CHAPTER 10

POWER SYSTEM PLAN

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10.1 POWER TRANSMISSION AND DISTRIBUTION PLANS

10.1.1 Summary of existing plans

In the past, GEC planned and implemented a number of projects concerning expansion and improvement of its power transmission and distribution systems to improve the power supply reliability together with its plans for expansion of power generating facilities. Although certain achievements have been attained in terms of expansion of power transmission and distribution facilities as the result of these projects, the efforts for improvement and rehabilitation of power system functions have not been sufficiently successful so far.

The projects that were implemented by GEC for enhancement of the transmission and distribution systems include the following:

i) GEC Phase I Expansion Program (from 1972 to 1978) and
ii) Rehabilitation and Development of the GEC System (from 1982 to 1990)

(1) GEC Phase I expansion program

The "GEC Phase I Expansion Program" was implemented under co-financing from the World Bank, ODA (Overseas Development Administration) and CIDA (Canadian International Development Agency) from 1972 to 1978. The following transmission and distribution lines as well as substations have been completed under the project.

i) 69 kV transmission line from Linden Substation to Garden of Eden Power Station;

ii) 69 kV transmission line from Garden of Eden Power Station to Sophia Frequency Converter Station;

iii) 69 kV transmission line from Onverwagt Power Station to Canefield Power Station;

iv) Linden Substation, Sophia Frequency Converter Station and Garden of Eden Power Station, and

v) Expansion of 13.8 kV distribution lines.

The 69 kV transmission line from Onverwagt Power Station to #53 village substation was constructed by a Guyanese contractor. This included the sections of transmission lines crossing Berbice and Canje Rivers. The materials for these lines and substations at Onverwagt, Canefield and #53 village substation were provided under the above-mentioned program but GEC did not complete this phase until 1987.

(2) Rehabilitation and development of the GEC system

The loan from IDB was awarded in 1985 for this project of improving the power supply. The objective of this project was to increase the supply of electricity of GEC without power from GUYMINE and reduce power outage by the transmission and distribution line faults, thereby increasing the system reliability. Although this project had been scheduled to be completed in 1988, the implementation of the project was delayed substantially and procurement of materials were not realized, and as a result, the reliability of existing facilities has been further reduced.

Today, GEC has completed the review of materials to be procured, and it is striving to execute the implementation of the project. The programs related to the transmission and distribution facilities under this project include the following:

i) Refurbishment of the 11 kV interconnection lines between Kingston Power Station and Sophia Frequency Converter Station,

ii) Replacement of distribution line materials (wooden poles, transformers, insulators, electricity meters, etc.),

iii) Rehabilitation of the New Amsterdam distribution systems,

iv) Installation of capacitors for reactive compensation,

v) Purchase of maintenance and test equipment such as vehicles, hand tools, spares and measuring instruments,

vi) Training of transmission and distribution manager and protection and instrumentation engineer and,

vii) Formulation of a "Distribution Master Plan".

The "Refurbishment of Major Plant in the Guyana Electricity Corporation System (January, 1985)" has been prepared to formulate this project. The current status and problems involved in the organization and facilities of GEC have been surveyed and described in detail in this report. The measures to be implemented by the rehabilitation program including the distribution lines and the amount of funds required have been also discussed in the report.

10.1.2 Review of existing plan

(1) Construction of new 69 kV, East-West interconnection transmission line

Demerara Power System of the western area of Guyana (where 35% of population is located including population center of Georgetown), and Berbice Power System in the eastern area (where there are active sugar industries along the river mouth area of Berbice River and future economic growth is expected), are two independent power systems and they are currently not interconnected by a 69 kV transmission line. At present, Sophia Frequency Converter Station and Onverwagt Power Station are interconnected by a 13.8 kV distribution line.

The 69 kV, east-to-west interconnection transmission line for Demerara Power System and Berbice Power System, which will run from Sophia Frequency Converter Station to Onverwagt Power Station, has been planned with a schedule of starting construction in 1989 and completing in 1990. This plan is being implemented, and the materials are being procured.

The east-to-west interconnection by a 69 kV transmission line will not only strengthen the power systems and facilitate easier system operation, but also will bring about various advantages including common possession of reserve generating capacity and rationalization of business operation.

Therefore, this 69 kV interconnection plan should be aggressively implemented.

(2) Construction of new 69 kV transmission line

GEC plans to construct a new 69 kV, single circuit transmission line from Sophia Converter Station to Garden of Eden Power Station by 1990, and install two 20 MVA transformers in each substation. However, this plan remains a conceptual plan at this moment, and no specific program has been formulated, nor is there any definite prospect of financing this project. There is an existing 69 kV, single circuit transmission line between these stations, which is capable of stably transmitting 45 MVA of power. In addition, there is a single circuit, 13.8 kV interconnection line. Considering future prospect of demand growth, there seems to be no urgent need to construct this new 69 kV. Construction of this transmission line should be implemented at some time in the future when there is actual need for this line as power supply capability and load of the power system increase.

(3) Rehabilitation of distribution line

There is a report named "Refurbishment of Major Plant of GEC" which describes the plan for rehabilitation of the distribution system. This report has been published in 1985 as a part of the project named "Rehabilitation and Development of GEC", and the current status and problems involved in the distribution systems, methods of rehabilitation, required materials and budgets are discussed in detail in this report. Considering the findings in this report and future deteriorations that have occurred in the facilities after the report was issued, GEC has now completed its own review on the equipment and materials needed for the distribution system rehabilitation as well as the tools and measuring instruments required for construction and maintenance works, and now is ready to procure these items. The rehabilitation program is scheduled to be completed in 1990, and it is important that GEC implements this program completely in order to reduce distribution losses and improve customer services.

The rehabilitation of distribution lines should be implemented in coordination with frequency unification program. For example, new transformers to be purchased or repaired should be so designed that they have dual rating of 13.8 kV and 11 kV, and the line insulators should be designed for 13.8 kV operation.

(4) Distribution master plan

The "Distribution Master Plan", which identifies major investments in distribution facilities to permit the load growth from 1990 onwards, will be formulated by GEC by January, 1989. It is recommended that this plan is formulated with due considerations to the power development programs, transmission and distribution line construction programs, and frequency unification programs under this Power Development Plan. In particular, the 11 kV distribution lines should be so designed that they can be stepped up to 13.8 kV in view of the frequency unification program, and it is recommended that this principle is incorporated into the "Distribution Master Plan".

10.2 POWER SYSTEM PLAN CORRESPONDING TO POWER DEVELOPMENT PLAN

10.2.1 Outline of power system plan

The Power System Plan corresponding to the Power Supply Enhancement Plan of this Power Development Plan is outlined below. The schedule of this Power System Plan is presented in Fig. 10.1, while the power system configuration in the final year of this Power Development Plan (1998) is illustrated in Fig. 10.2. The construction cost of this Power System Plan is presented in Chapter 11, Cost Estimate for Master Plan. Although the existing plans for the power system facilities are not included in this Power System Plan, they must be implemented in coordination with this Power System Plan as discussed in 10.1.2, "Transmission and Distribution Plans to be Incorporated into the Power Development Plan" are as follows:

i) Construction of a new single circuit, 69 kV transmission line between the New Kingston Power Station and the Sophia Frequency Converter Station.

ii) Implementation of 13.8 kV interconnection between East Demerara Area and West Demerara Area, and restoration of the submarine cable.

iii) Expansion of substation facilities.

10.2.2 Construction of new 69 kV transmission lines

New units will be installed in the New Kingston Power Station by adding 26 MW capacity (13 MW x 2) in 1993 and another 26 MW capacity (13 MW x 2) in 1995. This will make the New Kingston Power Station a large power supply base which will constitute 60% of the total generating capacity of the Demerara-Berbice Power System. In order to supply this power to the whole power system, a new 69 kV transmission line will be constructed from the New Kingston Power Station to the Sophia Frequency Converter Station in 1993, thereby interconnecting the Demerara Power System to the Berbice Power System.

The amount of power to be transmitted from the New Kingston Power Station by 69 kV transmission line is expected to be 20 to 25 MW according to our load projection and site survey, and considering the power flow status in the Georgetown District. Based on this estimate, it has been decided to select a single circuit in order to realize high economy for the time being.

The time of construction was selected at 1993, because this will make it possible to interconnect the New Kingston Substation to the 69 kV power system to facilitate unification of power system frequency in the Georgetown District before the New Kingston Power Station is commissioned, and stable power supply is assured as soon as the New Kingston Power Station is commissioned.

In order to attain high economy, the transmission line will be an overhead line with wooden poles or steel poles. The insulator strings and their accessories will be designed to withstand salt pollution. Cables will be used for the section of the transmission line which is inside the power station premises and its proximity. The specification of the cable is CVAZV (interlinked polyethylene insulated, polyvinyl chloride sheath, aluminum protected, electrolysis protection cable), having 300 mm^2 conductor with current rating of 500 A.

