No. 1

BASIC DESIGN STUDY REPORT

ON

THE PROJECT FOR IMPROVEMENT

OF

THE GARDEN OF EDEN POWER STATION

IN

THE COOPERATIVE REPUBLIC OF GUYANA

JULY 1989

JAPAN INTERNATIONAL COOPERATION AGENCY

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PREFACE

In response to the request of the Government of the Cooperative Republic of Guyana, the Government of Japan has decided to conduct a Basic Design Study on the Project for the Improvement of Garden of Eden Power Station and entrusted the study to the Japan International Cooperation Agency (JICA). Based on the results of a study on development master plan, entitled "ELECTRIC POWER DEVELOPMENT IN THE COASTAL AREA", which was carried out from July 1988 to May 1989. JICA conducted a supplementary domestic study from June 1 to 30, 1989.

This report has been prepared on the basis of the supplementary study.

I hope that this report will serve for the development of the Project and contribute to the promotion of friendly relations between our two countries.

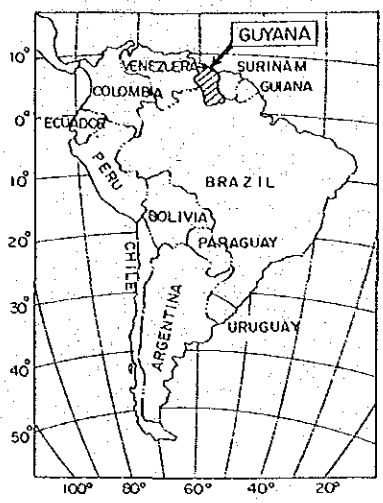
I wish to express my deep appreciation to the officials concerned for their close cooperation extended to the team.

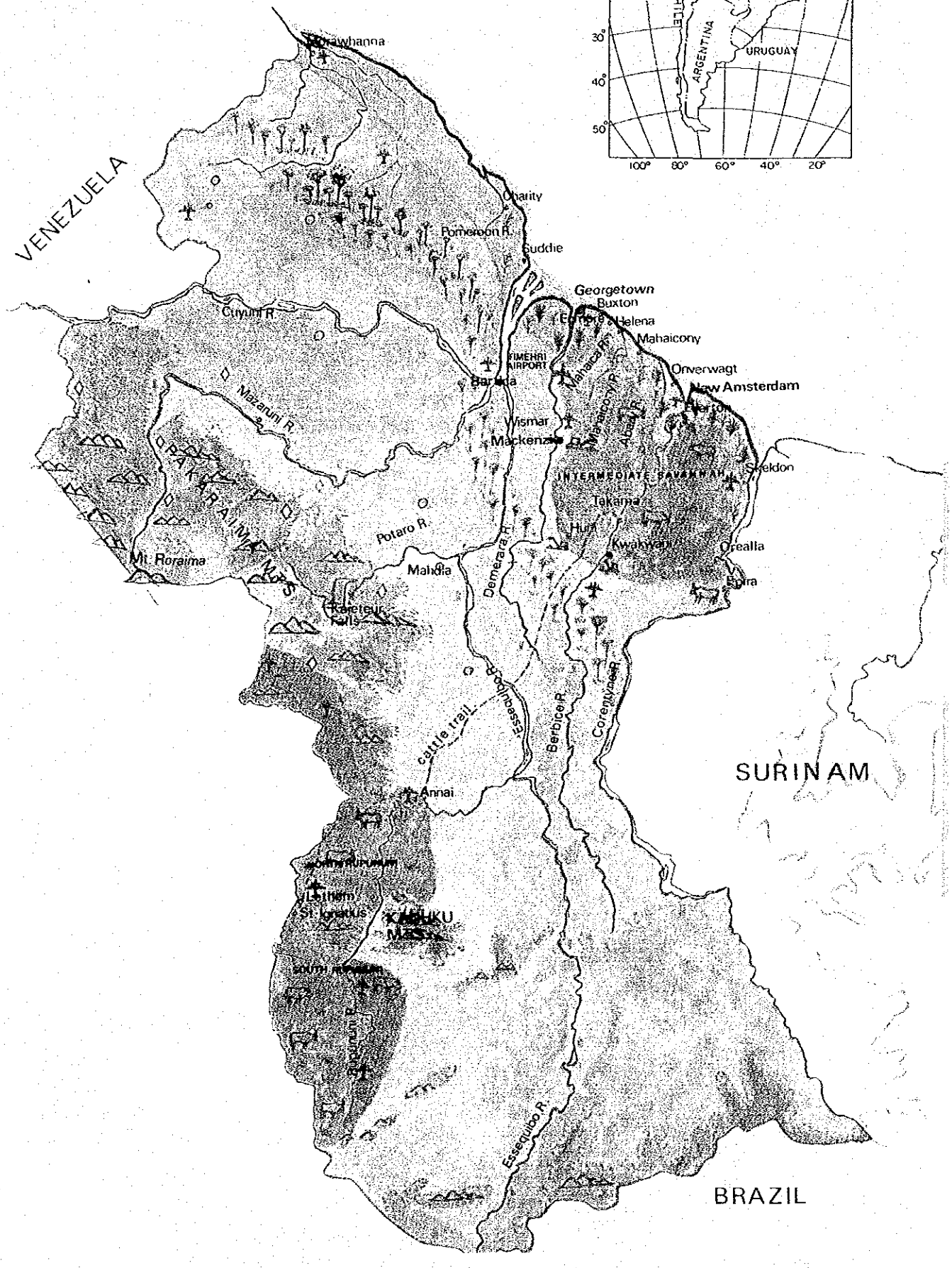
July, 1989

Kensuke Yanagiya

Kensuke Yanagiya
President
Japan International Cooperation Agency

THE COOPERATIVE REPUBLIC OF GUYANA





ANNA REGINA GEN. STATION

MAP of the SEACOAST of GUYANA
Compiled and drawn in the CARTOGRAPHIC DIVISION from the records of the SURVEY DIVISION, LANDS DEPARTMENT Ministry of Agriculture.
March 1972
SCALES

SOPHIA FREQUENCY CONVERTER STATION & SUBSTATION

KINGSTON GEN. STATION

ONVERWAGT GEN. STATION & SUBSTATION

WAKENAAM GEN. STATION

VERSAILLES GEN. STATION

RUIMVELDT GEN. STATION

GARDEN-OF-EDEN GEN. STATION & SUBSTATION

BARTICA GEN. STATION

LINDEN SUBSTATION

FREQUENCY CONVERTER STATION

ATION

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MAP
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SEACOAST of GUYANA
Compiled and drawn in the CARTOGRAPHIC DIVISION
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LANDS DEPARTMENT, Ministry of Agriculture
April, 1971
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Sheet 1 of 3 Sheets

ONVERWAGT GEN. STATION
& SUBSTATION

CANEFIELD GEN. STATION
& SUBSTATION

NO. 53 SUBSTATION

KEY

69 kV. TRANSMISSION LINE

13.8 kV Distribution Line

11 kV

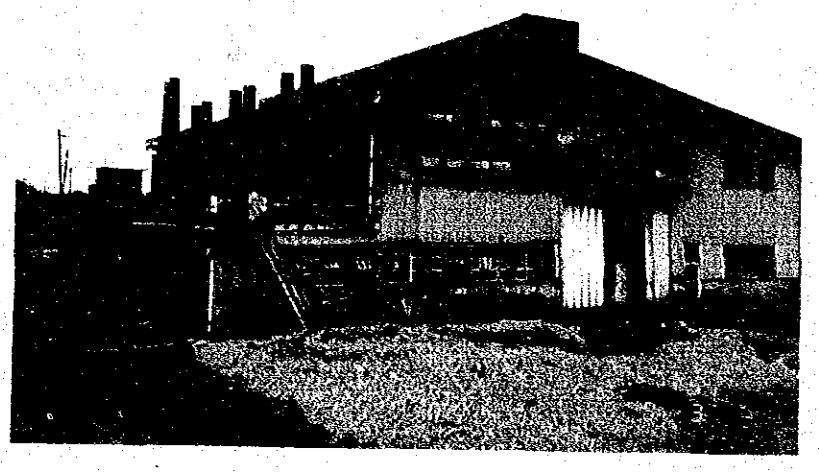
GARDEN-OF-EDEN GEN. STATION
& SUBSTATION

LINDEN SUBSTATION

S U R I N A M

Garden of Eden Power Station

(5.7MW × 3)



SUMMARY

SUMMARY

The Cooperative Republic of Guyana is situated in the northeastern corner of the South American Continent facing the Atlantic Ocean between at latitudes approximately 1° and 8° North.

The area of the country is approximately 215,000km^2, and the population is approximately 800,000, as of 1984. The nation was independent from the United Kingdom in 1966. The capital city is Georgetown.

Guyana's economy is supported mainly by the production of bauxite, sugar and rice. In particular, exports of bauxite represent 50% of the country's total exports.

In 1985, the major economic indicators were US$473.3 million in GDP, US$215 million in exports, and US$262 million in imports. The GDP per capita was US$493.

The Guyana Electricity Corporation (GEC) is the only public power supply corporation in the country. GEC was established in December, 1960 by the Government of Guyana by means of the purchase of the assets of the Demerara Electric Company. The installed capacity of the existing facilities in 1988, was 72.6MW; 42.6MW (59%) by diesel power generation and 30MW (41%) by steam power generation.

The Demerara/Berbice power system which supplies electricity to Georgetown and its suburbs, is the largest power system, having approximately 93% of Guyana's power generation facilities. There are three other small independent systems in the country.

The Demerara/Berbice electric system consists of four diesel power plants and one steam power plant. A total of 12 power generation units (capacity; 67.2MW, operation started from 1960 to the beginning of 1970) are operated.

