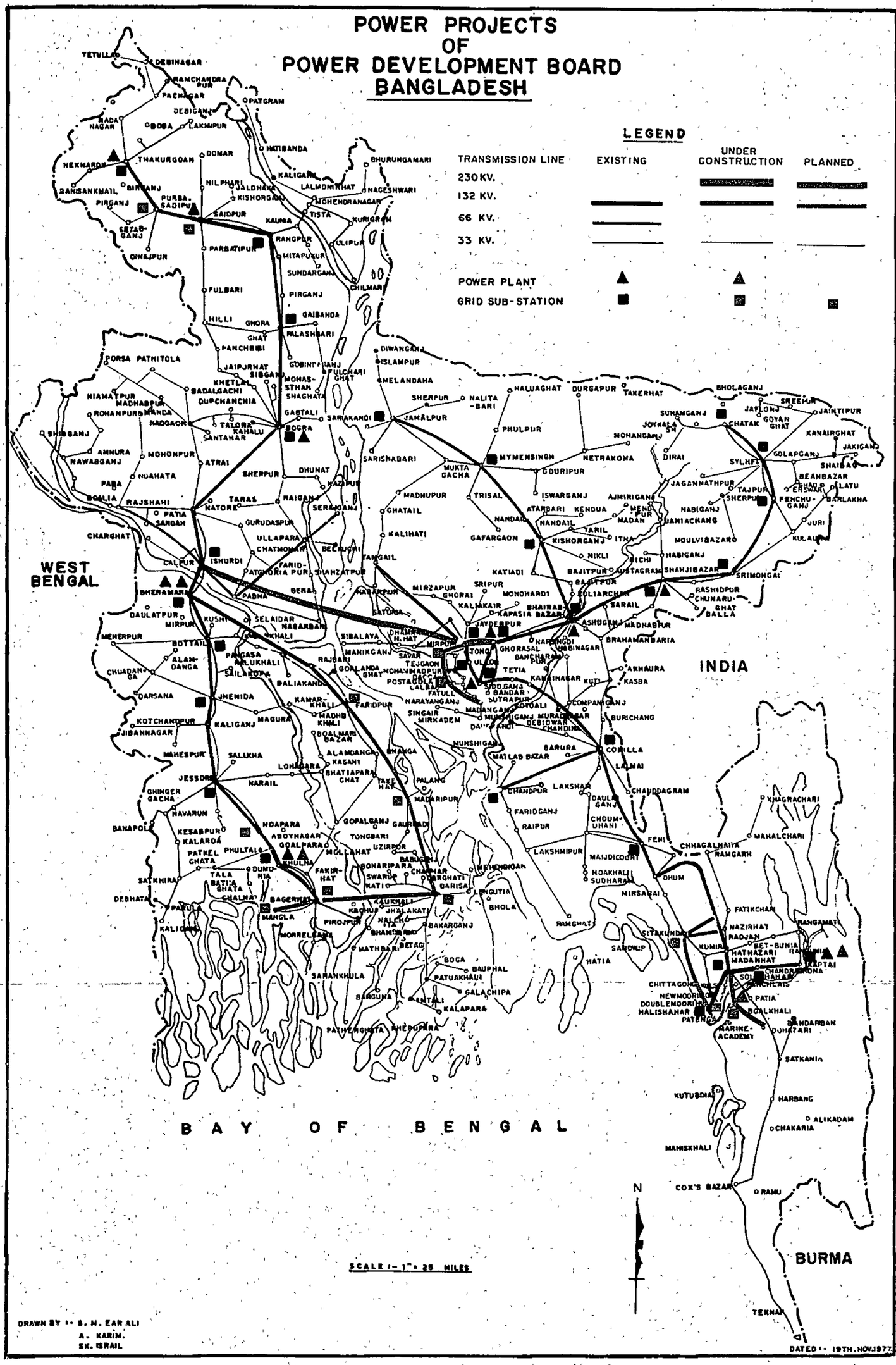
A load dispatching center for control of the entire power system of Bangladesh, including the eastern and western grids, is under construction at the Siddhirganji substation, adjacent to the existing eastern grid load dispatching office. Financial aid for construction has been provided by Canada and the start of operations is expected by 1980.

SV (supervision) and TM (telemetery) equipment for the entire system, including the eastern and western grids, will be installed upon completion of the central load dispatching facility, making possible speedy and efficient operation of the system.

A microwave telecommunications system will also be constructed between the central load dispatching facility and the western load dispatching center in Khulna.

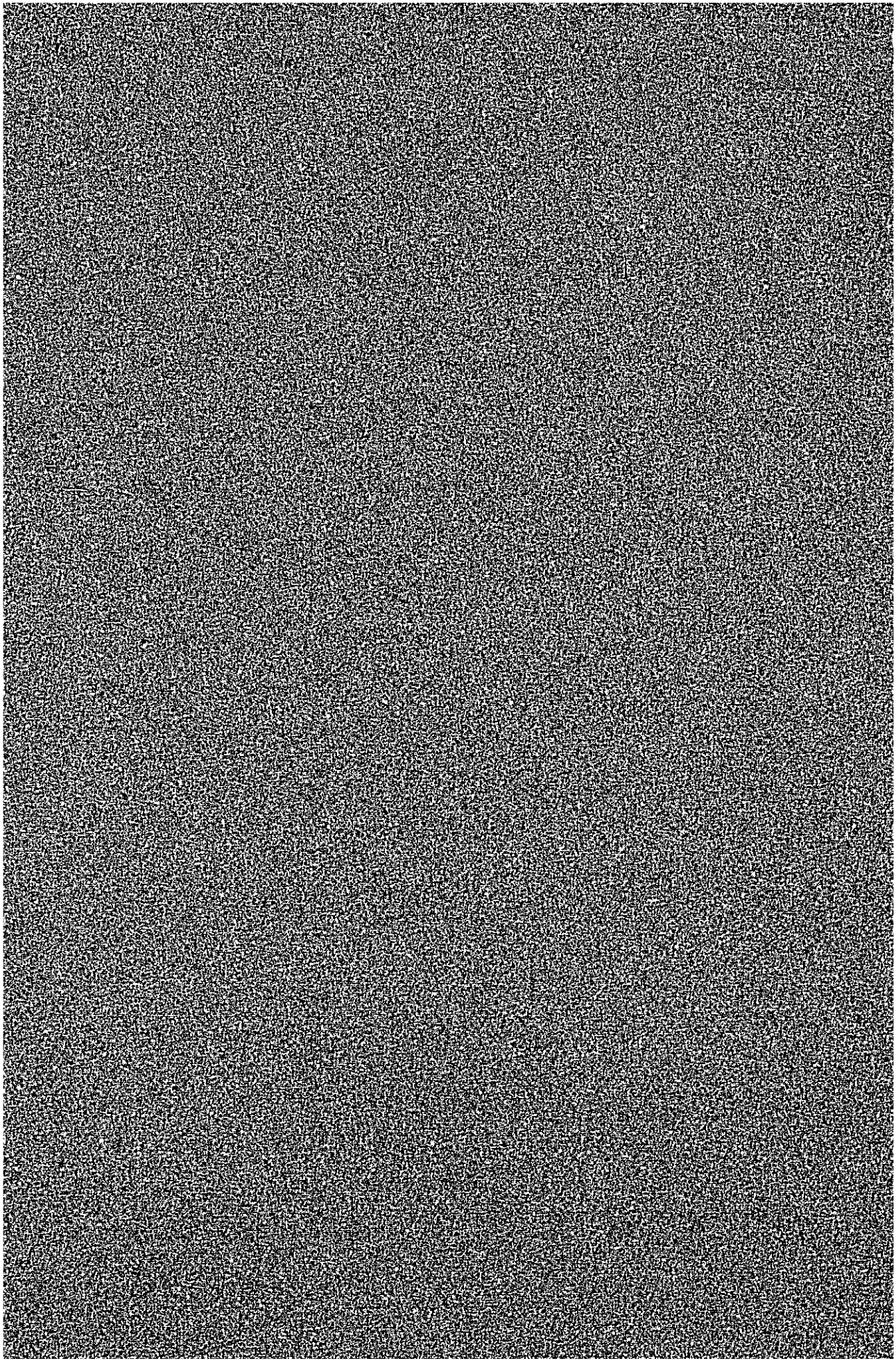
After completion of the 230kV east-west interconnection line, expected to go into operation in 1983, the two (2) grids will be interconnected by means of the power line carrier telephone. Consequently, duplication of the communication circuit will reinforce considerably the exchange of information between the two (2) grids.