10.2.3 13.8 kV interconnection between east and west Demerara systems and restoration of submarine cable

There are two submarine cables, one for 50 Hz and another for 60 Hz, between the East Demerara System (Georgetown District) and the West Demerara System. The 50 Hz cable was designed to interconnect Kingston "B" Power Station to Versailles Power Station, and the 60 Hz cable was installed to commence the frequency conversion of the West Demerara Area. Power is distributed by this cable to Concervancy area which is approximately 10 km from Versailles Power Station.

The 50 Hz interconnection cable has been cut by an accident caused by a ship in May, 1987, and the two power systems are currently separated. Accordingly, Versailles Power Station is now operated at 50 Hz, to supply power only to the West Demerara Area. This has made the 4.2 MW (1.4 MW x 3) supply capability of the Versailles Power Station more than sufficient for the West Demerara Area, which peak load is approximately 3.0 MW, and this isolated power system is currently not experiencing scheduled blackouts. In addition, the generating facilities are not forced to operate under severe condition, and they are now operated on a sound basis as routine and periodical inspections can be conducted easily.

This blessed status of the isolated power system will be enjoyed for some time to come even when the load growth of West Demerara Area is taken into account. In addition, when the power supply capability of the East Demerara System is strengthened by the repair and improvement program on the existing facilities as well as the new power development plan, there is no need to supply the power of the Versailles Power Station to the East Demerara System. Considering this situation, there is no need to speed up the restoration of the submarine cable. Therefore, it is planned in this Project to restore the submarine cable in question and establish a second 60 Hz, 13.8 kV interconnection by the time the frequency of West Demerara Power System is unified, possibly by 1997. By this time, the existing 60 Hz, 13.8 kV distribution line will be connected to Versailles Power Station to realize two-circuit interconnection between the two power systems.

10.2.4 Expansion of substation facilities

(1) Construction of a substation in New Kingston Power Station

The power generated by New Kingston Power Station will be stepped up from 13.8 kV to 69 kV and supplied to the whole GEC power system through the Demerara-Berbice Power Systems which will be interconnected together.

For this purpose, a new substation will be constructed in the premise of New Kingston Power Station coincident with the construction of this power station, and two interconnection transformers, having 69/13.8 kV voltage and 16.7 MVA capacity each, will be installed in this new substation.

The number of interconnection transformers has been selected as two, so that the 69 kV line is not stopped even when one transformer is shut down for inspection or by other reasons.

The unit capacity of the interconnection transformer has been selected at 16.7 MVA due to the following reasons.

i) The power to be transmitted to the Demerara-Berbice Power System from the New Kingston Power Station will be from 20 to 25 MW (25 to 32 MVA) as discussed in paragraph 10.2.2.

ii) The standard unit capacity of transformers used in Demerara-Berbice Power Station is 16.7 MVA.

iii) As inspection of a transformer will be commonly conducted with that of a generator, the power to be transmitted by 69 kV line will be approximately 16 MW when one unit is shut down.

(2) Expansion of substation facilities of the Sophia Frequency Converter Station

69 kV transmission line will be constructed between the New Kingston Power Station and the Sophia Frequency Converter Station, before the New Kingston Power Station is commissioned in 1993. Although frequency unification work in Georgetown District can be started before 1993, it is expected that 50 Hz supply will still be required until frequency unification work is completed in 1996. Since supply capability of Kingston "B" Power Station will be decreased as its equipment age further and the decommissioning plan progresses, 50 Hz power may be supplied from the Sophia Converter Station.

Therefore, one interconnection transformer, 69/13.8 kV and 16.7 MVA must be installed in addition at the Sophia Frequency Converter Station. Through that transformers, the Sophia Converter Station can cater for remaining 50 Hz load in Georgetown in place of the Kingston B Power Station when a new 69 kV transmission line is constructed in 1993.

10.3 FREQUENCY UNIFICATION PLAN

10.3.1 Benefit of frequency unification

(1) Benefit of frequency unification

The frequency unification will bring about the following benefits, just like the system interconnection which is discussed in Chapter 10.1.2:

i) All generators in the power system can be commonly used for power supply, and reserve capacity can be held at any part of the system and the total amount of reserve capacity can be reduced. This means capital investment saving.

ii) Larger generating units, which have higher economy, can be adopted.

iii) Fuel and other resources can be utilized more efficiently, and the operating cost can be reduced.

iv) The power system can be strengthened, the scheduled outage for maintenance can be planned more easily, and the service to the customers can be enhanced.

(2) Frequency unification in other countries

To date, many countries in the world have implemented frequency unification. From 1945 to 1961, following the end of the Second World War, frequencies of consumers' facilities having a total installed capacity of more than6,000 MW were converted to unify countries' frequencies in Japan, USA, Italy, Canada and France. In the United Kingdam, facilities totaling 930 MW had frequencies of 17 different kinds unified during the period from 1928 to 1938.

In Japan, power facilities with a total capacity of approximately 260 MW were converted from 60 Hz to 50 Hz in Hokkaido and Tohoku Districts before the Second World War. In addition, some 50 Hz systems have been converted to 60 Hz in Kyushu District from 1949 to 1961, the total capacity amounting to approximately 400 MW. The outline of this frequency unification project is presented in the Appendix.

Speaking of countries nearer to Guyana, power system frequencies have been unified into 60 Hz in Venezuela, Brazil and Mexico. This was done in Venezuela on 450 MW of power facilities between 1961 to 1967, and on 1,200 MW of power facilities in Brazil in 1970.

10.3.2 History and current status of frequency unification

(1) Frequency standardization in Guyana

The Government of Guyana selected 60 Hz as the national standard frequency in 1971, and decided to make the necessary modifications on the 50 Hz equipment. This selection was made because the neighboring countries, such as Surinam, Brazil and Venezuela, either have their power systems operated at 60 Hz or are in the process of unifying the frequency from 50 Hz to 60 Hz, and exchange of electric power can be conveniently done in the future if Guyana has the same power system frequency.

At the same time, the Governemnt requested the importers to import electrical equipment rated for both 50 Hz and 60 Hz, and not to import 50 Hz equipment, but this request turned out to be not very effective. Therefore, the Government has enacted a law in 1973 which made it mandatory to secure special permission for import of 50 Hz electrical equipment. This law has encouraged the domestic manufacture and import of electrical equipment designed solely for 60 Hz or for both 50 Hz and 60 Hz.

It was under such circumstances that GEC started the "Frequency and Voltage Standardization" project.

(2) Frequency and voltage standardization

This project was financed by the World Bank, ODA and CIDA and started in 1972 with the target of completion set at 1976. It was planned that, at the same time as the frequency is standardized, the voltage is also standardized based on ANSI of the U.S. Standard, so that 11 kV was to be converted to 13.8 kV. The frequency unification programs included in this project were as follows:

i) Installation of 13.8 kV distribution facilities for 60 Hz operation,

ii) Installation of 30 MW of frequency converters in Georgetown,

iii) Conversion of all 50 Hz equipment of consumers to 60 Hz rating, and

iv) Conversion of 50 Hz diesel generators at Versailles and Anna Regina Power Stations to 60 Hz.

Of these programs, the following two were actually implemented:

i) Conversion of frequency for Power Station facilities and consumers' equipment in Onverwagt which was implemented in July and September of 1973, and

ii) Installation of three 10 MW frequency converters, which were completed in February, 1978, at Sophia Frequency Converter Station.

Other programs could not be realized due to the financial status of GEC and the shortage of engineers. According to the recommendation of the World Bank, GEC planned to complete the above frequency standardization project by May, 1985, but this has not been realized until today.

Concerning this project, a report named "Master Plan for frequency standardization in Guyana" was issued on the frequency standardization in October, 1973.

(3) Current status of power system frequency in Guyana

In Guyana, electric power is being supplied at 50 Hz and 60 Hz. 50 Hz is being used in the old districts of Georgetown, the West Demerara area and Anna Regina area. 60 Hz is being used in the new residential and industrial areas of Georgetown, on the east bank of the Demerara River, and in the east areas such as Onverwagt and New Amsterdam, which total power consumption is approximately 40%.

The approximate division between 50 Hz and 60 Hz in Georgetown, which is the largest load center of Guyana, is illustrated in Fig. 10.3. In this area, three quarters of electric power is being supplied at 50 Hz. The distribution line voltage in these areas are 11 kV and 4 kV. The facilities in these areas are not in good condition, and prompt improvement is required.

At 20 hours on August 18, 1988, which is the peak time, the record of power demand in the Georgetown area was as presented below.