However, the operation of four generation units (capacity; 19.7MW) has been suspended as of September, 1988. In addition, the maximum output of the operable units (capacity; 47.5MW) is restricted to 37.2MW. On the other hand, the maximum demand had enlarged up to approximately 46MW in 1987, thus resulted in a shortfall of approximately 9MW. The reason for this imbalance is that the majority of generation facilities were old, which

constructed between 1960 and the beginning of 1970, and some of them has been obsolete due to improper maintenance and shortage of spair parts.

In this situation, the Demerara/Berbice power system constantly enforces scheduled load shedding at peak demand despite it receives power from the Guyana Mining Enterprise (GUYMINE).

Concerned with this chronic power shortage (approx. 9MW), the Government of Guyana has planned the following projects as countermeasures.

* Renovation of existing facilities
  GEC is making effort to complete the renovation of existing facilities by 1990 with loans from the Inter-American Development Bank (IDB).

* Power development project in the coastal area
  In 1989, the Government of Guyana has made a master plan for the development of power generation facilities in the coastal area through technical cooperation by the Japanese Government.

As the result of the study which compiled in the "Report of The Master Plan on Electric Power Development Project in the Coastal Area", the imbalance of power supply/demand was confirmed. The maximum demand and energy requirement of the Demerara/Berbice system are estimated at 52.9 MW and 283.4 GWH in 1989, and 56.2 MW and 301.3 GWH in 1991.

A 11.2 MW shortfall in 1989 and a 14.5 MW shortfall in 1991 are respectively predicted.

Consequently, the development of the Garden of Eden Power Plant and Onverwagt Power Plant have been proposed as appropriate countermeasures.

The Government of Guyana has planned the development of the Garden of Eden Power Plant and Onverwagt Power Plant. Due to financial difficulties, however, the Government of Guyana requested the Japanese Government to provide grant-aid for the replacement of the old unit at the Garden of Eden Power Plant by a new diesel power generator (5.7 MW).

In response to this request, the Government of Japan decided to conduct a Basic Design Study and Japan International Cooperation Agency (JICA) carried out the study based on the survey results of the power development project in the coastal area. The team studied the most optimum scale of

development, the capability of Guyana to operate the plant when implemented, and the justification to implement the project with Japanese grant-aid.

Studies revealed that if the 7.8 MW unit of Onverwagt Power Plant is replaced with a new unit, there will be a 6.7 MW shortfall in power supply according to the projected power demand/supply in 1991. To remedy the demand/supply imbalance, the installation of a 5.7 MW diesel power generation is planned as the permissible maximum unit capacity considering the utilization of the existing site and foundation of diesel engine generator at the Garden of Eden Power Plant.

The outline of this generation unit is described below.

· Diesel engine	1 unit (8,070 ps)
· 3-phase alternating current generator	1 unit (5,700 KW)
· Control boards, switching apparatus, station service transformer and others	1 set
· Spare parts, tools, others	1 set

This power generation unit is to be installed in the existing building of the Garden of Eden Power Plant. The existing fuel supply system, cooling water system and overhead crane and other equipment are usable for the operation and maintenance of the new diesel power generator.

For the implementation of the project, the construction cost to be borne by the Government of Guyana is about G$1.65 million, that will be mainly applied to the removal of the existing equipment.

Regarding the construction period, 4 months will be required for detailed design work, and 13 months for manufacture, installation and test operation of the equipment.

The energy output, revenues and expenditures of the project are estimated below.

Generator output	: 5.7 MW
Annual energy generation (at generating end)	: 34,950 MWh
Annual energy sales	: 28,660MWh
Annual revenues	: G$24 million
Annual operation and maintenance costs	: G$23 million

The operation and maintenance costs for this unit after completion can be covered by the revenues from the sale of energy.

The fuel for the diesel power plant is imported from Venezuela through the Guyana National Energy Authority (GNEA), a government subsidized enterprise. Therefore, the fuel supply presents no problems.

The principal implementing organization of this project in Guyana side is the Department of International Economic Co-operation (DIEC), in the Office of the President.

GEC conducts the physical work for this project under the supervision of DIEC. Juding from the fact GEC has 15 years experience of diesel power plant operation, no difficulties are foreseen in the operation and maintenance of this diesel power plant.

For more safe operation and maintenance of this particular diesel power generation
unit, engineers from Japanese manufacturer will provide on-the-job training to the GEC's staffs through the period from site installation to test operation.

The expected benefits of this project are described below.

Direct effects

* Increased power generation will mitigate the imbalance in demand and supply of electricity. The imposed load shedding will be reduced from a few hours to approximately 1 to 2 hours during the peak demand hours.

* The thermal efficiency of the new unit is estimated about 43%, which is higher than thermal efficiency of 26.2% of the existing unit, resulting in savings in fuel costs of approximately G$6.7 million annually.

* Annual energy generation of the new unit is expected to be equivalent consumption of 12% of the total population (approx. 660 thousand) served by the Demerara/Berbice system.

* The estimated annual revenues from the new unit is G$24 million.

* Shut-down time for equipment inspection and repair is secured by the increased power supply capability.

Indirect effect

* Stable power supply will serve to stabilize the daily life of the people and enhance industrial activities.

From the abovementioned reasons, this project is fit for the "The Master Plan on Electric Power Development Project in the Coastal Area", and there are no particular technical problems in the operation and maintenance of the facility. Furthermore, the economic effects of the project is also viable. Therefore it is concluded that this project is justifiable for a Japanese grant-aid program.

In order to maintain the functions of the facilities over a long period of time, as many staffs as possible shall participate in the on-the-job training and carry out inspection and maintenance strictly along with procedure described in manuals. It is needless to say that budget for the procurement of parts and fuel must be permanently secured.

CONTENTS

CHAPTER 1

INTRODUCTION

Chapter 1 INTRODUCTION

Georgetown, the capital city of the Cooperative Republic of Guyana, is the center of the nation's political and economic activities. The power demand in the Demerara/Berbice Power System, which supplies electric power to the area around Georgetown, accounts for approximately 96% of the total power demand of the nation (as of 1987).

There are four diesel power plants and one steam power plant in the Demerara/Berbice Power System, and these power plants are equipped with 12 power generation units. The total installed capacity of these units amounts to 67.2 MW, and they have been commissioned during the period from 1960 to 1970. However, 4 generating units (with total installed capacity of 19.7 MW) are shut down due to mechanical failures as of September, 1988. The remaining units (with total installed capacity of 47.5 MW) are in such condition that they can not work fully, and the total output of these units is currently constrained at 37.2 MW. On the other hand, the maximum demand of this power system is 46 MW as of 1987, and as a result power supply is short of approximately 9 MW.

The Government of Guyana, concerned with this status of electric power supply that is indispensable for the people's livelihood and industrial activities, and keenly aware of the urgency of improvement measures, has requested the Government of Japan a grant cooperation for a new diesel power generator (5.7 MW) to replace the obsolete generating unit at the Garden of Eden Power Plant.

In response to the request, the Government of Japan decided to conduct a Basic Design Study and necessary supplemental studies for grant aid had been conducted in Japan and basic design was made based on the "The Master Plan on Electric Development Project in the Coastal Area". In the supplemental studies the appropriateness of this Project was evaluated, and the optimum plan which includes the selection of materials/equipments to be

procured, the basic design of power generation facility, the estimated project cost, and the operation and maintenance programs is given in this report.

CHAPTER 2

BACKGROUND OF PROJECT

Chapter 2 BACKGROUND OF PROJECT

2.1 General Situation of Cooperative Republic of Guyana

2.1.1 Geography and Climate

(1) Geography of Guyana

The Cooperative Republic of Guyana is situated on the northeastern tip of the South American Continent facing the Atlantic coast. The country is situated between 1 degree and 8 degrees North Latitude. The area of the country is 215,000 square kilometers, bordering Venezuela to the west, Surinam to the east, and Brazil to the south.

The Atlantic coast line is a long plain having scattered swamps, small bays and small rivers. The western and southern sides of the coastal plain is covered with tropical forest with scattered hills, which become higher near the boarders with Venezuela and Brazil.

Four large rivers, the Essequibo, the Demerara, the Berbice and the Corentyne flow from south to north, and drains into the Atlantic Ocean.

The total population is estimated to be about 800 thousand in 1984. The annual population growth rate is about 2.1%.

Main cities are Georgetown, capital of the country, in the Demerara area and New Amsterdam in the Corentyne area. Linden in the hinterland is the center of bauxite production. In the Essequibo coast there are the main towns of Anna Regina and Wakenaam.

(2) Climate

The climate of this country is typically tropical and wet. The annual average rainfall is approximately 2,500 mm (1971 to 1985). The maximum temperature is 30 to 31 degrees centigrade, and the minimum temperature is 23 to 24 degrees centigrade (1974 to 1985).

2.1.2 General Description of Project Site

Garden of Eden Power Plant, which is the site of this Project, is approximately 22 km to the south from the center of Georgetown city, and is situated on the eastern bank of Demerara River.

Power generated at Garden of Eden Power Plant is stepped up to 69 kV, and transmitted to Sophia Frequency Converter Station and Linden Substation in the Demerara Power System. In addition, this power plant plays an important role by delivering its output to Georgetown City and international airport by 13.8 kV distribution lines.

Heavy equipments to this power plant can be transported either by land or by water from Georgetown Harbor. If marine transportation is employed, an unloading wharf, which had been used for construction of existing power facility, can be utilized if it is repaired. As there are no people living nearby, and as the power plant premise is wide, there are no environmental problems, such as noise, vibration, exhaust gas. The site of this power plant is an ideal place for the new project.

2.2 Economic and Social Activities

2.2.1 Major Industries

The national economy of Guyana mainly depends on bauxite, sugar and rice. Needless to say earning of foreign exchange is indispensable for steady economic growth of this nation. According to IMF Statistics (1987), as shown below, the composition of the nation's export in 1985 was of bauxite (48.2%), sugar (32.2%), and rice (6.5%), and other products (13.1%).