POWER PROJECTS
OF
POWER DEVELOPMENT BOARD
BANGLADESH



CHAPTER 5

POWER DEMAND AND SUPPLY



CHAPTER 5 POWER DEMAND AND SUPPLY

5-1 Power Demand Forecast

Survey team made the power demand forecast for planned district and zone, taking into consideration the past tendency of actual demand in Bangladesh, sector-wise load demand forecast assumed and macroscopic demand forecast.

5-1-1 Power Demand in Bangladesh

Maximum load of the eastern zone in 1978 was 287,323 kW, consisting of 285,800 kW in the grid system, and 1,523 kW in isolated areas. In comparison, in the western zone load in the grid system is 94,360 kW, and load in isolated areas is 14,278 kW, totaling 108,638 kW. (Refer to Table 5-1)

In the western zone load in isolated areas is approximately 10 times larger than that in the eastern zone. This is due to the fact that in the western region the trunk system does not cover the entire region. Many local areas are served by independent diesel engine power plants. According to statistical data, load in the isolated areas in the western zone is gradually decreasing, indicating development of power system are progressing.

The monthly maximum demands in the western zone are summarized in Figure 5-1 and Table 5-1.

The dry season presents a larger demand than the rainy season, due to the more intensive industrial activity, and to a higher operation rate for the irrigation pumps.

The electric power demands and the growth rates in Bangladesh during the last six (6) years are summarized below. (According to the 1977/1978 Annual Report)

Actual power demand (BPDB)

Year	Maximum Demand in MW		
	Eastern Zone	Western Zone	System Total
1972-73	174.395	47.179	221.574
1973-74	184.845	65.262	250.107
1974-75	198.762	67.257	266.019
1975-76	219.917	81.417	301.334
1976-77	253.995	88.303	341.998
1977-78	287.323	108.638	395.961
Average growth rate in the last five (5) years	11%	18%	12%

As the data above shows, Bangladesh shows a rather high growth rate. Especially in the western zone the demand is being supressed, in view of the weakness of the power supply system. A considerable growth of demand is expected to occur in the western zone after augmentation of the system.

5-1-2 BPDB's Forecast

According to the Project Proforma of the BPDB in 1978, the growth rate of the demand in the western zone and in the eastern zone is expected to be as follows.

In the eastern zone the power system is better equipped and in addition, their industrial activity is more developed, mainly around Dacca, the capital city, and Chittagong. A growth rate of 11% will be expected up to 1990. Thereafter, the growth rate is expected to slow to 9%.

Western zone power network equipment development is far behind the eastern zone, and in addition there is shortage of power, as stated previously. Consequently, after augmentation of the power system, a growth rate of 16% is expected until 1990. Thereafter, the growth rate is expected to slow to 11%.

5-1-3 Power Demand and Future Scheme in Faridpur District

In the Faridpur district, where the new 132 kV transmission line will be constructed, many cases of load shedding and load staggering occur because it is impossible to cope with all of the applications of consumers.

For example, Madaripur Jute Mill Ltd., located in this district, has installed an independent power generation plant (500 kW x 2 units), but the factory still has a 150 kW shortage of power necessary to guarantee daily production. The company is coping with the situation by doing overtime work, contracting temporary employees, etc., but a stable supply of power by the BPDB is earnestly hoped for.

(1) Agricultural Load

In the Faridpur district there is no remarkable industrial activity and most residents depend upon agriculture for their subsistence.

Consequently, the use of pumps for irrigation is indispensable in this district. Approximately 6% of these pumps are actuated by means of electric power, the remaining 94% being powered by locally installed diesel generator plants.

The BADC (Bangladesh Agricultural Development Corporation) is in charge of the development of this irrigation project. Current status of irrigation facilities existing in the Faridpur district is summarized in the following table.

BADC irrigation pump

Type of pump	Cap./ 1 set	Electri-fied (unit)	Diesel plants (unit)	Total unit	Power required after electrification (1989)
Shallow tube well	3 kW	7 sets	349 sets	356 sets	$356^{sets} \times 3^{kW} \times 0.6^{*} = 640^{kW}$
Deep tube well	15 kW	46 sets	214 sets	260 sets	$260^{sets} \times 15^{kW} \times 0.6^{*} = 2,340^{kW}$
Low lift pump	5 kW	93 sets	1,637 sets	1,730 sets	$1,730^{sets} \times 5^{kW} \times 0.5^{*} = 4,320^{kW}$
Total	-	146 sets	2,197 sets	2,346 sets	* diversity factor $7,300^{kW}$

The irrigation pumps are used primarily in the dry season lasting from November to April. During the rainy season they are not used because the area is flooded.

The cost (fuel and personnel expenditures) for operating a 15 HP pump 8 hours a day is approximately 72TK/day for diesel engines, and approximately 34TK/day for electric motors, illustrating the cost saving effect of electrification. Consequently, electrification of irrigation pumps in this area is urgently required.

BADC intend to electrify the whole pumps shown above by 1989.

Required power demand in 1989 will be assumed to be 7.3 MW for 2,346 sets of irrigation pump on the assumption of the diversity factor of 50% to 60%

In order to cope with flood and drainage problems in this area, the WDB (Water Development Board) is executing the Faridpur Project. This project covers the construction of 212 miles of dikes, with drainage of water during the rainy season and irrigation during the dry season.