Load in 50 Hz area:	
Supply from Kingston "B" Power Station;	22.1 MW
Supply from Sophia Frequency Converter Station;	1.1 MW
Total	23.2 MW
Load in 60 Hz area:	
Supply from Sophia Frequency Converter Station;	8.4 MW

At this time, Sophia Frequency Converter Station was converting 5.0 MW of power from 50 Hz to 60 Hz.

GEC has explained that it has not abandoned the frequency standardization plan, and is still engaged in this project, but its implementation is being delayed by shortage of funds. On the other hand, it expressed the view that the construction works involved for conversion of frequency in Georgetown, where there are many customers, are very difficult. The policy and the law mentioned in the previous paragraph are still effective, and the system of permission for manufacture and import of 50 Hz electrical equipment have not changed.

10.3.3 Frequency unification plan

(1) Outline of unification plan

The plan for unification of the power system frequency is outside the scope of this Power Development Plan. However, as this is an important issue, we present the following frequency unification program, which has been studied internally, as information for those concerned. It is recommended that detailed studies are conducted on this problem of frequency unification, and a specific implementation program be established as soon as possible.

i) Formulation of frequency unification implementation plan.

ii) Frequency unification of the Georgetown District.

iii) Frequency unification of the West Demerara Area.

iv) Frequency unification of the Anna Regina Area.

v) Restoration of whole unit in Sophia Frequency Converter Station

It must be noted that frequency unification of Georgetown District is an important plan which implementation must commence by the time of the commissioning of the New Kingston Power Station, since 60 Hz units will be selected for this new power station, and the power will be supplied to Georgetown District by 60 Hz, 13.8 kV lines. If this unification plan is held up, there will be serious impediment against power supply, which may lead to a social issue. It is expected, therefore, that GEC understands the gravity of this program, and conducts the necessary surveys, formulate adequate plans, and implement the construction works with all its resources.

(2) Formulation of frequency unification plan

In unifying the power system frequency, a detailed plan must be formulated to define the method and scope of frequency modification, the necessary surveys to be conducted on customers and the methods, materials and equipment required, etc.

GEC has the experience of applying "Frequency and Voltage Standardization Project" to a part of the Georgetown District and unifying the frequency of the Onverwagt Area, and now is formulating frequency unification plans for the Georgetown District and the West Demerara Area. In the "Master Plan for Frequency Standardization in Guyana", a report complied in October, 1978 to summarize experiences and policies related to frequency standardization in the Demerara Area, detailed descriptions are presented concerning the objective and method of frequency standardization, method of surveys on customers, public-relations activities in dealing with customers' consultation and complaints, implementation organization (corporate organization and staffing) and equipment/materials required. Most of the contents of this report can be useful for the frequency unification program if only certain descriptions on equipment are modified to facilitate the new versions. It is recommended that the frequency unification implementation programs are quickly fomulated based on such experience and data.

(3) Frequency unification in the Georgetown District

It is recommended to implement the first phase of frequency unification and voltage standardization project for the Georgetown District at the time of construction of the New Kingston Power Station which will be commissioned from 1993 to 1995. It would be an appropriate schedule to convert the southern side of Georgetown, covering approximately 2/3 of the supply area, during the period from 1992 to 1994, and then standardize the remaining 1/3 during 1995 to 1996. As the distribution systems here form complicated networks it is recommended to construct several new 13.8 kV trunk lines to feed the current distribution lines which are used as the sectional branch lines after the voltage conversion works conducted sectionally are finished. The current division of supply frequencies in Georgetown and the area subjected to each phase of the frequency unification project are illustrated in Figure 10.3.

The detailed steps for 60 Hz conversion work based on the concept described above are presented below.

i) The new 69 kV transmission line from the New Kingston Power Station to the Sophia Frequency Converter Station will be completed before commissioning of the New Kingston Power Station.

ii) 5 to 6 circuits of 13.8 kV distribution lines will be constructed from the New Kingston Power Station and/or the Sophia Frequency Converter Station to the Georgetown District during the period from 1992 to 1993.

iii) The existing distribution lines will be divided by installing sectionalizing switches at suitable locations so that they are used as branch lines feeded by the above trunk lines at the new system frequency.

iv) One section of the distribution network will be converted to 60 Hz on an experimental basis by separating this section with the sectionalizing switch and supplying power to this section through the new distribution trunk line. This experiment will help identify potential problems.

v) Each section divided by sectionalizing switches will be shutdown one by one, their distribution transformers replaced by 60 Hz, 13.8 kV transformers, and then connected to the new distribution trunk line to supply 60 Hz power.

vi) The above procedure will be repeated until the whole area is converted to 60 Hz.

The 50 Hz loads will remain until the frequency unification project is completed. This means that 50 Hz power will have to be supplied from Kingston "B" Power Station or Sophia Frequency Converter Station. That is, Kingston "B" Power Station should not be decommissioned too early.

(4) Frequency unification in the West Demerara Area

It had been planned to unify the system frequency of the West Demerara Area in conjunction with the project of rehabilitating the generating facilities of Versailles Power Station, which has been implemented by grant cooperation of the Japanese Government in 1985, but the former plan has not been implemented. If realized, this plan would have unified the system frequency for 35% of the Demerara Power System. The outline of this unfinished plan was as described below.

i) All pole transformers used on the West Coast Distribution Line (38 km) and the West Bank Distribution line would be changed from 50 Hz, 11 kV/220 V ratings to 60 Hz, 13.8 kV/220 V ratings so that the above mentioned distribution lines could be converted to 60 Hz, 13.8 kV operation.

ii) Customer facilities in the West Demerara Area would be converted to 60 Hz rating.

iii) Existing West Bank Distribution Line (50 Hz, 11 kV) would be stepped up to 13.8 kV, and connected to existing 60 Hz, 13.8 kV distribution lines (serving areas along the West of the Demerara River from Garden of Eden Power Station)

iv) West Bank Distribution Line would be disconnected from East Bank Distribution Line.

[Note 1] West Coast Distribution Line supplies power to West Demerara Area from Versailles Power Station.

[Note 2] West Bank and East Bank Distribution Lines are those connecting Versailles Power Station to Kingston "B" Power Station through the submarine cable under Demerara River. The section of this line from Versailles to the cable is called "West Bank Distribution Line", and the section from the cable to Kingston "B" is called "East Bank Distribution Line".

As mentioned in 10.2.3, the West Demerara Power System is an isolated power system today due to a cable accident, but it is being operated under favorable condition. Therefore, it would be appropriate to implement this frequency unification plan for the West Demerara Area at a time around 1997 when the frequency unification of the Georgetown District is completed and the East-West Demerara Systems can be interconnected by 13.8 kV distribution lines.

The following steps must be followed in this plan.

i) The 60 Hz, 13.8 kV distribution line, which is now supplying power to Concervancy Area of West Demerara from Garden of Eden Power Station, will be connected to Versailles Power Station.

ii) West Coast Distribution Line will be raised to 60 Hz, 13.8 kV.

iii) The submarine cable will be restored.

iv) West Bank Distribution Line will be raised to 60 Hz, 13.8 kV, and this line will be connected to East Bank Distribution Line through the restored submarine cable.

v) The customers' power facilities will be converted to 60 Hz.

(5) Frequency unification in the Anna Regina Area

Anna Regina Area is supplied by an isolated power system, which is operated at 50 Hz and 11 kV. In this Power Development Plan, it is scheduled to replace one generator (2.0 MW x 1) at Anna Regina Power Station by 1991, and another (1.0 MW x 1) in 1992; the new generators being rated at 60 Hz. Therefore, it will be necessary to convert the system frequency of Anna Regina Area to 60 Hz, and voltage to 13.8 kV at the time.

However, interconnection of Anna Regina System to other 60 Hz power system is not foreseen in the near future, the benefit gained by frequency unification of Anna Regina System will be small. For this reason, it would be appropraite to review again the current plan for adoption of 60 Hz generators and unification of system frequency.

(6) Restoration of converter units in Sophia Frequency Converter Station

Some units of Sophia Frequency Converter Station are out of service now due to machine trouble. Although GEC is considering purchase of a new stator and a rotor, there is no specific plan.

When we visit the plant during the site survey, the power exchange between 50 Hz system and 60 Hz system was 5 MW, from 50 Hz to 60 Hz, while 3 units in Kingston "B" Power Station were operated at full load. However, according to this Power Development Plan, a 5.7 MW unit will be added to Garden of Eden Power Station and a 7.8 MW unit to Onverwagt Power Station, both belonging to the 60 Hz system, as the emergency power supply enhancement program which will be implemented in 1990 and 1991. After this enhancement, when we consider the scheduled shutdowns at Kingston "B" Power Station and aging of the plant facilities, the power exchange will be in the direction of 60 Hz to 50 Hz. This power exchange will increase if the frequency unification plan is not smoothly implemented in coordination with construction of New Kingston Power Station.