	Export (million US$)	Share (%)	Estimated Production in 1986
Bauxite	421.6	48.2	1.47 million tons
Sugar	282.0	32.2	245.44 million tons
Rice	56.6	6.5	183.00 million tons
Other Products	115.2	13.1	---
Total	875.4	100.0	

When the Cooperative Republic of Guyana became an independent nation in 1966, the bauxite industry and sugar industry were controlled by foreign enterprises, and local private industries were engaged in local transactions, distribution, agriculture and small manufacturing business. The Government of Guyana nationalized the bauxite and sugar industries in early 1970s, and thereafter the Government participated more and more in other industrial activities.

Most agricultural activities are conducted on the coastal plain. Access to mineral and forestry resources is difficult due to undeveloped infrastructures, such as roads and the vast hinterland is mostly undeveloped.

2.2.2 Economic Growth

Prices on the international market of Guyana's export commodities were favorable during the early 1970s, and this made it possible for Guyana to attain a high average growth of net national products of around 4% per annum.

In contrast, the economic growth from 1975 to 1980 dropped sharply, mainly due to reduced export price of sugar, and decrease of demands for major export commodities in the international market, and reduced production of bauxite and sugar, caused the nation to face an economic crisis. The Government embarked on a economic rehabilitation program in 1980. This program was aimed to recover economic growth, increase employment and improve the international trade balance by expanding export and promoting a movement for increased use of domestic products. Despite such an effort, the real GDP in 1982 and 1983 dropped sharply, and the GDP in 1983 was 16.5% lower than that of 1980. The production of bauxite and sugar was drastically reduced due to low international prices, leading to reduction of foreign exchange earning.

From 1984, there appeared a trend of recovery in the national economy mainly due to improved production of bauxite. The growth rate of real GDP over the previous year was 2.1% in 1984, 0.9% in 1985, and 0.3% in 1986. This trend was an improvement from the declining trend during the early 1980s.

The GDP of Guyana from 1974 to 1986 are presented in the following table.

Year	Nominal Price (million G$)	Deflator (100 in 1980)	1980 Price (million G$)
1974	955.0	68	1,400.0
1975	1,188.0	77	1,546.0
1976	1,136.0	71	1,591.0
1977	1,125.0	74	1,515.0
1978	1,268.0	85	1,489.0
1979	1,326.0	90	1,479.0
1980	1,508.0	100	1,508.0
1981	1,697.0	101	1,576.0
1982	1,446.0	105	1,380.0
1983	1,468.0	117	1,259.0
1984	1,700.0	---	1,285.0(estimated)
1985	1,964.0	---	1,297.0(")
1986	2,219.0	---	1,301.0(")

(Source: International Financial Stistics, 1987 (IMF))

2.2.3 International Balance of Payment

The international balance of payment recorded some surplus in 1984, but deficits continued from 1980 to 1985, as illustrated below.

(in million US$)

	1983	1984	1985
Export	193.2	217.0	215.0
Import	-248.3	-214.3	-262.2
Trade Balance	- 55.1	+ 2.7	- 47.2
Service Balance	-100.5	-108.3	-112.3
Transfer Balance	1.0	6.2	6.5
Ordinary Balance	-154.6	- 99.4	-153.0
Capital Balance	- 1.7	- 7.8	- 47.6
Error and Omission	- 7.9	- 10.3	- 47.6
Total Balance	-164.2	-117.5	-178.2

(Source: Recent Economic Development (IMF))

2.3 Situation of Electric Power Supply in Guyana

2.3.1 History of Electric Utility

The Guyana Electricity Corporation was established by the Government of Guyana on December 28, 1960, by acquiring the assets of Demerara Electric Co., Ltd., which was founded in the 1950s with the objective of supplying power to the areas surrounding Georgetown. The total installed capacity of power plants belonging to GEC at the time of establishment, was only 15.1 MW, including Kingston "A" Power Plant, Ruimveldt Power Plant, and two small diesel facilities installed in the cargo storage yard of Transportation and Harbor Bureau. At that time, 14 kV primary distribution lines extended to the Georgetown urban districts, to the eastern coast of Demerara (to Better Hope) and to Diamond along the eastern bank of Demerara River, to serve approximately 31,000 customers. Today, all of these power facilities have come to the end of their service lives, and have been completely decommissioned.

From 1962 to 1967, three steam power generation units, each 10.0 MW, were installed at Kingston, and this facility was named Kingston "B" Power Plant. In 1978, two, 10.0 MW gas turbine generators were installed in the premises of Kingston "B" Power Plant, but these units became inoperable due to instrument failures, and have been retired from service for several years.

In 1964, electrification was introduced into "Best" area on the western bank of Demerara Area by a submarine cable interconnection with Kingston Power Plant. In this area, a total of five diesel generator units were installed from 1967 to 1972 in order to meet the increasing power demand of this area, and this facility was named Versailles Power Plant. This plant has been operated since then, and in 1985, the facility was refurbished by three, 2.0 MW diesel generator units which was supplied by a grant cooperation of the Japanese Government.

Between 1976 and 1977, four 5.7 MW diesel generator units were installed and commissioned at Garden of Eden in order to meet the increasing power demand in the southern districts of Georgetown. In Berbice area to the west, electricity was first introduced by a small diesel power plant which was constructed by GEC at Onverwagt. Four 1 MW units were added to this

power plant in 1973, and another 2.5 MW unit in 1981. However, only one 2.5 MW unit is in service today, and all other units were decommissioned as their service lives ended.

In New Amsterdam and Corentyne areas, it was in 1972 that power supply service was started by GEC, when a small diesel power plant was installed at #53 village. In the following year of 1973, another small power plant was constructed at Rose Hall. In 1979, the New Amsterdam Electric Works was purchased by GEC. Today, GEC supplies power to New Amsterdam and Corentyne areas by Canefield Power Plant which is equipped with two, 5.8 MW units.

The power supply service to electrically isolated areas such as Anna Regina, Wakenaam and Bartica was started in the years listed below. All of them are supplied by small diesel power plants.

Anna Regina	1964
Wakenaam	1981
Bartica	1970

2.3.2 Electric Utility of Guyana (GEC)

GEC is an governmental corporation founded by the Government of Guyana, and its role is to supply power to all areas of the nation, and develop and operate efficient and economic power supply systems. GEC functions as an executive branch of the Guyana State Corporation (GUYSTAC), a governmental organization which supervises and controls various governmental corporations.

The activity of electric utility in Guyana is supervised by various branches of the Guyanan Government. That is, the National Energy Authority (NEA), a bureau of the Ministry of Energy and Natural Resources formulates the electric power supply program of the nation, while the Ministry of Finance exercises various legal jurisdictions on matters related to power supply area, power supply license, electricity rates (tariff), and control of electric power facilities.

The organization of GEC is described below.

(1) Board of Directors

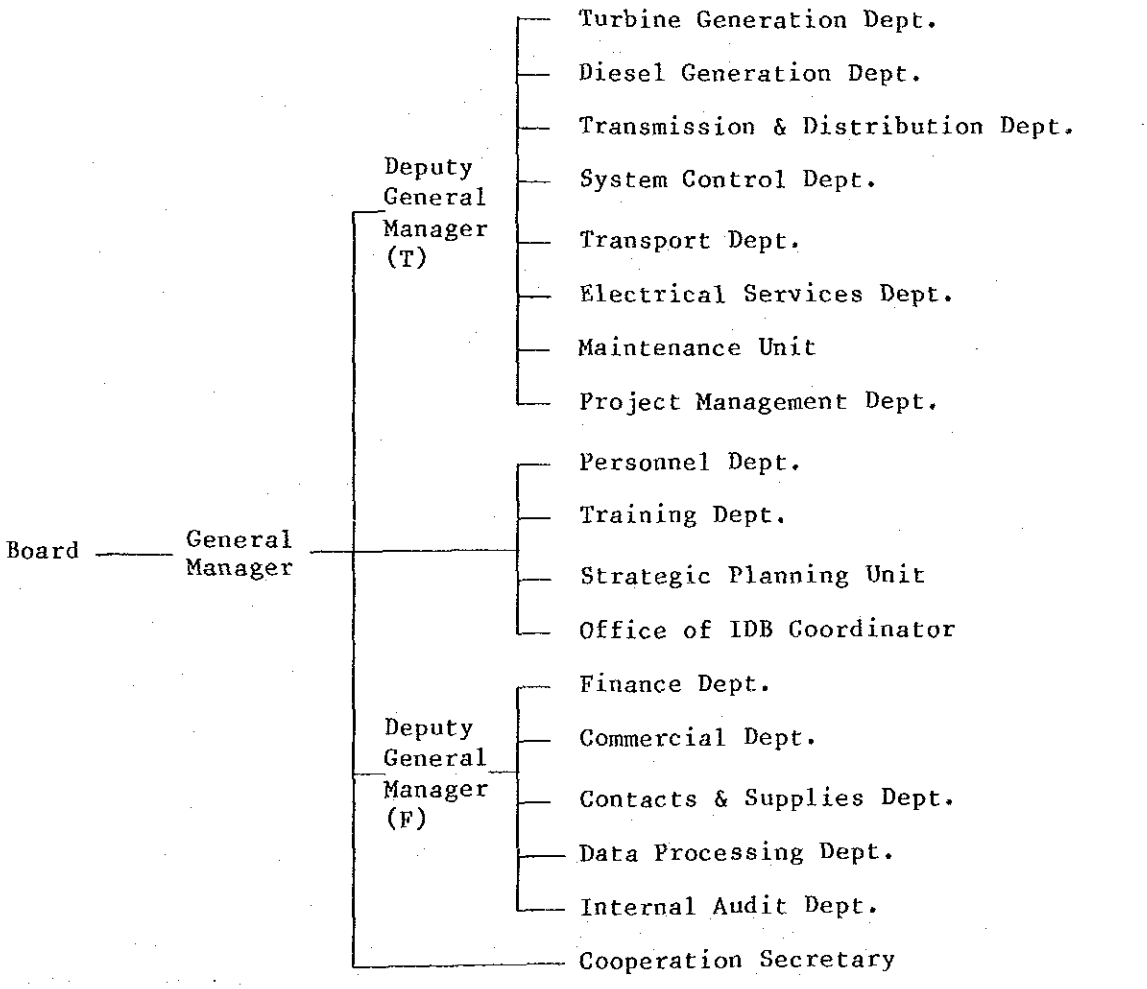
The Board is the supreme decision making authority of GEC. The Board members consists of representatives of government ministeries con-

cerned, public corporations such as GUYMINE, Guyana Sugar Corporation (GUYSCO), labor unions, etc. as well as men of learning. The Board considers and resolves matters related to GEC's business and financial policies, electric power development programs, power system expansion programs, and other important matters.