The project covers an area of 905,000 acres, with irrigation of 653,000 acres, and is expected to give strong impetus to agricultural development in the region.

Irrigation pumps and power required by that project are summarized in the following table.

WDB irrigation project

Faridpur project

Location	No. of Pumps	Capacity (HP)
Gorai Pump Station	3	2,550
Gauges Pump No. 1	6	3,300
" " No. 2	4	2,600
" " No. 3	3	2,800
Shekpara	5	1,250
Kabirajpur	5	1,250
Muksadpur	36	2,035
Total	62	15,785 HP (11,838 kW)

Faridpur - Barisal Project*

Location	No. of Pumps	Capacity (HP)
Kabirajpur	41	2,005
Gopalganj - Madaripur	162	5,800
Total	203	7,805 HP (5,853 kW)

Note: * Data above concerns the Faridpur district covered by the Faridpur - Barisal Project.

The quantity of pumps and necessary power listed above have been calculated by taking 1989 as the target year.

The total required power will be assumed to be 14,150 kW, taking into account a diversity factor of 80%.

$$(11{,}838 \text{ kW} + 5{,}853 \text{ kW}) \times 0.8 = 14{,}150 \text{ kW}$$

(2) Residential Load

The Faridpur district is composed of five (5) sub-divisions and 26 thanas. It has a population of approximately four (4) million in the 720 thousand households. Of the 26 thanas, 17 are actually electrified, with nine (9) not yet electrified.

Most of the residential load is for lighting (the most common rural household has only two (2) bulbs of 60 W). Air conditioning equipment and electrical home appliances are rare and are negligible with regard to total load.

According to the 2nd 5 years plan (1980 ∿ 1985) proceeded by the BPDB, the rural electrification will be made by 20% of rural region by 1985. Accordingly, the total assumed demand in 1985 will be 8,640 kW (720,000 x 120W x 20% x 50%) taking into account the diversity factor of 50%. And demand in 1989 will be 12,650 kW assuming 10% of annual growth rate after 1985.

(3) Industrial Load

The present industrial load in the district is composed of the following factories.

- Eastern Milk Producers Co-operation Union Ltd.
  This Union operates the Faridpur Pasteurization Plant, which requires approximately 500 kW.

- The Goalanda Textile factory consumes approximately 500 kW.

- Faridpur Sugar Mill
  This sugar mill consumes approximately 200 kW.

Total industrial load including small scale industrial load in Faridpur district is 3.15 MW, in 1977/78.

Following industrial loads are expected in future.

- Bangladesh Textile Mills Corp.
  This factory is under construction in Madaripur. Completion is expected in 1981 and the factory will require 2.5 MW.

- Madaripur Jute Mills Ltd.
  As mentioned earlier, this factory has independent power generation plants but is urgently in need of stable supply of approximately 800 kW.
  This project will solve the problem with shortage of power.

From the above aspect, the forecasted load in 1989 will be 6,300 kW.

(4) Consideration

Sector-wise load growth upto 1989 in Faridpur district are presented below.

Sector-wise load growth (Unit: MW)

Year		1979/78	1989
Agriculture	BADC	0.64	7.3
	WDB	0	14.15
Industrial		3.15	6.3
Residential		0.5	12.65
Others		0.02	* 0.4
Total		4.3	40.8

Note:

1. Numerals in 1977/78 denotes the actual demand.
2. * One (1) % of total demand.

An extremely high average growth rate of the order of 23% is expected for the 10 year period lasting from 1978 (4.3 MW) to 1989 (40.08 MW).

It must be noted, however, that the demand mentioned above is intimately related with the irrigation and rural electrification projects.

Taking into account that these projects may encounter delays in implementation or reduction of scale due to financial problems, and the diversity factor for individual demands, 70% of the growth rate of 23% calculated above, i.e., 16% seems to be an appropriate value as the annual growth rate for this district.

From above consideration, the expected demand for the Faridpur district are assumed to be 21.7 MW as mentioned in Table 5-2.

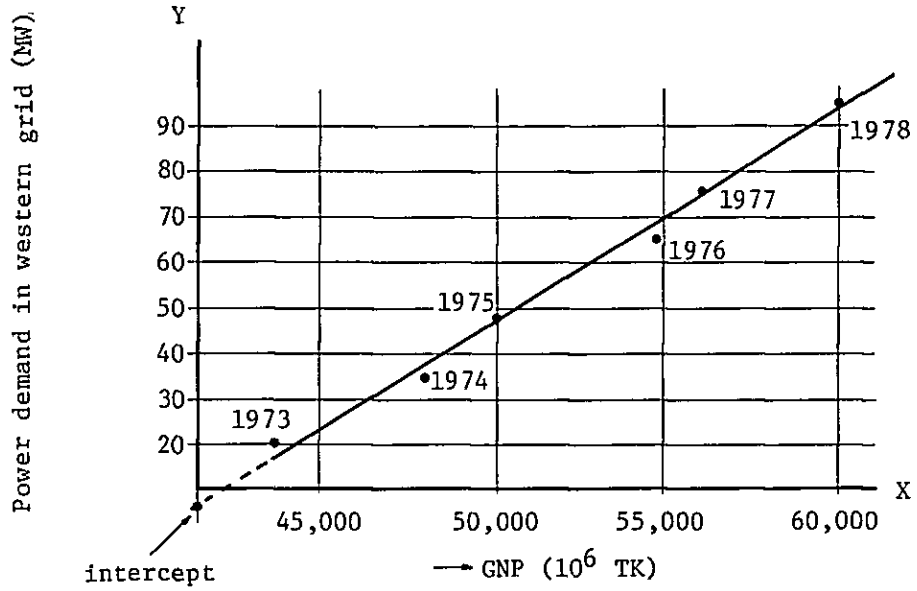
5-1-4 Macroscopic Demand Forecast

The survey team has calculated the demand forecast of the western zone by relating it macroscopically with the growth of the GNP (Gross National Product). This is a method for estimating the future demand by adopting a correlation between past power demand and economic indexes of GNP.

The relationship between the GNP and power demand generally indicates a correlation of linear function when viewed from a long-term perspective, as shown below.

Relationship of GNP and power demand

Year	1972/73	73	75	76	77	78
Power demand (MW), X in western grid	22	33	47	63.9	75.5	94.36
GNP (10^6 TK) , Y in Bangladesh	43,203	47,906	50,101	54,734	55,855	60,005



This correlation is expressed by the following formula;

$$Y = a + bX$$

where Y : Power demand
ΣX : GNP
a : Y intercept
b : Gradient

In consequence,

$$a = \frac{\Sigma Y - b\Sigma X}{N} = -178.93$$

$$b = \frac{\Sigma XY - \frac{\Sigma X \Sigma Y}{N}}{\Sigma X^2 - \frac{(\Sigma X)^2}{N}} = \frac{1}{221.24}$$

where N : Number of data

$$Y = -178.93 + \frac{X}{221.24}$$

Hence, the power demand forecast is calculated by substituting the values of expected GNP on the assumption of 8%* ∿ 9% annual growth rate, in above formula. The calculated power demand and GNP are given in Figure 5-3.