Therefore, it would be appropriate to restore the whole unit of frequency converter by 1993 when 60 Hz power generation capacity is increased. In restoring converters, the cause of past failure should be clarified, and the necessary measures for prevention of failure should be worked out, including insulation coordination between system abnormal voltage and lightning arrester rating, and location of arresters.

As Sophia Frequency Converter Station will not be needed after the power system frequency in Georgetown District is unified, its equipment will be decommissioned.

APPENDIX

Experience of Frequency Unification in Japan

1. In Japan today, the areas to the east of the central part of Japan, including Tokyo, are supplied with 50 Hz power and those to the west, including Osaka, are supplied with 60 Hz power.

2. The electric utility business in Japan started in 1887. In the early period, power systems were isolated and independent from each other, and no consideration was given to the unification of power system frequency. Therefore, various frequencies, such as 25 Hz, 40 Hz, 50 Hz, 60 Hz, 100 Hz and 120 Hz, or even DC systems were used.

3. Later on, the eastern areas of Japan tended to be dominated by 50 Hz power systems, and the western areas by 60 Hz power systems, and these two groups of power systems developed quickly.

4. As power transmission technology progressed, it became desirable to interconnect power systems spreading over a wide area, and the need for unification of system frequency has been discussed frequently. However, as the power demand was growing rapidly and unification of system frequency needed a large amount of capital investment, the two different power system groups, having 50 Hz and 60 Hz each, were allowed to grow independently.

5. Before 1946, 129 MW of power systems in Tohoku District, the northern part of Honshyu Island, and 126 MW of power systems in Hokkaido District, the most northern part of Japan, were converted from 60 Hz to 50 Hz. In addition, several smaller frequency unification projects were implemented in the period from 1956 to 1962.

6. Outside Japan, there were large frequency unification projects such as described below:

1) Southern California Area, U.S.

In this area, a total of 1,000 MW of power capacity, for 700,000 customers, were converted from 50 Hz to 60 Hz at a cost of 35 million dollars from 1946 to 1948.

2) The United Kingdam

17 different frequencies were unified into 50 Hz together with expansion of transmission systems during a period from 1928 to 1938. The total size of the power capacity involved was 930 MW and the cost was 17.3 million pounds.

7. In Japan, the unification of frequency in Kyushu Island, one of the largest islands and the most southern part of Japan, was accomplished in a period from December, 1949 to May, 1961. The total capacity of the exchanged frequency was 370 MW.

8. In this frequency unification project, the electric utilities involved converted 130 MW of thermal power plants and 300 MW of hydroelectric power plants to 60 Hz. The thermal power plants, turbines and generators were modified and pump runners and motors were replaced. In the hydroelectric power plants, runners were replaced and generators were modified.

9. Large customers took appropriate measures such as modification of pumps and adjustment of speed of production lines. Generating facilities owned by private companies were either abolished or modified.

10. The following procedures were followed when the frequency of Kyushu Island was unified:

1) A conference was established by representatives of governmental authorities, the electric power company, large customers and experts.

2) A pamphlet named "Introduction to Conversion of Frequency" was distributed to general customers, such as residential, commercial and small industrial, in order to develop better understanding.

3) The conversion costs were funded by corporate bonds and governmental subsidies for the electric power company, and large customers

were financed by bank loans under auspices of authorities of the company.

4) Corporate income taxes, corporate taxes and fixed asset taxes on the facilities related to frequency conversion were reduced.

5) Costs incurred by the customers were compensated under certain rules.

6) The compensations were recovered by the electricity rates.

11. The pamphlet, "Introduction to Conversion of Frequency" had the following contents:

1) General Explanation of the Effect of Frequency Change

The output of transformers (kVA) is increased by 2 to 5% due to reduction of transformer total losses. The speed of induction motors is increased by 20%, but the starting torque is reduced by 17 to 40%.

2) Effects of 60 Hz operation on Various Electrical Equipment

a) Lights

The ignition of fluorescent lamps become unstable as the impedance of choke coil (ballast) is increased, and the lamp life is reduced. It is required to replace the choke coil to avoid this.

b) Appliances with small capacity, single phase motors

Most electrical appliances can be used as they are (refrigerators, washing machines, vacuum cleaners, fans, air conditioners, hair dryers and so on). The electric clock and time recorder can not be used as their speed is increased by 20%. Pulleys of record players have to be replaced.

3) Effects of Frequency Change on Machine Tools of Various Industries

The effects of the change of frequency on various machines used in light and small industries are described. Although the motor speed is increased by 20%, most machines can be operated by changing pulleys. Pumps operated by belts can be used by changing pulleys. Directly connected pumps must have their motors replaced or winding re-wound, or have the impellers modified.

12. Concerning office automation equipment which are rapidly being introduced into business offices, copying machines may not be used under different frequency. Word processors and computers are not affected.

13. The constant voltage, constant frequency power supply units or battery chargers rated at 50 Hz can be used with 60 Hz. But in case of the opposite some equipment may become overheated.

14. It may be difficult to change the rated speed of diesel engines depending on the engine characteristics. Some engines produce shaft vibration when speed is changed, and detailed consultation with the manufacturers will be required.

Fig. 10.1 Master Plan of Transmission and Distribution Line and Frequency Unification

Description	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
1. Transmission Line, Distribution Line and Substation										
i) New Kingston～Sophia 69kV Transmission Line				←→	←→					
ii) Restoration of Submarin Cable										←→
iii) New Kingston and Sophia Substation				←→	←→					
2. Frequency Unification										
i) Formation of Plan	←···→	←···→	←···→							
ii) Georgetown Region										
• Frequency Unification				←···→	←···→	←···→	←···→	←···→		
• 13.8kV Distribution Line										
• Construction of New Lines			←···→	←···→	←···→					
• Up-grading of Existing Lines					←···→	←···→	←···→	←···→		
iii) West Demerara Region										←···→
iv) Anna Regina Region			←···→	←···→						
v) Sophia Converter Station		←···→ Restoration of Rotary Converters								←···→ Removal