(2) Headquarter's Organization

GEC's operations are administered by the General Manager who is assisted by two Deputy General Managers (Technical and Finance). The daily business activities are implemented by a total of 18 departments and units. The total number of employees is 1,581 (25 engineers, 1,556 staff members, as of March, 1988).

ORGANIZATION CHART



2.3.3 Outline of Power Facilities

(1) Power Systems

The power systems owned and operated by GEC consists of two interconnected power systems, which are Demerara Power System and Berbice Power System (the latter including Western Berbice and Coretyne), and isolated power systems of Anna Regina, Wakenaam and Bartica. (Refer to Fig 2.3.3.)

The power generation facilities of GEC, as classified according to the power system they belong, are illustrated below.

Power Plant	Number of Units	Installed Capacity (MW)	Available Capacity (MW)
Demerara System			
Kingston "B"	3	30.0	25.5
Versailles	3	6.0/4.8 (Note 1)	4.2
Garden of Eden	3	17.1	3.0
Subtotal	9	53.1/51.9	32.7
Berbice System			
Canefield	2	11.6	4.5
Onverwagt	1	2.5	(1.8) (Note 2)
Subtotal	3	14.1	4.5
Isolated Systems			
Anna Regina	3	4.08	2.3
Wakenaam	1	0.5	0.5
Bartica	2	0.78	0.3
Subtotal	6	5.36	3.1
Total of All Power Systems	18	72.6/71.4	40.3

Note 1: 60 Hz/50 Hz

2: Capacity inside ( ) means out-of-service due to mechanical trouble

1) Interconnected System

a) Demerara System

In Demerara System, there is Kingston "B" Power Plant, a steam power plant, and Versailles and Garden of Eden Power Plants which are diesel power plants. The total installed capacity of this system, as of August, 1988, is 51.9 MW, and the available capacity is 32.7 MW. This power system is divided into the 50 Hz supply area and the 60 Hz supply area. Kingston "B" Power Plant is a 50 Hz power plant, while Garden of Eden Power Plant is a 60 Hz power plant. Versailles Power Plant is designed for both 50 Hz and 60 Hz operation.

For transfer of power between two power systems having different frequencies, Sophia Frequency Converter Station, equipped with three, 10.0 MW rotary converters, has been constructed in 1976, and this stations is in operation.

Power Plant	Frequency (Hz)	Installed Capacity (MW)	Available Capacity (MW)	Commissioned
Kingston "B" Versailles Garden of Eden	50 60/50 60	10.0 x 3 2.0/1.6 x 3 5.7 x 3	8.5 x 3 1.4 x 3 3.0 x 1	1963 - 67 1985 1975
Total		53.1/51.9	32.7	

Demerara System is connected to Sophia Frequency Converter Station through Linden Power Plant (60Hz) of GUYMINE and Garden of Eden Power Plant by a 110.4 km long 69 kV transmission line, and the 60 Hz bus of Sophia Frequency Converter Station is connected to the West Feeder of the Onverwagt Power Plant of Berbice System, which is described later, by a 93 km long, 13.8 kV transmission line.

Between East Demerara Area and West Demerara Area, there are submarine cables installed on the river bed of Demerara River that flows between these two areas, and one of the cable circuit is for 50 Hz and another for 60 Hz. The 50 Hz cable

circuit is connected to Versailles Power Plant, and the 60 Hz circuit extends to Concervancy which is located 10 km away from Versailles Power Plant. However, this 50 Hz cable circuit has been cut off by a river vessel accident in May, 1987. Therefore, Versailles Power Plant is supplying only the loads in West Demerara Area as of July, 1988.

The maximum demand in Demerara Area in 1987 was 37.8 MW, as against the available generating capacity of 32.7 MW. This deficit has been covered by power purchased from Linden Power Plant of GUYMINE through the 69 kV transmission line, but the power supply capacity within GEC system is definitely short, and scheduled load shedding is being enforced almost every day.

According to an agreement between GUYMINE and GEC, maximum power which GUYMINE will supply is 4 MW. However, in order to meet the large deficit of power supply capability of GEC's power plants, 5 to 8 MW of power is being supplied to GEC when there is surplus capacity at GUYMINE's power plant.

The power plant of GUYMINE at Liuden is a steam power plant having an installed capacity of 27.5 MW.

b) Berbice Power System

The power plants owned by GEC in Berbice Power System are the two diesel power plants named Onverwagt and Canefield. The power is supplied at 60 Hz. In this power system, Onverwagt Power Plant, Canefield Power Plant and No. 53 Substation are interconnected by 69 kV transmission lines having a total length of 97.6 km.

As stated in the preceding paragraph a), Onverwagt Power Plant is connected to Sophia Frequency Converter Station of Demerara Power System by a 93 km long, 13.8 kV transmission line. The total installed capacity of these two power plants is 14.1 MW, but its available output is currently only 4.5 MW.

Power Plant	Frequency (Hz)	Installed Capacity (MW)	Available Capacity (MW)	Commissioned
Onverwagt Canefield	60 60	2.5 x 1 5.8 x 2	(1.8) 4.5 x 1(2)	1981 1978
Total		14.1	4.5	

In the Berbice-Coretyne districts, there are Everton Power Plant of GUYMINE (1.05 MW x 3 installed capacity) and Albion Estate Power Plant of GUYSCO (1.7 MW x 2 installed capacity), but these plants are isolated from GEC's power system. There is no interchange of electric power between GEC and GUYSCO. However, power from Everton Power Plant is supplied to GEC only when the latter is faced with a severe power supply shortage.

2) Isolated Systems

There are Anna Regina Power Plant, Wakenaam Power Plant and Bartica Power Plant in the isolated power systems of GEC. Anna Regina supplies 50 Hz power, and other power plants supply 60 Hz power.

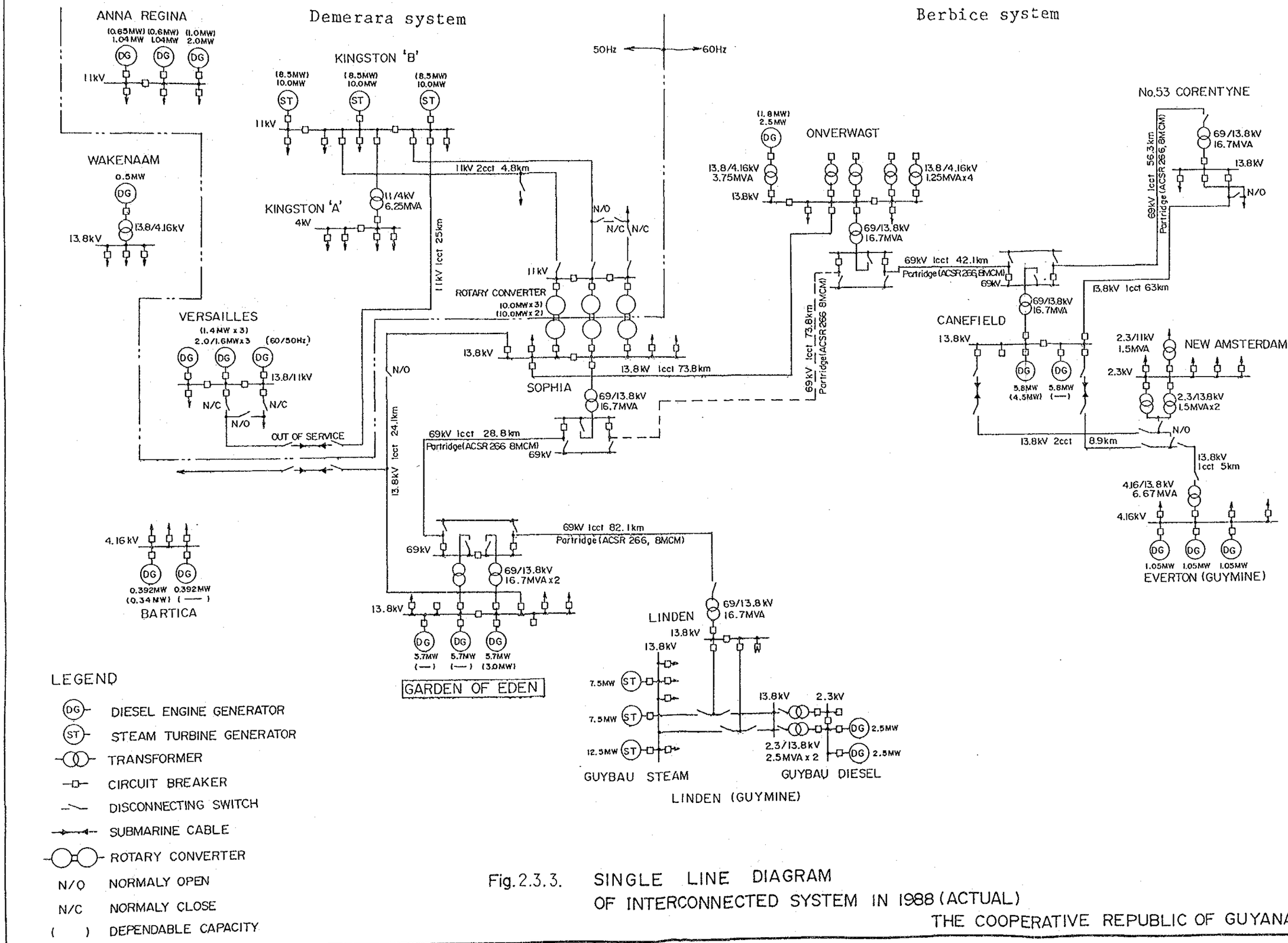


Fig. 2.3.3. SINGLE LINE DIAGRAM
OF INTERCONNECTED SYSTEM IN 1988 (ACTUAL)
THE COOPERATIVE REPUBLIC OF GUYANA

(2) Power Generation Facilities

1) Outline of Facilities

As described above, all the power generation facilities of GEC are thermal power plants, and there is no hydro power plant. There are 8 thermal power plants in the country with a total installed capacity of 72.6 MW. They consist of 15 diesel units, with the total installed capacity of 42.6 MW (59%), and three steam units, with the total installed capacity of 30 MW (41%).