The calculated values show a growth of demand similar to that forecasted by the BPDG, i.e., 16% until 1990, and 11% thereafter, suggesting that these figures are reasonable.

5-1-5 Forecasted Value of Power Demand

From the considerations above, the expected demand for the western zone and the Faridpur district are assumed to be as follows:

a. Annual growth rate — Until 1990 16%
After 1990 11%

b. Forecasted demand
Detailed data for forecasted demand contained in Table 5-2 is summarized as below.

Forecasted demand

Year	1979	1983	1986	1989	1992	1995
Western zone	110 MW	199.2	310.9	485.3	693.5	948.5
Faridpur district	4.8 MW	8.9	14.0	21.7	31.1	42.5

(Note) * Arguments endorsing 8%-9% GNP growth rate are explained at the end of this Chapter.

[Explanation of 8% - 9% GNP growth rate]

The Bangladesh Bureau of Statistics gives the following net GNP statistics:

Actual net GNP

Year	72/73	73/74	74/75	75/76	76/77	77/78
Total amount (10^6 TK)	43,203	47,906	50,101	54,734	55,855	60,005

Summarizing the above results, an average growth rate of the order of 7% for the period through 1972/73 - 77/78 might be calculated.

The government of Bangladesh is earnestly devoted to economic development and recognizes the importance of securing funds for this purpose. The Government is therefore making efforts to establish an economic structure well balanced between the public and private sector. In addition to foreign financial support, the government has plans to reinforce the capacity of fund raising within the country in order to accelerate reconstruction of the economy.

As there are many examples of developing countries, which attained high GNP growth rates with overseas aid and the strong drive of the government towards economic development, survey team is convinced that this country can increase the growth by 1% to 2%. Survey team assumes in this report a growth rate of 8 - 9% based upon the arguments presented above.

Fig. 5-1 Monthly Peak Demand in Western zone

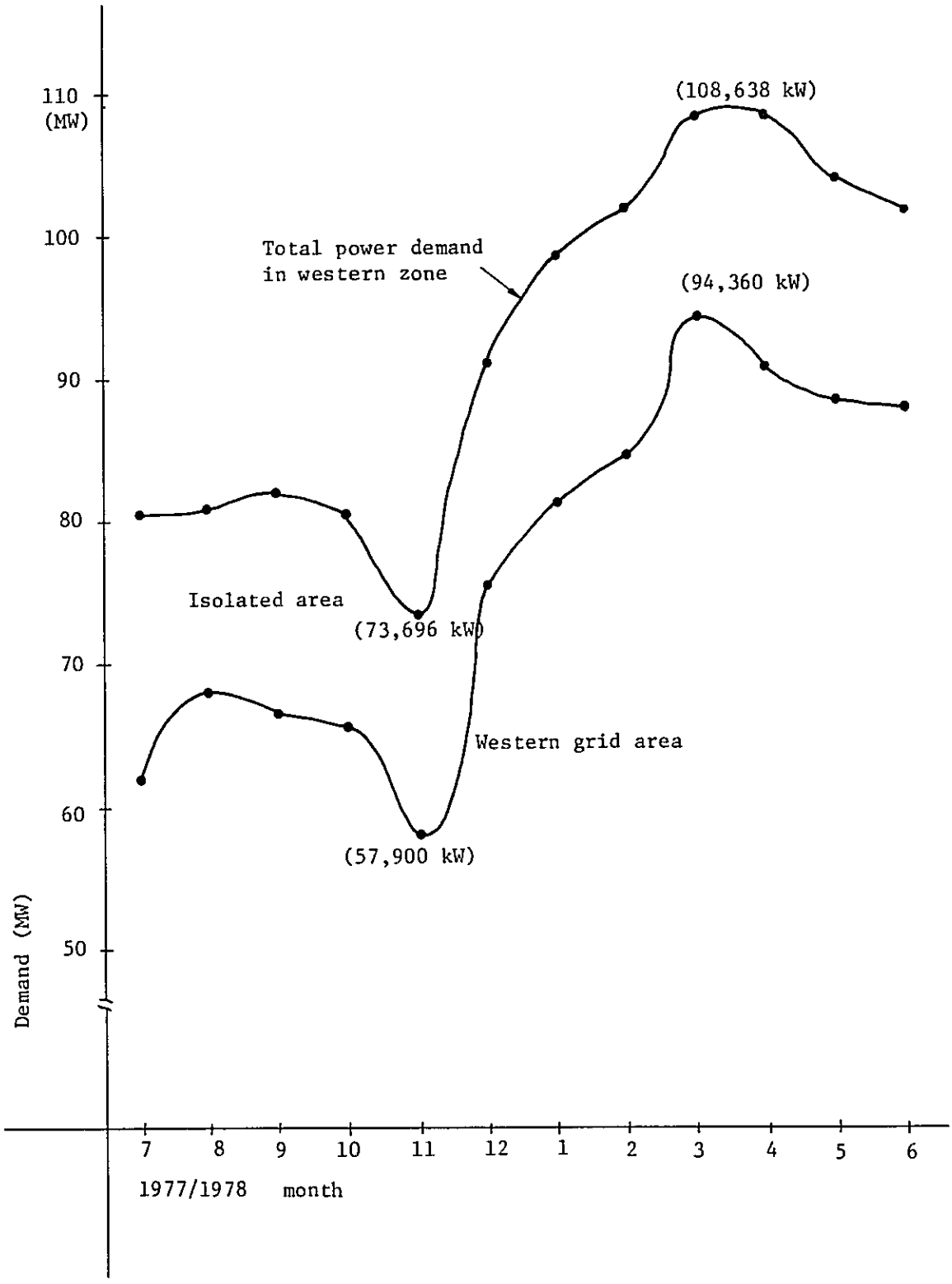


Table 5-1 Monthly Peak Demand (KW) (1977 - 1978)

Month	Eastern grid	Eastern isolated	Eastern zone	Western grid	Western isolated	Western zone	System total
7	246,000	378	246,378	67,300	14,243	81,543	327,921
8	250,900	338	251,238	68,050	13,678	81,728	332,966
9	268,000	270	268,270	66,830	15,429	82,259	350,529
10	280,500	290	280,790	65,850	14,793	80,643	361,433
11	266,100	331	266,431	57,900	15,796	73,696	340,127
12	261,100	343	261,443	75,500	16,010	91,510	352,953
1	277,300	1,535	278,835	81,200	16,976	98,176	377,011
2	269,500	2,175	271,675	84,820	17,383	102,203	373,878
3	283,700	1,661	* 285,361	94,360	14,278	* 108,638	393,999
4	280,400	1,241	281,641	91,100	17,508	108,608	390,249
5	285,800	1,523	287,323	88,540	16,233	104,773	392,096
6	281,900	1,582	283,482	88,550	13,892	102,442	385,924

* Peak demand

Fig. 5-2 Power Demand Forecast in Western grid (MW)