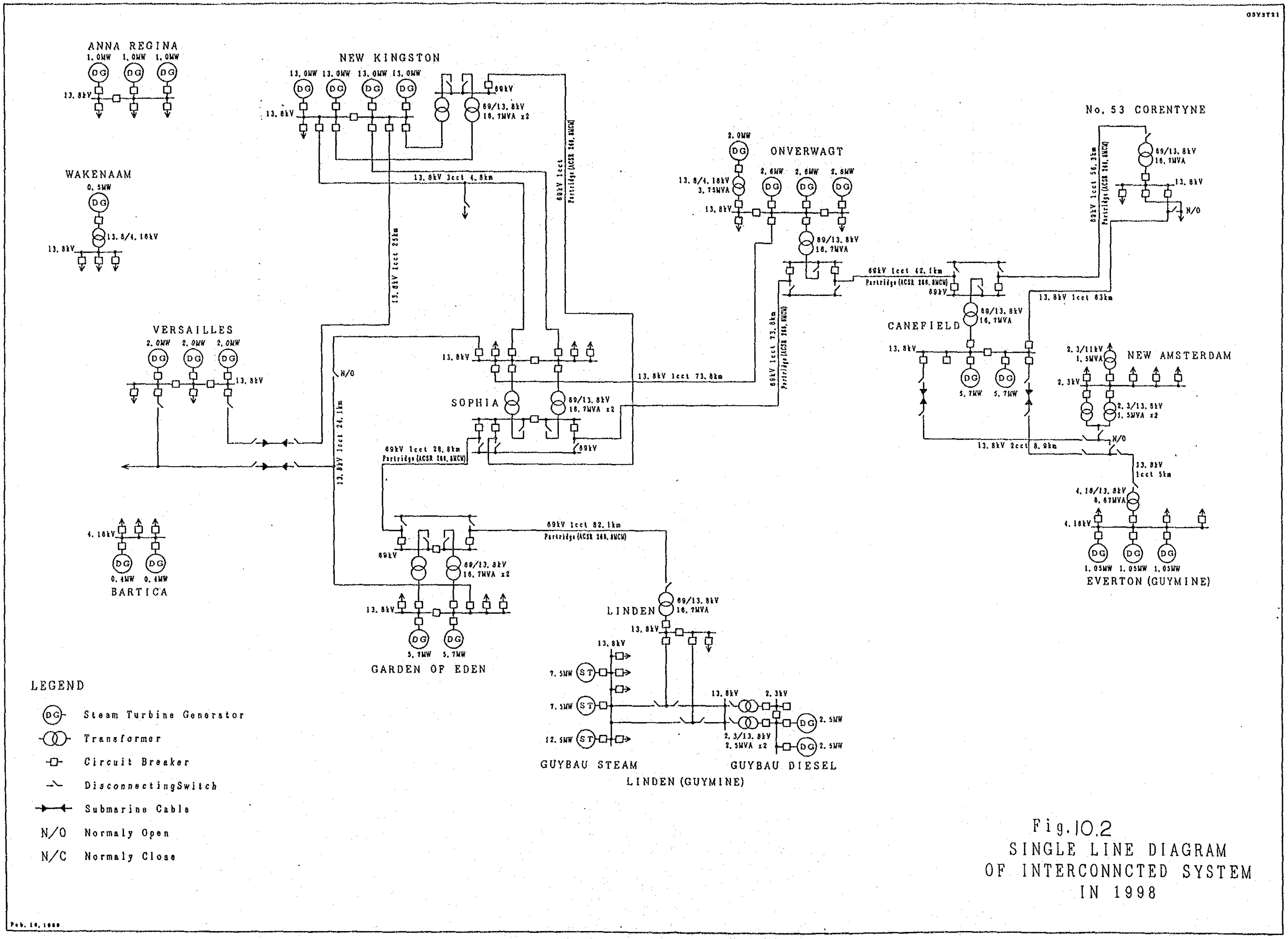


Fig.10.2
SINGLE LINE DIAGRAM
OF INTERCONNCTED SYSTEM
IN 1998

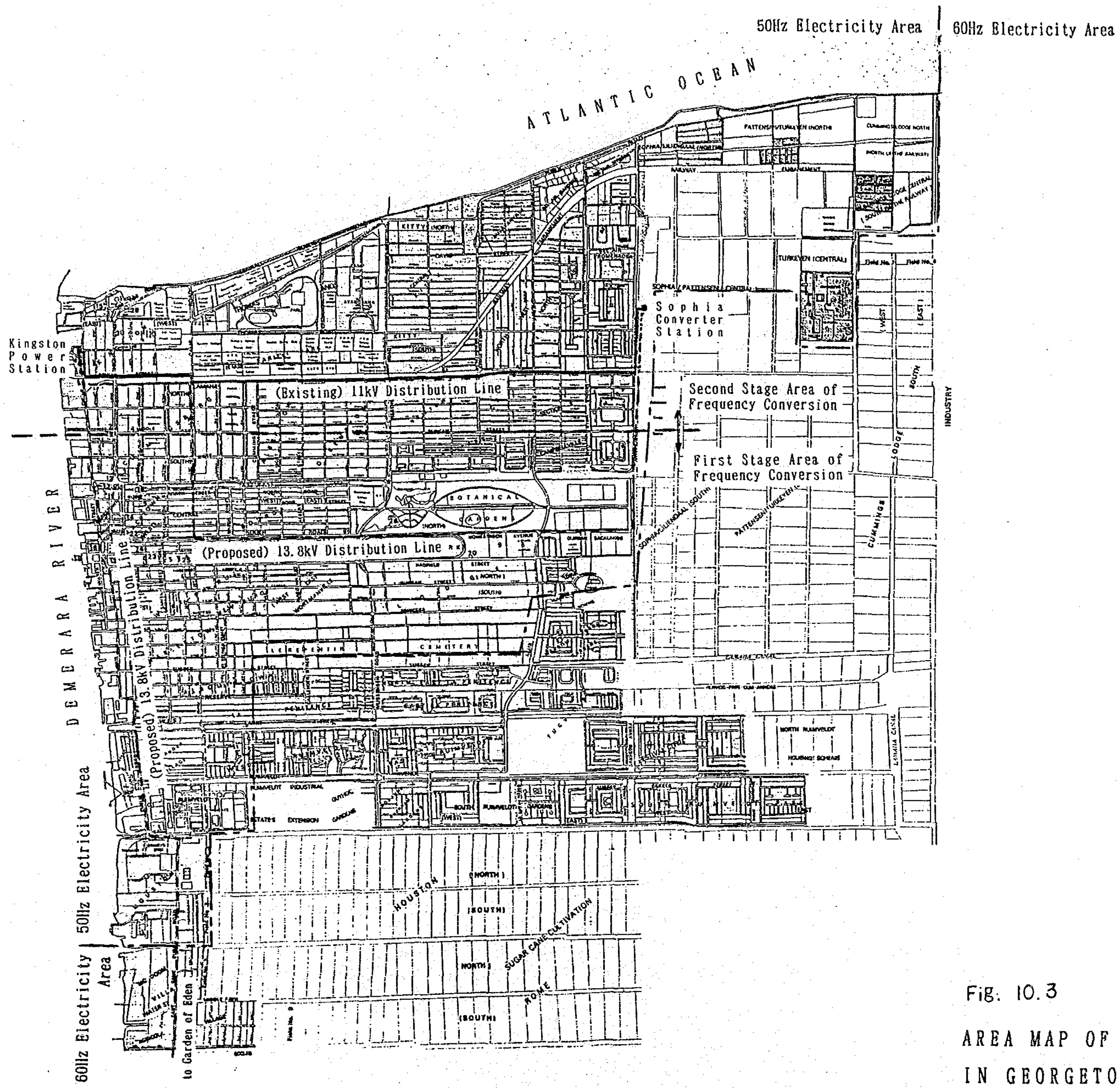


Fig. 10.3

AREA MAP OF FREQUENCY IN GEORGETOWN REGION

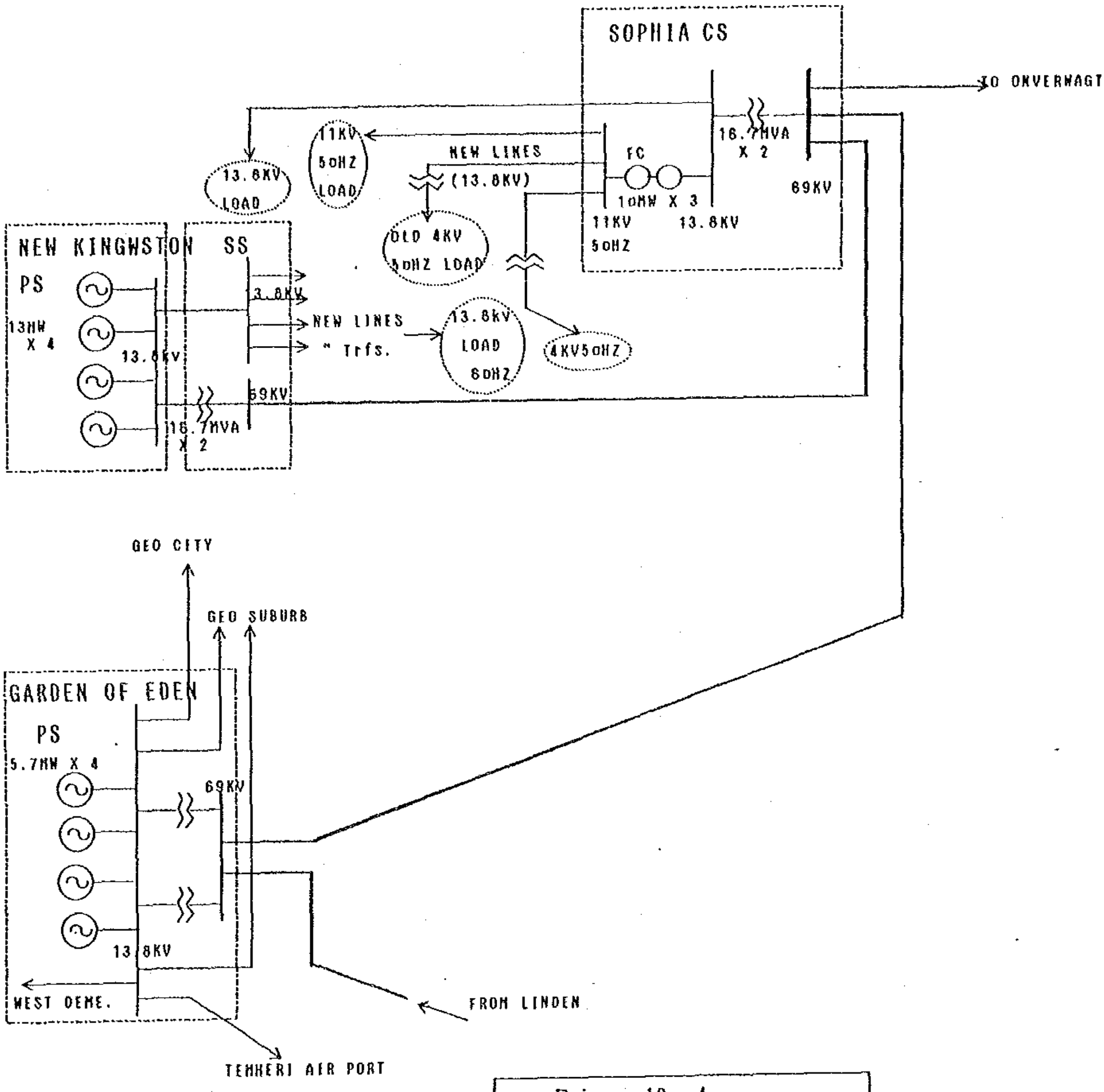
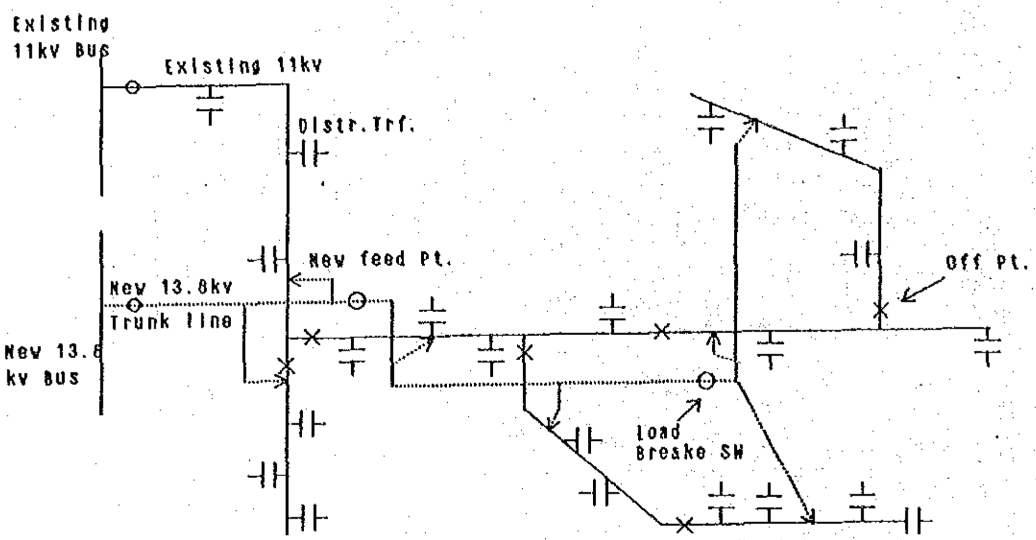