All of these power generation units are extremely superannuated, except for the three diesel units supplied to Versailles Power Plant under the grant cooperation of the Japanese Government, and they have not been repaired properly as it has been difficult to import the required repair parts due to shortage of foreign funds. Consequently, the output of these units are restrained or the units are out of service. In some cases, the usable parts of shutdown units are removed and transferred to operational facilities, and the out of service units are disassembled and left in the power plants.

For this reason, the total available capacity of the remaining units is only 40.3 MW, or as low as 56% of the total installed capacity. The shortage of power supply capacity is being made up by the power purchased from GUYMINE (5 to 8 MW) and scheduled load shedding enforced in each of the service area.

The condition of these thermal power generation facility, as of the end of August, 1988, is presented in Table 2.3.3 (1).

Table 2.3.3(1) Existing Thermal Power Stations

(as of August, 1988)

Name of P.S	Type	Name of Manufacturer	Unit NO	Frequency (Hz)	Installed Capacity(MW)	Available Capacity(MW)	Commissioning year
Kingston "B"	Steam	Boiler: International Combustion LTD. UK Turbine: Associated Electrical Industries, UK Generator: Ditto	1	50	10	8.5	1963
			2	50	10	8.5	1964
			3	50	10	8.5	1967
Versailles	Diesel	Engine : Nigata Engineering CO., LTD Japan Generator; Nishishiba Electric CO., LTD. Japan	1	60/50	2.0/1.6	1.4	1985
			2	60/50	2.0/1.6	1.4	1985
			3	60/50	2.0/1.6	1.4	1985
Garden of Eden	Diesel	Engine: Crossly Pielstick, UK Generator: GEC, UK	2	60	5.7	※(3.0)	1975
			3	60	5.7	※(3.0)	1975
			4	60	5.7	3.0	1976
Canefield	Diesel	Engine: Mirrlees Blackstone, UK Generator: Brush Electric, UK	3	60	5.8	4.5	1978
			4	60	5.8	※(4.5)	1978
Onverwagt	Diesel	Engine: GM, USA Generator: GM, USA	5	60	2.5	※(1.8)	1981
Anna Regina	Diesel	Engine: Ruston, UK Generator: AEI, UK	1	50	1.04	0.65	1972
			2	50	1.04	0.60	1972
			4	50	2.0	1.0	1986
Wakenaam	Diesel	Engine: GM, USA Generator: GM, USA	3	60	0.5	0.50	1980
Bartica	Diesel	Engine: Mirrlees Blackstone, UK Generator: Brush Electric, UK	1	60	0.39	0.34	1978
			2	60	0.39	※(0.20)	1978
Total	—	——	18	——	72.6／71.4	40.3	——

Note: ※( ) shows generating units which are out of order at present due to troubles.

2) Status of Each Power Plant

a) Kingston "B" Power Plant (Refer to Table 2.3.3 (1).)
This power plant is located near the center of the capital city of Georgetown on the eastern side of Demerara River. It is the key power source in Demerara Power System, and it is the only steam power plant of GEC.

Kingston "B" Power Plant has been completed during the period from 1963 to 1967. It is equipped with three steam power units (available capacity of 8.5 MW x 3). These units have been operated for more than 20 years after commissioning. The facilities are badly superannuated, and currently they are barely being kept in operation.

b) Versailles Power Plant (Refer to Table 2.3.3 (1).)
This power plant is located on Demerara River on the opposite side of the capital city of Georgetown, that is, on the western side of the river. This was originally a power plant belonging to Demerara Power System, but it now forms an isolated power system supplying only to the western Demerara area, since the submarine cable crossing Demerara River (operated at 50 Hz) has been damaged by a vessel in May, 1987. (preparation of repair work is under way.)

Versailles Power Plant was completed in 1972, but it has been practically shut down due to deterioration of facilities. The plant has been refurbished under a grant cooperation of the Japanese Government in 1985 (three diesel generator units of 2 MW/1.6 MW, 60 Hz/50 Hz dual rating), and the plant is today in service.

This district belong to the 50 Hz supply area, but the plant equipment has dual rating according to the plan to unify the frequency to 60 Hz in the future.

c) Garden of Eden Power Plant (Refer to Table 2.3.3 (1).)
This power plant is situated on the eastern side of Demerara River, approximately 22 km to the south of the center of Georgetown. It is a diesel power plant which has the second

largest output next to Kingston "B" Power Plant in Demerara Power System among the power plants owned by GEC. Garden of Eden Power Plant has been constructed from 1975 to 1976.

Garden of Eden Power Plant had No. 2, No. 3, No. 4 and No. 5 Units (each 3.0 MW in available output). Due to trouble including damage on crank shaft, No. 3 Unit has been shut down since 1986, following by failure and shutdown of No. 2 Unit in September, 1987 and No. 5 unit in 1986. No. 5 Unit has been dismantled and only its foundation remains today.

Therefore, the only unit operated in this power plant today is No. 4 Unit having 3.0 MW capacity.

d) Canefield Power Plant (Refer to Table 2.3.3 (1).)
This power plant is located in an outskirts of New Amsterdam. It was completed in 1979, and it is a major diesel power plant in Berbice Power System.

Canefield Power Plant had two generating units (No. 3 and No. 4 Units) having available output of 4.5 MW each. Then No. 4 Unit was shut down in January, 1987 due to a damage of crank shaft bearing, and only No. 3 Unit (4.5 MW) is being operated today.

e) Onverwagt Power Plant (Refer to Table 2.3.3 (1).)
This power plant is located 80 km to the east of the capital city of Georgetown on the Atlantic Coast. It is a diesel power plant constructed during the period from 1973 to 1981, and it belongs to Berbice Power System.

Onverwagt Power Plant had five diesel generator units, (No. 1, No. 2, No. 3 and No. 4 Units), each rated at 1.0 MW, plus No. 5 Unit rated at 1.8 MW. Due to crank shaft damage and other trouble, the first four units were shut down one by one, that is, No. 1 Unit in 1979, No. 2 Unit is 1985, No. 3 Unit in 1986 and No. 4 Unit in 1987, and all of them are abandoned today. The only remaining No. 5 Unit has been shut down due to trouble on June 9, 1988.

f) Anna Regina Power Plant (Refer to Table 2.3.3 (1).)
This power plant is a diesel power plant located 60 km to the west of Georgetown, and it is operated in an isolated power system which supplies power to Anna Regina area.

Anna Regina Power Plant is equipped with three diesel generators, which are No. 1 and No. 2 Units (available capacity of 0.65 MW and 0. 6 MW), plus No. 4 Unit (1.0 MW available capacity). These units are operated at reduced output due to lubrication oil leak, cooling water leak and excessive temperature rise of cooling water and engine exhaust gas. No. 3 Unit has been abandoned in 1985.

g) Wakenaam Power Plant (Refer to Table 2.3.3 (1).)
This power plant is in Wakenaam Island which is approximately 40 km to the west of Georgetown, and two decommissioned power generation units are left in the premises of the power plant. The only unit in service today is No. 3 Unit which has been installed in 1985. Power supply service was interrupted in this island during the period 1974 to 1980.

h) Bartica Power Plant (Refer to Table 2.3.3 (1).)
This power plant is located in the center of Bartica Town which is located about 50 km upstream from the mouth of Essequibo River. It is a diesel power plant which supplies an isolated power system serving Bartica area.

Bartica Power Plant has two generating units, No. 1 and No. 2 (available output of 0.34 MW and 0.2 MW respectively). No. 2 Unit has been shut down in 1985 due to a crack on the engine, but it is planned to restore this unit back to service as soon as a budget appropriation is secured.

(3) Transmission, Distribution and Substation Facilities

1) Transmission Facilities

The outline of GEC's transmission facilities is presented in Table 2.3.3 (2).

Table 2.3.3(2) Existing Transmission Line

(As of August, 1988)

Name of Line Section	Line Voltage x No. of circuits	Length (km)	Commission-ing year
Linden - Garden of Eden	69 kV x 1 cct	81.6	1976
Garden of Eden - Sophia	69 kV x 1 cct	28.8	1977
Onverwagt - Canefield	69 kV x 1 cct	41.6	1978
Canefield - No.53 Corentyne	69 kV x 1 cct	56.0	1987
Total	-	208.0	-

GEC has an expansion program to construct a single circuit, 69 kV, 73.6 km long transmission line from Sophia Frequency Converter Station to Onverwagt Power Plant by 1990 in order to interconnect the eastern power system and western power system. The materials for this line is now being procured.

2) Distribution Facilities

The primary distribution voltage classes are 11 kV and 4 kV in the 50 Hz system and 13.8 kV, 11 kV, 4.16 kV, 4 kV and 2.3 kV in the 60 Hz system. GEC defines 11 kV as the standard voltage in 50 Hz and 13.8 kV in the 60 Hz system. Description of the primary distribution systems is presented in Table 2.3.3 (3).