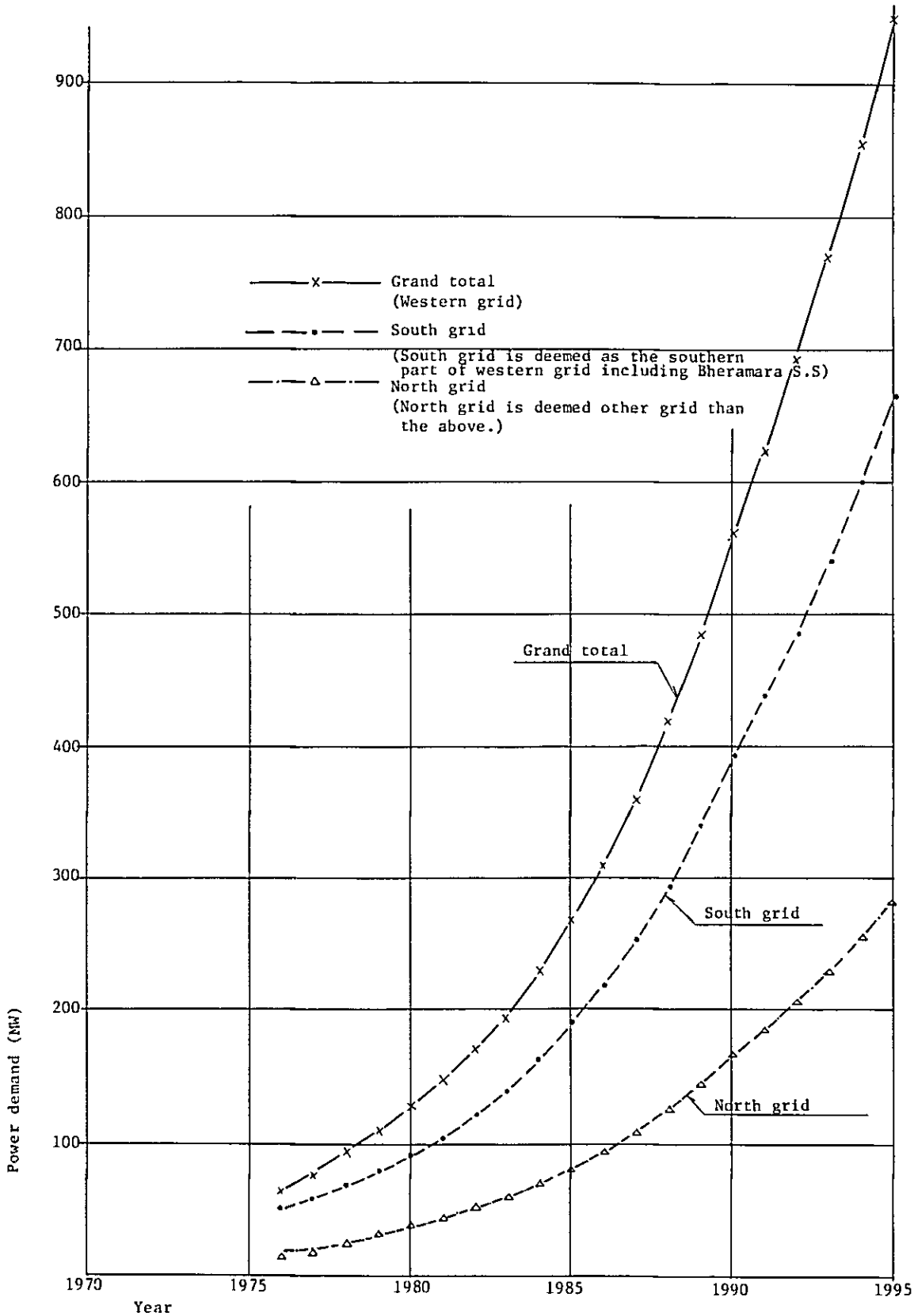
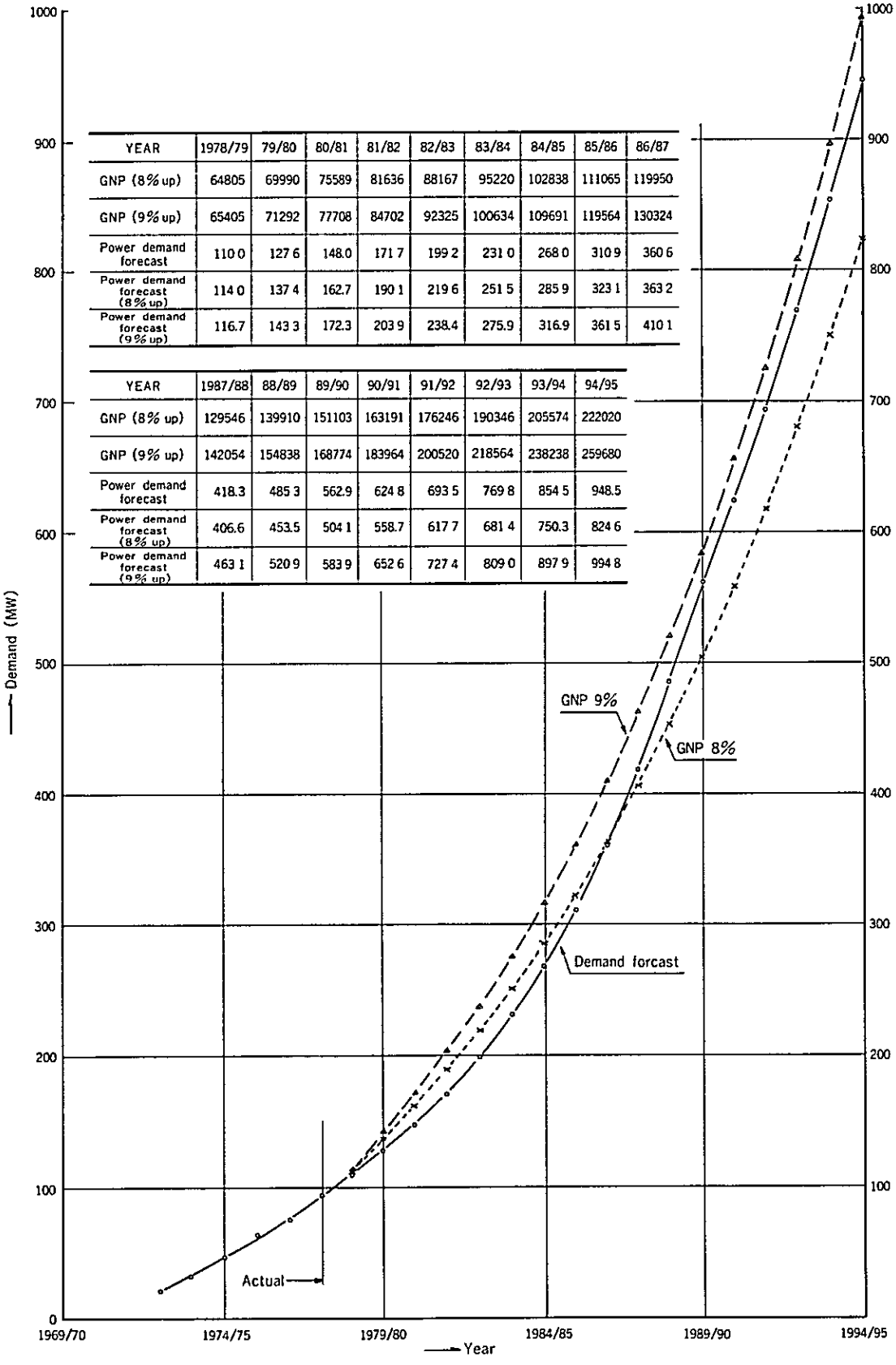