Fig. 10－4
SYSTEM DIAGRAM AS OF 1995
EPDC INTERNATIONAL JAN.1989



Work order

1)Determination of breake points of existing lines
in order to use these parts as the branch lines.

2)Construction of new 13.8kv trunk lines along appropriate routes.

3)Test of freq. change work.

i) Replace of distribution transformers of a designated suitable model area from existing 11kv to new 13.8 kv within short hours supply-stoppage.

ii) Connection of the above portion of existing line to new trunk line at a suitable point.

iii) Supply 60HZ power to the consumers of the area through new trunk line and a part of existing line.

iv) Investigation of influence of freq. change for consumers.
Pointing out improvement points.
If necessary, tentative 50HZ power be supplied again, by mobile diesel generator etc.

4)Suitable counter measures aginst troubles cleared up by the test.

5)Execution of 60HZ conversion work successively for other areas by same manner as test case.

Fig. 10-5
Conceptual Drawing for Frequency Conversion in Georgetown
EPDC International Ltd.

CHAPTER 11

COST ESTIMATE FOR MASTER PLAN

CHAPTER 11 COST ESTIMATE FOR MASTER PLAN

11.1 GENERAL

In this Master Plan, the construction costs were estimated for diesel power generating facilities and transmission and distribution facilities (including their rehabilitation). As for power generating facilities, the costs were estimated for "Plan II" sequence among the three alternatives considered in Chapter 6.

The construction costs of Tiger Hill hydro power development project are estimated in Chapter 9 separately.

The above estimates were made in accordance with the construction schedules shown in Fig. 11.1 and Fig. 11.2 and at prices as of November 1988.

The costs were broken down into foreign currency portion and local currency portion. The foreign currency portion includes costs of imported equipment and materials, ocean freight and insurance, salaries for foreign engineers and personnel, while local currency portion includes costs for inland transportation, locally available machine and materials such as cement, aggregates, timber, etc., as well as salaries and wages for local personnel and workers.

11.2 CONDITIONS FOR ESTIMATE

The GEC's administration cost, engineering fee, contingency, price escalation, interest during construction, and currency exchange rate were estimated under the following conditions:

(1) Administration cost, engineering fee and contingency

Physical contingency is to cover mainly unforeseen additional works. In the light of experiences in projects of similar nature, it is reasonable to include around 5% for mechanical and electrical equipment and 10 to 15% for civil and structural works of respective direct costs as physical contingency.

For diesel generating facilities in this Master Plan, contingency is included in each of equipment cost, cost of civil works and cost of installation works. Administration cost and engineering fee were estimated to be about 6 to 8% of the total costs.

For transmission and substation facilities, 15% of direct costs was included as contingency to cover unforeseen additional works, GEC's administration cost and engineering fee.

(2) Price escalation

In the last several years, there was almost no substantial price rise for mechanical and electrical equipment and other construction materials. No price escalation is included in this cost estimate.

(3) Interest during construction

The interest during construction is not included in this cost estimate because it would be normal to estimate this cost when it becomes possible to identify concrete loan conditions.

(4) Currency exchange rates

The currency exchange rates used in this cost estimate are as follows:

US$ 1.0 = Japanese Yen 130 = G$ 10.0

11.3 RESULT OF COST ESTIMATE

The results of cost estimate for Master Plan are shown in Tables 11.1.1, 11.1.2, 11.2.1 and 11.2.2, and summarized as follows:

(US$ thousand)

Item	Foreign currency	Local currency	Total
- Diesel power plants	81,923	14,457	96,380
- Transmission & substation facilities	2,484	851	3,335
Total	84,407	15,308	99,715

Fig. 11.1 CONSTRUCTION SCHEDULE
(Power Development)

	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Kingston power plant:											
13.0 MW x 2 (LS)				----	----						
13.0 MW x 2 (LS)						----	----				
Garden of Eden power planr:											
5.7 MW x 1 (MS)	----	----									
5.7 MW x 1 (MS)								----	----		
Canefield power plant:											
5.7 MW x 2 (MS)									----	----	
Onverwagt power plant:											
2.6 MW x 3 (HS)		----	----								
Anna Regina power plant:											
2.0 MW x 1 (HS)		----	----								
1.0 MW x 1 (HS)			----	----							
Wakenaam power planr:											
0.5 MW x 1 (HS)			----	----							
Bartica power plant:											
0.4 MW x 1 (HS)		----	----								
0.4 MW x 1 (HS)									----	----	

Fig. 11.2 CONSTRUCTION SCHEDULE (Transmission & Substation)

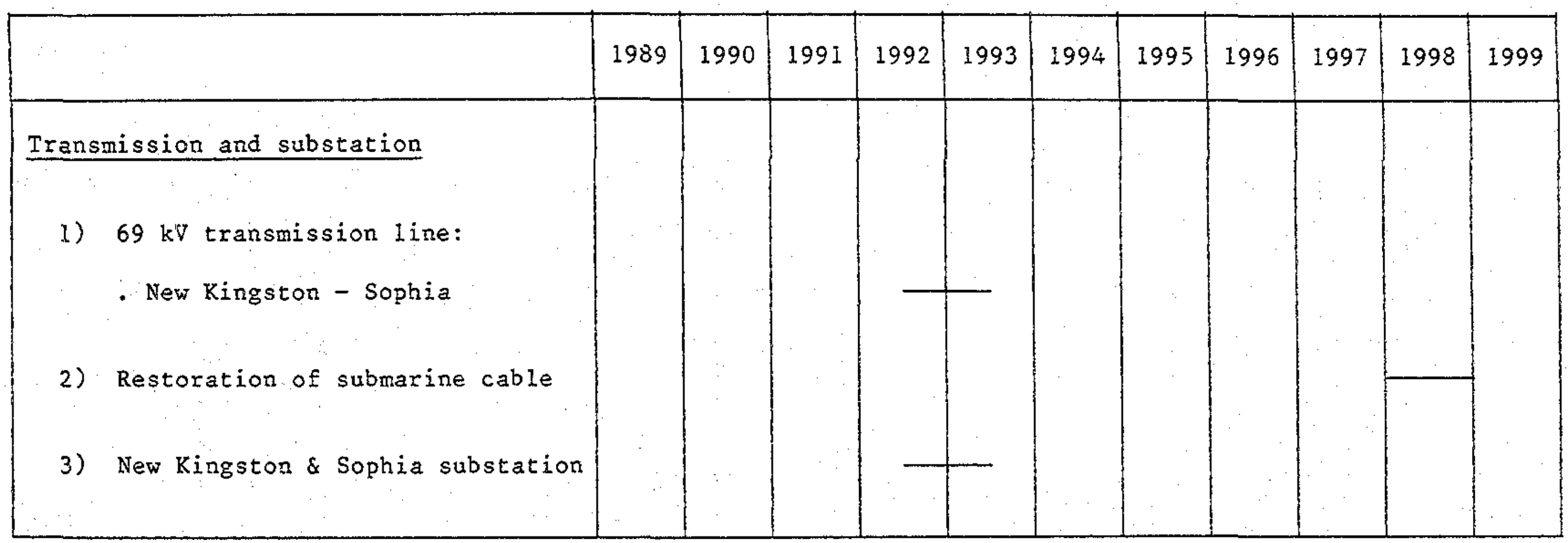


Table 11.1.1 INVESTMENT COST FOR MASTER PLAN
(Power Development Program)