Table 2.3.3 (3) Existing Distribution Facilities

(as of August, 1988)

Name of Line Section	Line Voltage (kV)	No. of Feeders	Length (km)	Installed Capacity (kVA)
Kingston P.S (50Hz)	11	7	70	59,125
Ditto (50Hz)	4	4	20	7,390
Sophia F.C (50Hz)	11	3	5	12,415
Versailles P.S (50Hz)	11	2	60	8,500
Garden of Eden P.S (60Hz)	13.8	3	65	16,215
Onverwagt P.S (60Hz)	13.8	2	71	5,630
Canefield P.S (60Hz)	13.8	3	106	6,398
Anna Regina P.S (50Hz)	11	3	92	6,850
Bartica P.S (60Hz)	4.16	3	24	691
Wakenaam P.S (60Hz)	13.8	3	26	740
Sophia F.C (60Hz)	13.8	3	—	—
Linden S.S (60Hz)	13.8	3	—	—
No.53 Corentyne S.S (60Hz)	13.8	3	—	—
New Amsterdam S.S (60Hz)	11 2.3	1 4	—	—
Connecting Line				
Versailles P.S— Kingston	11	1	25	
Sophia F.C— Kingston P.S	11	2	10	
Sophia F.C— Garden of Eden P.S	13.8	1	24	
New Amsterdam S.S —Everton P.S	13.8	1	5	
Canefield P.S — New Amsterdam S.S	13.8	2	12	
Sophia F.C— Onverwagt P.S	13.8	1	74	
Conefield P.S—No.53 Corentyne S.S	13.8	1	63	

There is no definite expansion program for the distribution systems, but "Distribution Master Plan" has been prepared in March, 1989 in order to strengthen the distribution systems in meeting the expected load growth after 1990.

The low voltage distribution lines and communication cables are often strung on same pole.

The details of low voltage distribution systems is not clear because the data of such systems are not properly recorded. GEC adopt the single phase, three wire, 120/240 V system and the three phase, three wire 480 V system as the standard systems, and is endeavoring to standardize the existing large number of voltage classes. The single phase, two wire (with one line grounded), 240 V system is used for low voltage distribution, except for Georgetown and New Amsterdam.

Transformers having a large variety of capacity are used as distribution transformers, and many of them are equipped with no-load tap changers (with $\pm$2.5% or $\pm$5% range).

Two circuits of submarine cables cross Demerara River. One circuit is an interconnection line between Versailles Power Plant and Garden of Eden Power Plant, which is a 50 Hz, 11 kV line. Another circuit is operated at 60 Hz, 13.8 kV, which is used for power distribution to the southern part of West Demerara Area. The 50 Hz interconnection cable was damaged by a vessel accident in May, 1987, and it is now out of service. A new submarine cable for replacement has already been purchased from Venezuela. The length of the submarine cables is 1.4 km each.

3) Substation Facilities

The outline of substation facilities is presented in Table 2.3.3(4).

Table 2.3.3(4) Existing Substation Facilities

(as of August, 1988)

Name of Substation	Voltage (kV)	Capacity (MVA)	Commissioning Year
Garden of Eden	69/13.8	2 x 16.7	1976
Linden	69/13.8	1 x 16.7	1976
Sophia	69/13.8	1 x 16.7	1977
Canefield	69/13.8	1 x 16.7	1984
Onverwagt	69/13.8	1 x 16.7	1986
No.53 Corentyne	69/13.8	1 x 16.7	1987
New Amesterdam	13.8/2.3	2 x 1.5	
Total		119.9	

In order to step down the distribution voltage from 11 kV to 4 kV, there are two substation facilities in Georgetown. These facilities consist of two 2,000 kVA transformers located at two places, and a 1,000 kVA transformer. They are installed in yards surrounded by fences.

There is a substation expansion program to install two, 69/13.8 kV, 20 MVA transformers at Sophia Frequency Converter Station and two same transformers at Garden of Eden Power Plant (total of 4 banks) by 1990. The time of implementation of this plan is not yet decided.

2.3.4 Power Demand/Supply Situation

(1) Power Consumption

The economy of the Cooperative Republic of Guyana is based on bauxite, sugar and rice, as discussed in Section 2.2.2.

The economy of this country recorded a healthy growth during the period from 1970 to 1977, owing to the price rise of the nation's major export commodities in the international market. Thereafter, with the fall of international prices, the nation's earning of foreign currency

declined caused a rapid deterioration of the national economy. In particular, real GDP registered a negative growth since 1981, partly due to the effect of the world wide recession caused by the second oil crisis. (Refer to Table 3.2.1)

Naturally, such changes in economic trend undoubtedly, directly and indirectly, influenced the consumption of electric power. During the period from 1974 to 1977, electric power consumption increased at a rate of around 6% per year, and there after the growth of consumption became relatively uneven. As indicated in Table 2.3.4 (1), the total electric energy sales in GEC power systems was 178.9 GWh in 1987, and this was below the level of consumption in 1977 (184.7 GWh). However, it must be noted that the recent decline of power consumption in GEC's power systems has been caused mainly by the deficit in power supply capability of GEC's power generation facility, rather than the decline of nation's economic activities. As a matter of fact, since several years ago GEC has been compelld to enforce scheduled load shedding almost daily in order to cover the supply capability deficit.

The consumers of GEC are classified into Residential (Rate A), Commercial (Rate B), Industrial (Rate C) and Street Lighting (Rate E).

A study of the energy consumption of each class of consumers in Demerara System and Berbice System for the year 1987, reveals that Residential was 47.3%, Industrial 31.1%, Commercial 19.6% in Demerara System, and Residential 63.6%, Commercial 20.2% and Industrial 15.6% in Berbice System, as illustrated in the table below.

(as of 1987)

Class	Energy Sales (MWh)	Share (%)	Number of Consumers	Consumption per Consumer (MWh)
Demerara System				
Residential	73.281	47.3	64,860	1.13
Commercial	30,379	19.6	6,396	4.75
Industrial	48,251	31.1	137	352.20
Street Lighting	3,008	2.0	27	111.41
Total	154,919	100.0	71,420	2.17 (average)
Berbice System				
Residential	11,233	63.6	21,915	0.51
Commercial	3,569	20.2	1,314	2.72
Industrial	2,753	15.6	5	550.60
Street Lighting	106	0.6	5	21.20
Total	17,661	100.0	23,239	0.76 (average)

(Data supplied by GEC.)

(2) Energy Generation and Aggregate Power Loss

The annual energy generation from power plants of GEC amounted to 195.5 GWH in 1974, and 215.0 GWh in 1987. The maximum energy delivered in the past was 256.2 GWh in 1981. The annual energy generation has declined from 1985 to 1987. This trend was caused by the following factors.

* The gas turbine units at Kingston and No. 5 Unit of Garden of Eden were abandoned in 1985.
* Garden of Eden No. 3 Unit has been shut down due to trouble since 1986.
* Garden of Eden No. 2 Unit has been shut down due to trouble since 1987.
* No. 3 Unit and No. 4 Unit of Canefield were shut down due to trouble from January to July, 1987 (No. 4 Unit is still shut down today).
* No. 4 Unit of Onverwagt was abandoned in April, 1987.

GEC is making up its power supply capacity shortage by purchasing power from GUYMINE, starting from 1977 for its Demerara System and from 1982 for Berbice System. The power purchased for Berbice System

is very small, but the power purchased for Demerara System from Linden Power Plant has increased rapidly since 1983, accounting to 10.4% of GEC's total power supply in 1983, 6.2% in 1984, 7.1% in 1985, 8.0% in 1986, and 10.6% in 1987.

The total power loss factor, including station-service loss and transmission/distribution loss is very high, and fluctuates from year to year. Loss factors in each power system from 1974 to 1987 inclusive are illustrated below.

Power System	Total Loss Factor (%)
Demerara	27.3
Berbice	37.2
Anna Regina/Wakenaam	22.4
Bartica	25.8
Average	27.5

(Data supplied by GEC.)

The total loss factor of 27.5% is extremely high compared to values in other nations. Such a high loss factor is thought to be caused by uncollectable power charge or illegal power consumption (pilferage).

(3) Peak Power Demand and Load Factor

Although Guyana experiences dry season and wet season during a year, the seasonal temperature change is not large, and therefore the peak power demand does not change appreciably from month to month.

The peak demand of a day occurs around 8 o'clock P.M. in all power systems. In Demerara System, a second peak occurs around 2 o'clock P.M., which is approximately 90% of the evening peak. In other power systems, the second peak occurs around 6 o'clock A.M., which is around 70% of the evening peak.

The maximum demand of Demerara System has increased from 33.0 MW in 1974 to 37.8 MW in 1987 (maximum recorded). The combined peak demand of all systems has increased from 36.7 MW in 1974 to 48.8 MW (maximum recorded) in 1987.

The load factor of each power system did not change appreciably during the period from 1974 to 1987. The average load factor of each power system for this period is given in the following table.

Power System	Load Factor (%)
Demerara	65.9
Berbice	40.1
Anna Regina/Wakenaam	45.9
Bartica	47.1
Average	61.4

(Data supplied by GEC.)

(4) Proportion of Energy Supplied by Each Power System

The proportions of energy supply by each power system, based on data from 1980 to 1986, are as illustrated below.

Power System	1980		1986		Average
	Energy (GWh)	Percent (%)	Energy (GWh)	Percent (%)	Percent (%)
Demerara	212.6	86.8	204.4	84.3	85.5
Berbice	23.0	9.4	29.6	12.2	10.8
Anna Regina/ Wakenaam	7.9	3.2	6.9	2.8	3.0
Bartica	1.4	0.6	1.6	0.7	0.7
Total	244.9	100.0	242.5	100.0	100.0

(Note) As the energy supplied in Berbice System decreased abnormally in 1986 due to failure of 3 generators, the 1986 record was used for all power systems.