Table 5-2 Power Demand Forecast in Western Grid (MW)

Year	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
Rajbari	1.0	1.2	1.5	1.7	2.0	2.3	2.7	3.1	3.6	4.2	4.9	5.7	6.6	7.6	8.9	9.9	11.0	12.2	13.5	15.0
Faridpur	1.2	1.4	1.8	2.0	2.4	2.8	3.2	3.8	4.4	5.1	5.9	6.8	7.9	9.2	10.6	11.8	13.1	14.5	16.1	17.9
Madaripur	0.7	0.8	1.0	1.1	1.3	1.5	1.7	2.0	2.4	2.7	3.2	3.7	4.3	4.9	5.7	6.3	7.0	7.8	8.7	9.6
Faridpur district Sub total	2.9	3.4	4.3	4.8	5.7	6.6	7.6	8.9	10.4	12.0	14.0	16.2	18.8	21.7	25.2	28.0	31.1	34.5	38.3	42.5
Bheramara	6.9	8.1	11.7	12.2	14.0	16.2	19.0	22.0	25.2	29.8	34.0	39.5	45.9	53.4	61.7	68.6	76.1	84.4	94.1	104.0
Barisal	2.5	3.0	3.7	4.3	5.0	5.8	6.7	7.8	9.1	10.5	12.2	14.1	16.4	19.0	22.1	24.5	27.2	30.2	33.5	37.2
Bagerhat	0.8	0.9	1.1	1.3	1.5	1.7	2.0	2.3	2.7	3.2	3.7	4.2	4.9	5.7	6.6	7.3	8.1	9.0	10.0	11.1
Khulna	28.1	32.6	37.8	43.0	49.9	57.9	67.1	77.9	90.3	104.3	121.5	141.0	163.5	189.7	220.0	244.2	271.1	300.9	334.0	370.8
Jessore	3.6	3.9	4.2	4.5	5.2	6.1	7.0	8.1	9.5	11.0	12.7	14.8	17.1	19.9	23.0	25.6	28.4	31.5	34.6	38.8
Jhenidha	2.2	2.5	3.8	3.0	3.5	4.0	4.7	5.4	6.3	7.3	8.5	9.8	11.4	13.2	15.4	17.0	18.9	21.0	23.3	25.9
Bottail	2.9	3.2	3.5	4.0	4.6	5.4	6.2	7.2	8.4	9.7	11.3	13.1	15.2	17.6	20.5	22.7	25.2	28.0	31.1	34.5
South grid Sub total	49.9	57.6	69.1	77.1	89.4	103.7	120.3	139.6	161.9	187.8	217.9	252.7	293.2	340.2	394.5	437.9	486.1	539.5	598.9	664.8
North grid	14.0	17.9	25.26	32.9	38.2	44.3	51.4	59.6	69.1	80.2	93.0	107.9	125.1	145.1	168.4	186.9	207.5	230.3	255.6	283.7
Grand total	63.9	75.5	94.36	110.0	127.6	148.0	171.7	199.2	231.0	268.0	310.9	360.6	418.3	485.3	562.9	624.8	693.5	769.8	854.5	948.5
Energy (GWH)	318.8	372.8	448.6	475.2	551.2	639.4	741.7	860.5	997.9	1157.8	1343.0	1557.8	1807.1	2096.5	2431.7	2669.1	2995.9	3324.5	3691.4	4092.5

Fig. 5-3 Inter-relation Curve between GNP & Power Demand



YEAR	1978/79	79/80	80/81	81/82	82/83	83/84	84/85	85/86	86/87
GNP (8% up)	64805	69990	75589	81636	88167	95220	102838	111065	119950
GNP (9% up)	65405	71292	77708	84702	92325	100634	109691	119564	130324
Power demand forecast	110 0	127 6	148.0	171 7	199 2	231 0	268 0	310 9	360 6
Power demand forecast (8% up)	114 0	137 4	162.7	190 1	219 6	251 5	285 9	323 1	363 2
Power demand forecast (9% up)	116.7	143 3	172.3	203 9	238.4	275.9	316.9	361 5	410 1

YEAR	1987/88	88/89	89/90	90/91	91/92	92/93	93/94	94/95
GNP (8% up)	129546	139910	151103	163191	176246	190346	205574	222020
GNP (9% up)	142054	154838	168774	183964	200520	218564	238238	259680
Power demand forecast	418.3	485 3	562.9	624 8	693 5	769 8	854 5	948.5
Power demand forecast (8% up)	406.6	453.5	504 1	558.7	617 7	681 4	750.3	824 6
Power demand forecast (9% up)	463 1	520 9	583 9	652 6	727 4	809 0	897 9	994 8

5-2 Power Generation Plants

5-2-1 Current Status of Power Generation Plants

As of 1978 the installed generating capacity of plants (Note 1) belonging to the BPDB was 752MW while the available generating capacity (Note 2) was 557MW. This is shown in Table 5-4.

In the western zone (both western grid and isolated areas) the installed generating capacity was 226MW, while the available capacity was 148MW, corresponding to 65% of the installed capacity.

This derated capacity results from the use of obsolete equipment, constructed 20 to 30 years ago and the shortage of necessary spare parts.

The installed generating capacity of plants in the western grid is 203MW, while the available capacity is 92MW, which means 45% of the installed capacity.

The firm capacity (Note 3) is approximately 48MW (refer to Table 5-3).

Note 1 Installed generating capacity means rated capacity of the generator.

Note 2 Available generating capacity means actual generating capacity of the generator derated.

Note 3 Firm capacity is calculated by taking into account maintenance, inspection and faults of the power generation plants. The firm capacity value is obtained by deducting the capacity of the largest and third largest generator units from the available capacity.

The following data is for power generation plants in the western grid existing in 1979.