(US$ thousand)

Power Plant	Capacity Unit x MW	Foreign currency	Local currency	Total Cost
Kingston	2 x 13.0 MW	28118	4962	33080
	2 x 13.0 MW	24191	4269	28460
Garden of Eden	1 x 5.7 MW	4905	866	5770
	1 x 5.7 MW	4777	843	5620
Canefield	2 x 5.7 MW	9682	1709	11390
Onverwagt	3 x 2.6 MW	5228	923	6150
Anna Regina	1 x 2.0 MW	1828	323	2150
	1 x 1.0 MW	1182	209	1390
Wakenaam	1 x 0.5 MW	655	116	770
Bartica	2 x 0.4 MW	1360	240	1600
Total	86.9 MW	81923	14457	96380

Table 11.1.2 INVESTMENT COST FOR MATER PLAN
(Power System Program)

(US$ thousand)

Item	Foreign currency	Local currency	Total Cost
Power system			
1) 69 kV line (5 km : 1 feeder)	150	70	220
2) Restoration-Submarine cable	260	90	350
3) New Kingston & Sophia substation	1750	580	2330
Subtotal	2160	740	2900
4) Contingency (15%)	324	111	435
Total	2484	851	3335

Table 11.2.1 ANNUAL DISBURSEMENT OF INVESTMENT COST
(Power Development Program)

(US$ thousand)

Year	Kingston	Garden of Enden	Canefield	Onverwagt	Anna Regina	Wakenaam	Bartica	Total Cost
1989	0	2308	0	0	0	0	0	2308
1990	0	3462	0	2460	860	0	340	7122
1991	0	0	0	3690	1846	0	510	6046
1992	13232	0	0	0	834	308	0	14374
1993	19848	0	0	0	0	462	0	20310
1994	11384	0	0	0	0	0	0	11384
1995	17076	0	0	0	0	0	0	17076
1996	0	2248	0	0	0	0	0	2248
1997	0	3372	4556	0	0	0	300	8228
1998	0	0	6834	0	0	0	450	7284
Total	61540	11390	11390	6150	3540	770	1600	96380

Table 11.2.2 ANNUAL DISBURSEMENT OF INVESTMENT COST
(Power Development & System)

(US$ thousand)

Year	Power development program			Power system program			Grand Total
	F.C.	L.C.	Total	F.C.	L.C.	Total	FC+LC
1989	1962	346	2308	0	0	0	2308
1990	6054	1068	7122	0	0	0	7122
1991	5139	907	6046	0	0	0	6046
1992	12218	2156	14374	1305	445	1750	16124
1993	17264	3047	20310	881	302	1183	21493
1994	9676	1708	11384	0	0	0	11384
1995	14515	2561	17076	0	0	0	17076
1996	1911	337	2248	0	0	0	2248
1997	6994	1234	8228	0	0	0	8228
1998	6191	1093	7284	298	104	402	7686
Total	81923	14457	96380	2484	851	3335	99715

Note: F.C. = Foreign currency portion
L.C. = Local currency portion

CHAPTER 12

ECONOMIC EVALUATION
(OPTIMUM POWER DEVELOPMENT PROGRAM)

CHAPTER 12 ECONOMIC EVALUATION (OPTIMUM POWER DEVELOPMENT PROGRAM)

12.1 SCALE OF POWER DEVELOPMENT PROGRAM

The results of power demand forecast in Chapter 5 show that in the Demerara and Berbice systems peak load and required capacity including reserve margin in 1998 will be 70.0 MW and 87.5 MW, respectively. In that year, remaining capacity of existing power plants in these systems will be only 6.2 MW (3 units of each 1.4 MW of Versailles power station and 2.0 MW of Onverwagt power station). Thus, a total capacity of 81.3 MW will have to be added to these systems during the period from 1990 to 1998.

In the isolated systems, a total capacity of 3.6 MW will have to be added, i.e. 2.3 MW in the Anna Regina/Wakenaam system and 0.8 MW in the Bartica system during the above period.

12.2 ECONOIC EVALUATION

12.2.1 Method of evaluation

(1) Conceivable types of power plant

Taking into account the scale of demand load of each power system, the following alternatives are considered for power plants to be constructed during the planned period:

a) Demerara and Berbice systems

- a) Diesel power plant: High speed: Diesel oil firing
- b) Diesel power plant: Medium speed: Diesel oil firing
- c) Diesel power plant: Medium speed: Bunker C firing
- d) Diesel power plant: Low speed: Bunker C firing
- e) Gas turbine: Diesel oil firing
- f) Gas turbine: Bunker C firing
- g) Steam power plant: Bunker C firing

Of the above 6 alternatives, c) and f) were omitted because, according to GEC the maintenance of heavy oil treatment plant had been difficult and expensive due to quality of imported heavy oil. In fact, existing units of Garden of Eden and Canefield power stations were designed to use Bunker C but after several years of running they were switched to use diesel oil because of frequent troubles and expensive maintenance costs.

For diesel power station, Bunker C is to be used only for low speed type.

b) Isolated systems

Diesel power plant: High speed: diesel oil firing

(2) Method of evaluation

The power generation cost per kWh varies with annual operation hours or plant factor. To select optimum type of power plant which is best adapted for load pattern of the power system, it is appropriate to use so-called "screening curves" method. This method consists of drawing cost-curves of net 1 kW at sending-end of all types of power plants to obtain break-even points for economic operation of these power plants, and projecting these break-even points on a forecasted load duration curve (*) for the future to determine an optimum scale of their development. The break-even point for economic operation can be calculated in the following manner:

a) For each type of power plant, annual fixed cost including annuitized capital cost and operation and maintenance costs per kW, and fuel cost per kWh, both at sending-end of power plant, are calculated.

The annuitized capital cost is calculated as follows:

A = C*R*(1 + R)^N/((1 + R)^N - 1)

Where:
A : Annuitized capital cost
C : Investment cost including interest during construction
R : Rate of interest
N : Service life (Years)

b) For each type of power plant, "time-cost curve" which varies with annual operation hours is plotted on a graph, by using the above fixed cost and fuel cost.

c) The intersecting point of time-cost curves of two power plants represents a break-even point for economic operation of these two power plants. If annual operation hours which correspond to the break-even point of power plants A and B is "H", "H" can be obtained from the following equation:

(Fixed cost of A) + (Unit fuel cost of A)*H
= (Fixed cost of B) + (Unit fuel cost of B)*H

Therefore:

$$H = \frac{\text{(Difference of fixed costs per kW between A and B)}}{\text{(Difference of fuel cost per kWh between A and B)}}$$

GEC has no data on the annual load duration curves. The data provided by GEC is a load duration curve which was drawn for the Demerara and Berbice systems based on information for the week beginning 1st February 1988. According to GEC, there was very little load shedding during this week. The curve is shown in "Reference".

The load factor estimated from the above duration curve would be around 40%. However, Table 2.2.4.(3) of Chapter 2 shows that the annual load factor in the Demerara and Berbice system is estimated to be more than 60%. Therefore, it is not appropriate to use the above 1-week load duration curve as the basis of the economic evaluation. In this study, an annual load duration curve was simulated and used, taking into account annual load duration curves of other Caribbean countries showing annual load factors of more than 60%.

12.2.2 Conditions for economic evaluation

Conditions adopted for this economic evaluation are shown in Table 12.1. These conditions cover the following items:

- Station service loss factors (power and energy losses)
- Availability factor which takes into account shutdown for scheduled maintenance and forced outage
- Output drop due to ambient temperature (for gas turbine)
- Thermal efficiency
- Economic service life
- Ratio of operation and maintenance cost to investment cost
- Investment cost per kW (in US$)

- Annual disbursement of investment cost
- Price of fuel (diesel oil and Bunker C)

12.2.3 Rate of interest

In the economic evaluation of the projects, a social rate of discount (or rate of interest) which reflects the opportunity cost of capital must be used. In Guyana there is no information about this matter. Therefore, considering that for the current rehabilitation program an interest rate of 7% is applied by Inter-American Development Bank (IDB), this rate shall be used for this economic evaluation.