The total energy sales, energy generation by GEC, energy purchased from GUYMINE, peak demand, total loss factor, load factor, and number of consumers are presented in Table 2.3.4(1) to 2.3.4(3).

Table 2.3.4(1) Evolution of Power Demand & supply

GEC Whole Power System

Year (AD)	Energy sold (GWh)	E.generated (GWh)	From GUYMINE (GWh)	Total Supply (GWh)	Peak load (MW)	System loss (%)	Load factor (%)	Number of consumers
1974	155.1	195.5	0.0	195.5	36.7	20.6	60.8	73514
1975	165.3	208.6	0.0	208.6	38.6	20.8	61.7	80088
1976	176.2	226.9	0.0	226.9	39.9	22.3	64.9	81014
1977	184.7	244.2	5.2	249.4	43.3	25.9	65.8	82478
1978	157.4	223.4	5.1	228.5	43.0	31.1	60.7	85840
1979	178.8	236.8	6.8	243.6	45.6	26.6	61.0	87266
1980	190.2	239.4	5.5	244.9	44.9	22.3	62.3	80900
1981	180.5	256.2	-4.3	251.9	47.5	28.4	60.6	95152
1982	164.2	230.5	4.6	235.1	45.5	30.2	59.0	89758
1983	178.9	224.3	24.6	248.9	46.7	28.1	60.9	82876
1984	162.7	235.8	13.0	248.8	46.3	34.6	61.4	86916
1985	169.5	235.8	15.3	251.1	48.4	32.5	59.3	84770
1986	160.9	226.0	16.5	242.5	47.7	33.6	58.1	85546
1987	178.9	215.0	22.4	237.4	48.8	24.6	55.6	101359

Table 2.3.4(2) Evolution of Power Demand & supply

Demerara System

Year (AD)	Energy sold (GWh)	E.generated (GWh)	From GUYMINE (GWh)	Total Supply (GWh)	Peak load (MW)	System loss (%)	Load factor (%)	Number of consumers
1974	147	184	0.0	184.0	33.0	20.1	63.7	61360
1975	155	192	0.0	192.0	33.9	19.3	64.7	63707
1976	163	208	0.0	208.0	34.8	21.6	68.2	65476
1977	170	222	5.2	227.2	37.6	25.2	69.0	66436
1978	141	200	5.1	205.1	36.9	31.3	63.5	68847
1979	159	206	9.5	215.5	36.4	26.2	67.6	67502
1980	166	204	8.6	212.6	36.2	21.9	67.0	54321
1981	153	213	0.0	213.0	36.1	28.2	67.4	66597
1982	138	187	2.1	189.1	34.7	27.0	62.2	60720
1983	154	184	21.4	205.4	34.8	25.0	67.4	54841
1984	136	193	12.8	205.8	34.2	33.9	68.7	58572
1985	145	197	15.1	212.1	37.4	31.6	64.7	56827
1986	138	188	16.4	204.4	36.9	32.5	63.2	57052
1987	155	187	22.3	209.3	37.8	25.9	63.2	71420

Table 2.3.4(3) Evolution of Power Demand & Supply

Berbice System

Year (AD)	Energy sold (GWh)	E.generated (GWh)	From GUYMINE (GWh)	Total Supply (GWh)	Peak load (MW)	System loss (%)	Load factor (%)	Number of consumers
1974	4.5	6.4	0.0	6.4	2.3	29.7	31.8	8438
1975	5.9	10.6	0.0	10.6	3.2	44.3	37.8	12336
1976	7.4	12.2	0.0	12.2	3.4	39.3	41.0	10892
1977	8.7	14.6	0.0	14.6	3.7	40.4	45.0	10946
1978	8.9	14.7	0.0	14.7	3.9	39.5	43.0	11126
1979	12.3	21.6	-2.7	18.9	7.0	34.9	30.8	13857
1980	17.6	26.1	-3.1	23.0	6.4	23.5	41.0	20024
1981	20.6	34.1	-4.3	29.8	9.2	30.9	37.0	22336
1982	18.3	33.9	2.5	36.4	8.5	49.7	48.9	22955
1983	18.4	30.5	3.2	33.7	8.9	45.4	43.2	22008
1984	18.5	33.5	0.2	33.7	9.4	45.1	40.9	21862
1985	18.9	32.2	0.2	32.4	9.1	41.7	40.6	21498
1986	17.3	29.5	0.1	29.6	8.3	41.6	40.7	22006
1987	17.7	18.5	0.1	18.6	8.4	4.8	25.3	23239

2.3.5 Electricity Tariff

The electricity tariff of GEC is classified into A (Residential Lighting), B (Commercial), C (Small industrial), D (Large industrial) and E (Street Lighting). The rates presented below are as of November, 1988.

(At official exchange rate of 1 G$ = 13 yen.)

Tariff A: Residential Lighting (excluding commercial load)

- 50 kWh or less per month:

Fixed charge	2.30 G$/month
kWh charge	0.45 G$/kWh

- Exceeding 50 kWh:

Fixed charge	2.50 G$/month
kWh charge up to 50 kWh	0.45 G$/kWh
kWh charge above 50 kWh	1.00 G$/kWh

Tariff B: Consumers Receiving at 1000 V or less

Fixed charge	4.14 G$/month
kWh charge	1.96 G$/kWh

Tariff C: Consumers Receiving High Voltage but not Higher than 1000 V

Fixed charge per maximum demand in kVA	32.30 G$/kVA/month
Minimum fixed charge	1615.00 G$/month
kWh charge up to 200 kWh/kVA	1.73 G$/kWh
kWh charge over 201 kWh/kVA	1.49 G$/kWh

Tariff D: Consumers Receiving High Voltage Exceeding 1000 V

Fixed charge per maximum demand in kVA	30.22 G$/kVA/month
Minimum fixed charge	3022.00 G$/month
kWh charge up to 200 kWh/kVA	1.82 G$/kWh
kWh charge over 201 kWh/kVA	1.51 G$/kWh

Tariff E: Street Lighting

Fixed charge	4.14 G$/month
kWh charge	0.90 G$/kWh

Energy consumptions by each categories of consumers are presented below for Demerara/Berbice Power Systems (for 1987).

Category	Demerara System		Berbice System	
	Share (%)	Annual Consumption per Consumer (MWh)	Share (%)	Annual Consumption per Consumer (MWh)
Residential (A)	47.3	1.13	63.6	0.51
Commercial (B)	19.6	4.75	20.2	2.72
Industrial (C, D)	31.1	352.20	15.6	550.6
Street Lighting (E)	2.0	111.41	0.6	21.2
Total	100.0	2.17	100.0	0.76

The average rate per unit sold during the period from 1974 to 1986 are presented on the following page.

Year	Average rate (G$/kWh)
1974	0.13
1975	0.19
1976	0.21
1977	0.24
1978	0.27
1979	0.27
1980	0.37
1981	0.58
1982	0.59
1983	0.59
1984	0.75
1985	0.84
1986	0.84
1987	--

The above energy price compared to the current fuel prices of Kingston Power Plant and Garden of Eden Power Plant are as follows.

Power Plant Thermal Efficiency

Kingston	20.5% (4,195 kCal/kWh)
Garden of Eden	26.2% (3,282 kCal/kWh)

Fuel Price

Kingston (C-Fuel Oil)	US$ 13.01/barrel
Garden of Eden (diesel oil)	US$ 21.16/barrel

Unit Fuel Price per kWh:

Kingston	US$ 0.03537 (=: G$ 0.3537) *
Garden of Eden	US$ 0.04977 (=: G$ 0.4977) *

* The official exchange rate (US$ 1 = G$ 10.0) was used.

The electricity tariff is composed of fuel cost, plus operation and maintenance costs, overhead expenses and capital cost (interest and depreciation), and the average unit tariff of GEC is G$ 0.84/kWh.

2.4 Problem of Power Demand/Supply Balance and Role of This Project

The problem with Demerara/Berbice Power System is that their supply capability does not balance with the power demand, and this is caused by shortage of power supply capacity. The reason why such shortage occurred is that most of existing power supply facilities are obsolete, and repair of these power plants have not been implemented because import of required parts was difficult due to fund shortage. This lead to reduction in power facility

output and frequent failures and plant shutdowns. In addition, construction of new power plants could not be realized due to fund shortage. The superannuation of old power generation facilities has reduced the fuel efficiency of power plants, which in turn increased the fuel consumption rate, thereby causing a burden on the operating condition of GEC.

This project is to install a new diesel power generation facility for Demerara and Berbice Power Systems which has not sufficient supply capabilities to meet the power demands. Therefore, this project will improve the power demand/supply balance in these power systems, which in turn will enable the old power facilities to be shut down for necessary inspection and repair, and improve the reliability of existing facilities and improve their specific fuel consumption.

2.5 Foreign Assistance to Electric Utility

The following technical and economic assistance has been extended to the electric utility of the Cooperative Republic of Guyana in the past. These are listed below in time sequence.

(1) GEC Phase I Expansion Program (From 1972 to 1978)

"GEC Phase I Expansion Program" was jointly financed by the World Bank, ODA (Overseas Development Administration) and CIDA (Canadian International Development Agency) from 1972 to 1978. The transmission lines and substations completed under this program are described below.

* The 69 kV transmission line from Linden Substation to Garden of Eden Power Plant.

* The 69 kV transmission line from Garden of Eden Power Plant to Sophia Frequency Converter Station.

* The 69 kV transmission line from Onverwagt Power Plant to Canefield Power Plant.

* Substation facilities of Linden Substation, Sophia Frequency Converter Station and Garden of Eden Power Plant.

* Expansion of 13.8 kV distribution systems.