Name of power plant	Installed capacity (MW)	Available capacity (MW)	Year of construc-tion	Presumed life
Khulna				
STG (oil)	60 MW x 1	40	1973	1997
STG (oil)	4MW x 4 = 16	8	1941	1982
GTG (Naphtha)	12.75MW x 2 = 25.5	0	1968	1984
GTG (Naphtha)	7.5MW x 1	4	1969	1983
DPG (HSD)	0.8MW x 6 = 4.8	3	1956-58	1981
Bheramara				
GTG	20MW x 2 = 40	20	1976	1992
Barisal				
DPG	1.5MW x 4 = 6	2.7	Unknown	1982
"	1.0MW x 3 = 3	1.8		1982
"	1.3MW x 2 = 2.6	0		1982
Rajshahi				
DPG	1.42MW x 3 = 4.26	1.5	Unknown	1983
Sirajganj				
DPG	0.87MW x 2 = 1.74 0.65MW x 2 = 1.3 1.23MW x 2 = 2.46	1.9	1969	1983
Bogra				
DPG	0.8MW x 1 = 0.8 1.3MW x 5 = 6.5	1.6	1966-69	1983
Saidpur				
DPG	3.75MW x 3 = 11.25	6.0	1975-77	1990
Thakurgaon				
DPG	1.5MW x 7 = 10.75	1.0	1964	1983
Total	203MW	91.5MW		

Fig. 5-4 Max. demand, Installed, Available and Firm Capacity (MW) in Western grid

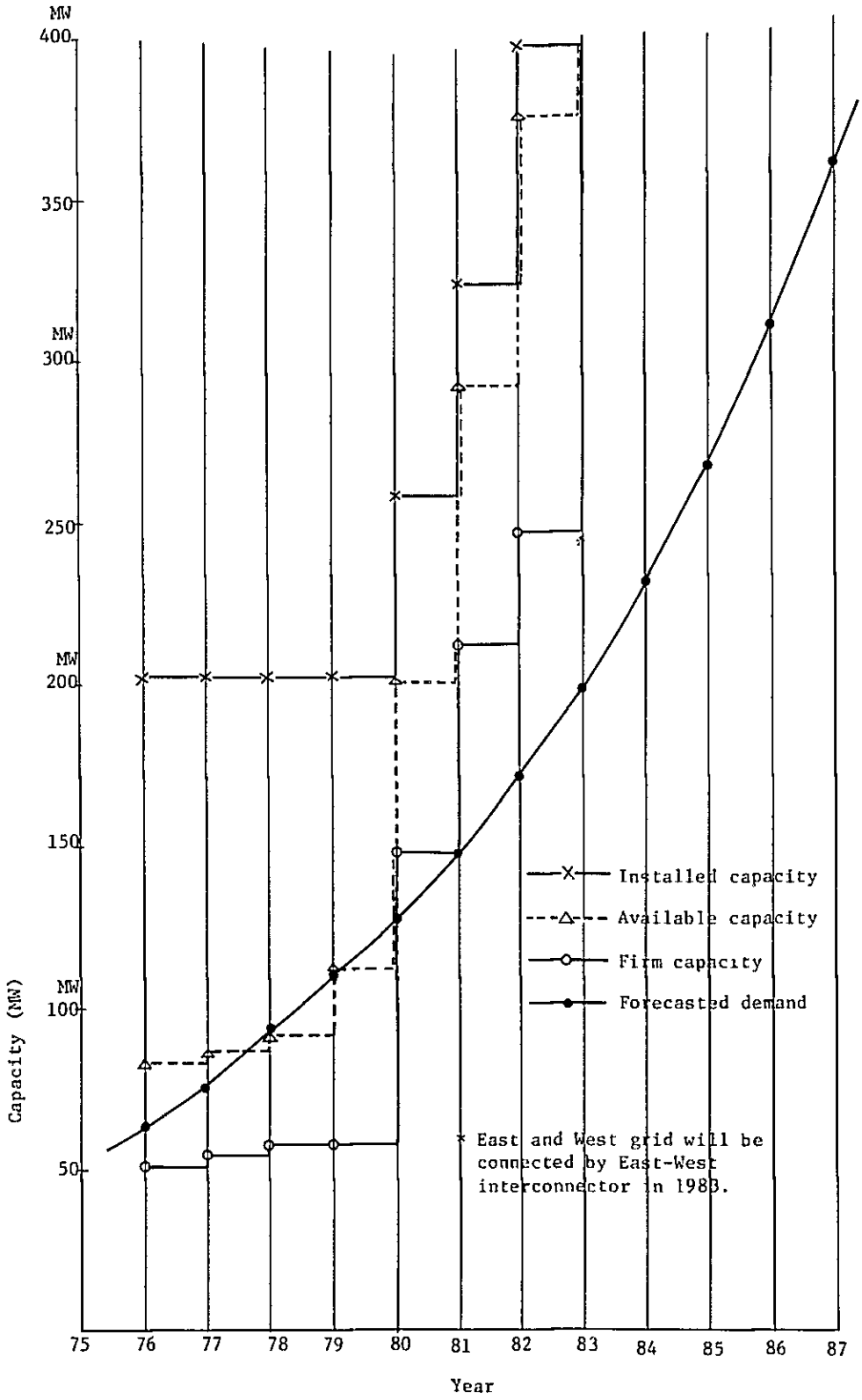


Table 5-3 Installed & Available Capacity in Western Grid

Power Station	type	Installed capacity		1978	'79 Mar	'79 Oct	'80 Mar	'80 Oct	'81 Mar	'81 Oct	'82 Mar	'82 Oct	'83 Mar	'83 Oct	'84 Mar	'84 Oct	'85 Mar	'85 Oct
Khulna	STG	110MW x1	110MW		-	-	-	-	-	-*	110	110	110	110	110	110	110	110
	"	60 x1	60	40	40	40	40	40	60	60	60	60	60	60	60	60	60	60
	"	4 x4	16	8	8	8	16	16	16	16	-**	-	-	-	-	-	-	-
	GTG	7.5 x1	7.5	4	4	4	6	6	6	6	6	6	-**	-	-	-	-	-
	"	12.75x2	25.5	0	0	0	10.4	12.0	12.0	12.0	12.0	12.0	12.0	12.0	-**	-	-	-
	"	28.0 x2	56	-	-	-*	56	56	56	56	56	56	56	Shifted after interconnector completed in 83.				
	DPG	0.8 x6	4.8	3	3	3	3	3	-**	-	-	-	-	-	-	-	-	-
	GTG	10.4 x1	10.4	-	-	-	-	-*	10.4	10.4	10.4	10.4	10.4	10.4	10.4	10.4	10.4	10.4
Bheramara	GTG	20 x2	40	20	20	40	40	40	40	40	40	40	40	40	40	40	40	40
	"	20 x1	20	-	-	-	-	-*	20	20	20	20	20	20	20	20	20	20
Barisal	DPG	1.5 x4	6.0	2.7	2.7	2.7	4.0	4.0	4.0	4.0	-**	-	-	-	-	-	-	-
	"	10 x3	3.0	1.8	1.8	1.8	2.0	2.0	2.0	2.0	-**	-	-	-	-	-	-	-
	"	1.3 x2	2.6	0	0	0	2.6	2.6	2.6	2.6	-**	-	-	-	-	-	-	-
	"	8.5 x3	25.5	-	-	-	-	-*	25.5	25.5	25.5	25.5	25.5	25.5	25.5	25.5	25.5	25.5
Rajshahi	DPG	1.42x3	4.26	1.5	1.5	1.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	-**	-	-	-	-
Sirajganj	"	0.87x2 0.65x2 1.23x1	4.27	1.9	1.9	1.9	1.9	3.5	3.5	3.5	3.5	3.5	3.5	-**	-	-	-	-
Bogra	"	1.3 x5 0.8 x1	7.3	1.6	1.6	1.6	1.6	5.0	5.0	5.0	5.0	5.0	5.0	-**	-	-	-	-
Saidpur	"	3.75x3	11.25	6.0	6.0	6.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0
	"	5.5 x2	11.0	-	-	-	-	-*	11.0	11.0	11.0	11.0	11.0	11.0	11.0	11.0	11.0	11.0
Thakurgaon	"	1.5 x7	10.5	1.0	1.0	1.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	-**	-	-	-	-
Total installed capacity			203	203	203	203	259	259	324	324	398	398	390					
Total available capacity				91.5	91.5	111.5	201	204	291	291	377	377	371					
Firm capacity				47.5	47.5	47.5	141	144	211	211	247	247	241					

▲East-West interconnector completed

1) Small generator and Standby generator are omitted.
2) Firm capacity means the remaining capacity which the 1st and the 3rd units in capacity extracted from the available capacity.

* Newly installed
** To be retired.

Table 5-4 Installed Generating Capacity and Available Capacity by Type of Fuel (KW)

(In 1977-1978)

		Eastern zone		Western zone	
		Installed capacity (KW)	Available capacity (KW)	Installed capacity (KW)	Available capacity (KW)
Zone total		525,575	408,406	226,563	148,587
Hydro turbine		80,000	88,000	-	-
Steam turbine	Coal	-	-	-	-
	Furnace oil	-	-	84,960	72,000
	Titas gas/ F. oil	318,000	258,425	-	-
Gas turbine	Shell gas	108,400	54,500	-	-
	Naphtha	-	-	32,700	5,000
	Diesel	-	-	40,000	40,000
Diesel		19,175	7,481	68,903	31,587
Total thermal capacity		445,575	320,406	226,563	148,587

5-2-2 Future Power Generation Plants

Of power generation plants in the western zone, the most modern ones are the 60MW steam generator in Khulna and the two (2) 20MW gas turbine plants in Bheramara, which are handling the base loads of this zone. All other plants are obsolete diesel plants which are barely fulfilling the demands of the zone. Construction of up-to-date generation plants is therefore urgently needed.

The following is a list of power plants presently under construction or with financing guaranteed.

1.	Khulna	110MW x 1	Steam plant
		Under construction, completion expected in 1981.	
2.	Bheramara	20MW x 1	Gas turbine
		Under construction, completion expected in 1980.	
3.	Khulna	28MW x 2	Gas turbine
		(Power plant barge)	
		Completion expected in 1980.	
4.	Barisal	8.5MW x 3	Diesel
		Completion expected in 1980.	
5.	Khulna	10.4MW x 1	Gas turbine
		Completion expected in 1980.	
6.	Saidpur	5.5MW x 2	Diesel
		Completion expected in 1980.	

As described above, power plants are being constructed and the system is being reinforced. In addition, with the completion of the east-west interconnection in 1983 it is expected that power generation capacity will be able to cope with demand.

After completion of the new plants, obsolete diesel plants will be shut down.

Table 5-3 summarizes the annual evolution plan for installed capacity, available capacity and firm capacity in the western grid. The desirable configuration for a power system is firm capacity exceeding demand. Data given in the table indicate an increase trend for firm capacity as a

consequence of construction of new power generation plants (Refer to Figure 5-4).

On the other hand, analysis of the western grid (including this project) and demand for the long term suggests that by 1993-1995 there will be a shortage of power source. Therefore, construction of power plants of 100MW x 2 in the Khulna area, which is the load center in the western grid, is recommended.

5-3 Power Situation and System Reinforcement Plan in the District Covered by the Project

The construction of 132 kV transmission line in the Faridpur district in the eastern region of the western zone is urgently required in view of the following facts.

5-3-1 Actual Power Demand and Supply

The power system in this area is now interconnected by means of a 33 kV single circuit power distribution line with a length of 160 miles (approximately 256km) between the Bottail substation and the Barisal substation and a partial section of 11 kV single circuit between Madaripur and Takerhat (Refer to Figure 5-5).

This line serves the whole area but, as noted in paragraph 5-1 above, whole western zone is affected by a shortage of power generation capacity. Consequently, it is impossible to supply sufficient power to this area. The power system is barely coping with demand (4,300 kW in 1978) and load shedding and load staggering is introduced.

Existing power generation plants in this district are listed below. Most are obsolete diesel plants which will eventually be shut down.

- Rajbari power station	650 kW x 1 unit	(Diesel)
	500 kW x 2 units	(Diesel)

Since the capacity of the step up transformer is 1,000 kW, maximum available capacity is restricted to 1,000 kW.

- Faridpur power station 200 kW x 2 units (Diesel)
  160 kW x 1 unit (Diesel)

  The maximum available capacity totals 200 kW.

- Madaripur power station 200 kW x 1 unit (Diesel)
  100 kW x 1 unit (Diesel)

  In addition to the units listed above there are three (3) more units presently out of operation. Their maximum available power amounts to 150 kW.

5-3-2 Plans for Reinforcement of the Power System

As described above, there are serious problems related to power demand and supply and the gap between them is increasing every year.

Most of the diesel generator units used during peak demand periods have already exceeded their expected life, and may be shut down soon. At present the system depends almost entirely on the 33 kV 0.1 dog (approximately 105mm^2) single circuit line coming from Bottail. However, since transmission is over a long distance, a large voltage drop results and since the capacity of the line is restricted to 15.5MW, after 1986 it will be impossible to guarantee stable power supply even by reinforcing the power sources of the existing western grid, as the data below indicate.

Existing 33 kV transmission capacity

Conductor size	Transmission capacity (MW)	Evolution of demand (MW)				
		1979	1984	1986	1987	1995
ACSR 0.1 (dog) Approx. 105 mm^2	$340^{A} \times 33^{kV} \times \sqrt{3} \times 0.8 \fallingdotseq 15.5$ MW	4.7	10.4	14.0	16.2	42.5

The problem might be solved by installing local power generation units in this district but this solution is not advantageous from the economical point of view, as discussed in the economic evaluation in Chapter 11.

Construction of an additional 33 kV transmission line as a solution to the problem is also unreasonable, in view of shortcomings such as voltage drop, transmission capacity, etc.

Consequently, the construction of a 132 kV transmission line in this district is indispensable.

In addition, the 132 kV trunk line will be interconnected with existing transmission lines to form a loop, and will consequently make possible stable and reliable power supply not only to this area but also to the entire western zone.

Fig. 5-5 Single Line Diagram of 33 kV Transmission Line from Bottail to Barisal (1978)