The 69 kV transmission line from Onverwagt Power Plant to Canefield Power Plant was constructed by local contractors in Guyana. However, as Guyanan contractors did not have experience on tower construction and conductor stringing for a line crossing a river, GEC awarded the construction of transmission lines crossing Berbice and Canje Rivers to foreign constructors according to the recommendation of the World Bank, and were completed in 1978. In 1979, GEC received an additional loan from CDB (Caribean Development Bank) by arrangement made by the World Bank for construction of a 69 kV transmission line between Sophia Frequency Converter Station and Onverwagt Power Plant, but this project has not been implemented so far.

(2) Rehabilitation and Development of the GEC System (from 1982 to 1990)

The objective of this project is to improve the supply capability and reliability of power generation facilities, and funding by IDB was agreed in November, 1985. It was planned to complete this project by 1988, but the schedule is delayed as disbursement by IDB was postponed to beyond November, 1987, and the reliability of existing facilities continued to deteriorate. At present, GEC is reviewing the list of parts to be procured and making effort to implement this project. The major power generation, transmission and distribution facilities to be rehabilitated by this project are presented below.

1) Power Plants

* Kingston "B" Power Plant:
  Steam Power, available output; 8.5 MW x 3
  (No. 1, No. 2 and No.3)

* Garden of Eden Power Plant:

  Diesel power, available output; 4.0 MW x 1 (No. 2)
  Diesel power, available output; 5.0 MW x 1 (No. 3, No. 4)
  Diesel power, available output; 5.0 MW x 1 (No. 5) (Rehabilitation cancelled)

* Canefield Power Plant

  Diesel power, available output; 4.5 MW x 1 (No. 3)
  Diesel power, available output; 5.0 MW x 1 (No. 4)

* Onverwagt Power Plant

  Diesel power, available output; 2.0 MW x 1 (No. 5)
  Diesel power, available output; 2.0 MW x 1 (Construction suspended.)

The rehabilitation plan has been reviewed by GEC in August, 1988, and the above description is according to this revised plan.

2) Transmission and Distribution Systems

* Improvement of 11 kV interconnection line between Kingston Power Plant and Sophia Frequency Converter Station

* Replacement of distribution equipment (wooden poles, transformers, insulators and meters).

* Rehabilitation of New Amsterdam distribution system.

* Installation of power factor compensation capacitors.

* Procurement of maintenance equipment/tools such as vehicles, parts and measuring instruments.

* Training of transmission/distribution managers and relay/instrumentation engineers.

* Formulation of "Distribution Master Plan".

For this project, a program for rehabilitation of GEC's major power facilities, titled "Refurbishment of Major Plant in the Guyana Electricity Corporation System" was prepared by a British Consultant, the British Electricity International Ltd. (BEI), in January, 1985. This report recommends the reinforcement of GEC's

power supply capability, to reduce dependence on the power purchased from GUYMINE, to reduce service interruption caused by line failures, and to enhance the reliability of power facilities.

2.6 Content of Request

(1) Objective

A new power generating facility having a 5.7 MW output shall be installed in the premises of existing Garden of Eden Power Plant in order to mitigate the power supply shortage in Georgetown and its surrounding areas.

(2) Implementing Organization

GEC shall operate and maintain the facilities requested.

(3) Effect of Project

The power supply capability is increased by installation of a new power generation facility, and the power will be supplied to customers in Georgetown and its surrounding areas where power supply is in shortage.

(4) Requested Facilities

1) A medium speed diesel generator (one, 5.7 MW unit) and its ancillary facilities.

2) Installation of the above facilities and connection thereof to existing facilities.

CHAPTER 3

DESCRIPTION OF PROJECT

Chapter 3 DESCRIPTION OF PROJECT

3.1 Objective of Project

The objective of this Project is to urgently increase the power source in Demerara/Berbice Power Systems so that the shortage of supply capacity is relieved.

To be specific, No. 5 Generating Unit will be refurbished in existing Garden of Eden Power Plant to increase the power supply capability of the system, thereby improving the functions of Georgetown Area as the capital city, stabilizing people's livelihood, and vitalizing the local industries.

3.2 Study of Content of Request

The content of the request has been studies based on the projection of future power demand, to evaluate the necessity of a new power supply source, the optimum increment in power generation capacity, the suitable timing of commissioning of new facility, and the operation of the power facility to be completed.

3.2.1 Power Demand Forecast

The Study Mission has estimated the projected power demand for the period from 1988 to 1998 based on the study of Coastal Area Power Development Program which had been formulated in the previous mission.

(1) Methodology

It is widely recognized that the electric power consumption is closely correlated to the level of national economy which is typically represented by GDP, and this correlation is often used in projecting the future electric power demand.

As a demand function of a commodity is determined by the income of the consumer and the price of the commodity, such demand function for electricity can be defined by taking the average rate per unit sold of electricity as the second explanatory variable.

However, in many developing countries, the supply of electricity is short in its absolute amount from the demand, and suppressed demand or

potential demand is generally observed in such nations. In such cases, it is difficult to establish statistical correlations between the power demand and GDP or average rate per unit sold.

In addition to GDP and average rate per unit sold, the number of consumers can be used as the third explanatory variable of demand function.

In this survey, multiple regression models or linear regression models were calculated by taking GDP, average rate per unit sold, and number of consumers as the explanatory variable, and the model that was found to be most realistic was used to project the future power demand.

In Demerara and Berbice Systems, there is a substantial number of suppressed consumers who has applied for power supply but not yet responded by GEC. As these consumers will consume electricity when the existing power facilities are refurbished and the power supply capacity of GEC is expanded, the estimated demands of such consumers are added to the projected demand obtained by the regression model discussed above.

The time series data of GDP, average rate per unit sold, number of consumers for the period from 1974 to 1986, used in this projection, are presented in Table 3.2.1.

(2) Regression Model

The regression equation calculated, based on data of Table 2.3.4(1) through 2.3.4(3) and Table 3.2.1, are as described below.

Symbols: Y : Annual electric energy generation (GWh)
X1: GDP (in million G$ at 1980 price)
X2: Average rate per unit sold (G$/kWh) or number of consumers
X : Number of consumers

1) Multiple Regression

a) Explanatory variables: GDP and unit electricity price

$Y = 0.01351\ X1 + 242.51041\ X2 + 122.02$

This model cannot be used theoretically because price coefficient shows positive (+) sign.

b) Explanatory variables: GDP and number of consumers

$Y = 0.03772\ X1 + 0.00214\ X2 - 6.36$

correlation coefficient $R^2 = 0.63$

This model is not also suitable because correlation coefficient is very low.

2) Linear Regression

Explanatory variable: number of consumers only

$Y = 41.74963 + 0.00223\ X$

correlation coefficient $r = 0.76$

standard deviation $s = 15.38$

Correlation coefficient of 0.76 is not high but it is considered that this model represents fairly the demand relationship up to the present.

(3) Assumptions for Projection

1) Increase in Number of Consumers

The number of consumers increased steadily with an annual average rate of 3.75% from 73,514 consumers in 1974 to 95,152 consumers in 1981, and then the number decreased with an irregular pattern until 1986. This means that even if the economic activities are slow to some extent (as it was from 1974 to 1981), the number of consumers would increase at a rate as quoted above if the supply capacity is not short. Therefore, we assumed that the number of consumers will increase in future at an annual rate of 3.75% after the refurbishment of existing generating facilities of GEC is compelted within coming one or two years.

2) The Share of Each Power System in Total Demand

The electrification in the supply area of Demerara System is fairly extensive, and probably it has already reached a saturation point. The future demand grown in Berbice System will not be very high either. However, it is expected that the new household will increase in future as population grows (currently 2.13% in the average) and there are the suppressed consumers. Considering all these factors, it has been judged that the proportions of the magnitude of demand in each power system to the total national demand will not change substantially in future. By this assumption, we assumed that the future shares of each power system in the total demand will be the same as those presented in Section 2.3.4, paragraph (4), that is, as given in the table below.

Demerara System	88.5%
Berbice System	10.8%
Anna Regina/Wakenaam System	3.0%
Bartica System	0.7%
Total	100.0%

3) Potential Power Demand

There are substantial potential power demands (mainly, residential demands) in both Demerara and Berbice Systems. They are as below.

Demerara System	3,510
Berbice System	4,200

(Data supplied by GEC)

The electric energy consumption per consumer in the above power systems are currently 1.13 MWH/year in Demerara System and 0.51 MWh/year in Berbice system, as discussed in Section 2.3.4, paragraph (1). On the other hand, the total transmission/distribution losses in Demerara and Berbice Systems are 27.3% and 37.2% respectively as discussed in Section 2.3.4, paragraph (2). Therefore, the required power generation which correspond to these potential power demand are estimated as follows.

Demerara System: (3,510 x 1.13)/(1 - 0.273) = 5.5 GWh

Berbice System : (4,200 x 0.51)/(1 - 0.372) = 3.4 GWh

4) Load Factor

As discussed in Section 2.3.4, Paragraph (3), the load factors in all power system changed little for the period from 1974 to 1987. Therefore, the following average load factors for this period have been assumed in future projection of demand.

Power System	Load factor (%)
Demerara	65.9
Berbice	40.1

5) System Loss Factor

The system loss factor, including the station-service power and transmission/distribution losses, is extremely high. No symptom has been found that this high loss factor is improving. For the period from 1974 to 1987, the average system loss factors in Demerara System and Berbice System were 27.3% and 37.2% respectively.

It can be conjectured that such a high loss factor is caused mainly by inability of billing the consumers or presence of illegal power users. In an effort to reduce this high loss factor, GEC is currently conducting a survey on consumers, and trying to introduce a computerized rate calculation system.

It is being planned to reduce the system loss factor in Demerara and Berbice Power System down to 24% by 1990. It is also expected that the system loss factor can be reduced down to 18% when the "Distribution Master Plan" under IDB loan is implemented by 1994.

Considering these possible improvement, the system loss factor in the future demand projection was assumed as presented below.