12.2.4 Sensitivity analysis

Sensitivity analysis were made for the interest rates of 5% and 9%.

12.3 OPTIMUM POWER SOURCE STRUCTURE

12.3.1 Demerara and Berbice systems

Tables 12.2.(1) to 12.2.(3) and Figs. 12.1.(1) to 12.3.(2) show that an optimum power source structure of the Demerara and Berbice systems for 1998 will be as follows:

Optimum power source structure	Interest rate 7% (MW)	Sensitivity analysis 5% (MW)	Sensitivity analysis 9% (MW)
. Low speed diesel	57.2	59.4	55.4
. High speed diesel or gas turbine	24.6	22.4	26.4
. Remaining capacity of existing power plants	6.2	6.2	6.2
Required capacity	88.0	88.0	88.0

Note: The aggregated peak load in the Demerara and Berbice systems in 1998 is estimated to be 70.0 MW.

As shown in Tables 5.4.(2) to 5.4.(4) of Chapter 5, the shortage of supply capability of these systems will be 14.5 MW in 1991 (10.7 MW for the Demerara system and 3.8 MW for the Berbice system). This shortage is for the case where a reserve margin of 13.5 MW is included. If this margin is not included, there would be still a shortage of 1 MW in 1991. Therefore, it would be necessary to commission an additional capacity of at least 10 MW by 1991 as the urgent power development program, in order to be able to meet the power demand should 1 unit (8.5 MW) of Kingston power station be in forced outage.

In around 1993/94, No. 1 and No. 2 units of each 10.0 MW of Kingston power station will have to be retired, and also in around 1995/96, 3 units of each 5.7 MW of Garden of Eden power station will have to be retired. Further, in around 1997/98, No. 3 unit (10.0 MW) of Kingston and 2 units of each 5.8 MW of Canefield power station will be retired. Therefore, with the retirements of these power plants, new power plants must be constructed.

Unit sizes of 10.0 MW for the Demerara system and 5.8 MW for the Berbice system would be both too large against demand loads of these systems, because when faults occur to these units the frequency drop will exceed 1.5 Hz, bringing these systems in danger of complete shutdown. However, the danger of complete shutdown could be avoided by adopting appropriate counter-measures such as frequency relaying system.

At Garden of Eden and Canefield, it would be appropriate to install new generating units on the foundations of retired units, therefore almost the same unit size as before (about 6 MW) will have to be adopted.

Attention should be paid to the fact that for annual operation hours of less than 1,928, gas turbine power plant would be more economical than diesel power plant (high speed), but when considering difficulties of maintenance and repair, diesel power plant would be recommendable from a practical viewpoint.

12.3.2 Isolated systems

Taking into account unit sizes of existing power plants and forecasted peak loads in the isolated power systems, the following power development programs can be considered:

Power system	Scale of development (MW)	Unit capacity (MW)	Optimum plant type
Anna Regina/Wakenaam	2.8 - 3.0	0.5 - 1.0	High speed diesel
Bartica	0.8 - 1.0	0.4 - 0.5	High speed diesel

12.3.3 Hydro power development program

Development of hydroelectric potentials at Tiger Hill site seems to be promising, therefore it is recommended that a feasibility study be conducted as soon as possible.

Time necessary for this development is roughly estimated to be 9 to 10 years. Therefore, if feasibility study is started in early 1990, it is expected that the first unit of Tiger Hill hydro power station will be able to enter service in around 1999/2000.

12.4 DETERMINATION OF OPTIMUM SEQUENCE OF POWER DEVELOPMENT

12.4.1 Conceivable sequences of power development projects

In 1998 which is the last year of the Middle-term Power Development Master Plan, the total required capacity and the remaining capacity of the existing power plants in the Demerara and Berbice systems are 88.0 MW and 6.2 MW, respectively, as shown in Table 5.4.(2) of Chapter 5. This means that during the period of 10 years from 1989 to 1998 it is necessary to add 81.8 MW of capacity to these power systems.

To select optimum sequence of power development projects to meet the above requirement, the following three alternatives are considered in Chapter 6:

Year	Plan I (MW)	Plan II (MW)	Plan III (MW)
1990	5.7 x 1 (MS)	5.7 x 1 (MS)	5.7 x 1 (MS)
1991	2.6 x 3 (HS)	2.6 x 3 (HS)	2.6 x 3 (HS)
1992			
1993	13.0 x 2 (LS)	13.0 x 2 (LS)	13.0 x 2 (LS)
1994			
1995	13.0 x 1 (LS)	13.0 x 2 (LS)	5.7 x 2 (MS)

1996	5.7 x 2 (MS)		13.0 x 1 (LS)
1997	5.7 x 1 (MS)	5.7 x 1 (MS)	5.7 x 1 (MS)
1998	6.5 x 2 (MS)	5.7 x 2 (MS)	13.0 x 1 (LS)

Note: HS ... High speed diesel power plant (diesel oil firing)
MS ... Medium speed diesel power plant (diesel oil firing)
LS ... Low speed diesel power plant (Bunker C firing)

12.4.2 Method of analysis

The method of analysis is to select in the order of least cost among the above three alternatives, converting the investment costs, operation and maintenance costs and fuel costs incurred during the entire service life of 20 years of the power plants to the present worths at the beginning of 1989.

12.4.3 Conditions uses for analysis

The conditions used for analysis are shown in Table 12.1.

The analysis was made at a discount rate of 7.0%. In addition, sensitivity analysis was made for discount rate of 5.0% and 9.0%.

To calculate fuel cost, it was assumed that all the power plants will be operated at a plant utilization factor of 60% during the entire service lives.

12.4.4 Optimum sequence of power development

The results of analysis are shown in Tables 12.3.(1) to 12.3.(3), and summarized as follows:

Discount rate	Plan I (US$ thousand)	Plan II (US$ thousand)	Plan III (US$ thousand)
7.0%	164,622	161,183	160,346
Sensitivity analysis:			
5.0%	201,359	195,536	194,852
9.0%	137,056	135,214	134,255

The above result shows that Plan III is the most economical, hence the optimum sequence for power development.

Table 12.1 CONDITIONS FOR ECONOMIC EVALUATION

Item	Diesel power plant High speed	Diesel power plant Medium speed	Diesel power plant Low speed	Gas turbine	Steam turbine
1. Installed capacity (MW)	3 x 2.6	2 x 5.7	2 x 13.0	2 x 13.0	2 x 13.0
2. Fuel used	Diesel oil	Diesel oil	Bunker C	Diesel oil	Bunker C
3. Station service loss:					
Power loss	2.0%	2.0%	2.0%	1.0%	4.5%
Energy loss	2.2%	2.2%	2.2%	1.3%	5.0%
4. Availability factor	0.85	0.87	0.87	0.80	0.89
5. Output drop due to ambient temperature	-	-	-	14 %	-
6. Thermal efficiency	35 %	39 %	43 %	27 %	34 %
7. Economic service life (Years)	20	20	20	15	30
8. Ratio of operation and maintenance cost to investment cost	3.0%	3.0%	3.0%	4.0%	4.0%
9. Unit investment cost (US$/kW)	790	1,000	1,200	450	1,400
10. Annual disbursement of investment:					
1st year	40 %	40 %	40 %	30 %	15 %
2nd year	60 %	60 %	60 %	70 %	30 %
3rd year	-	-	-	-	40 %
4th year	-	-	-	-	15 %
11. Price of fuel:					
Diesel oil	US$ 21.16/barrel (Specific gravity: 0.81)				
Bunker C	US$ 13.01/barrel (Specific gravity: 0.955)				

Table 12.2.(1) UNIT GENERATION COST BY TYPE OF POWER PLANT

Interest Rate: .07
Annual Operation Hours: 6000

Type of P.Plant	Capital cost (US$/kW)	O & M costs (US$/kW)	Fuel cost (US$/kW)	Total costs (US$/kW)	Unit fuel cost (Cent/kWh)	Unit generation cost (Cent/kWh)
DSL:HS:L.oil	95	28	225	349	3.76	5.82
DSL:MS:L.oil	118	35	202	355	3.37	5.92
DSL:LS:H.oil	141	42	104	287	1.73	4.78
GT:L.oil	77	26	290	393	4.83	6.54
ST:H.oil	152	66	135	352	2.25	5.87

Crossover-point for economic operation (DSL:HS:L.oil/GT:L.oil) 1928
Crossover-point for economic operation (DSL:HS:L.oil/DSL:LS:H.oil) 2946

Note: DSL (Diesel power plant): GT (Gas turbine): ST (Steam power plant)
HS (High speed): MS (Medium speed): LS (Low speed)
L.oil (Diesel oil firing): H.oil (Bunker C firing)

Fig. 12.1.(1) SCREENING CURVES (TIME-COST CURVES)
-Demerara & Berbice Systems-

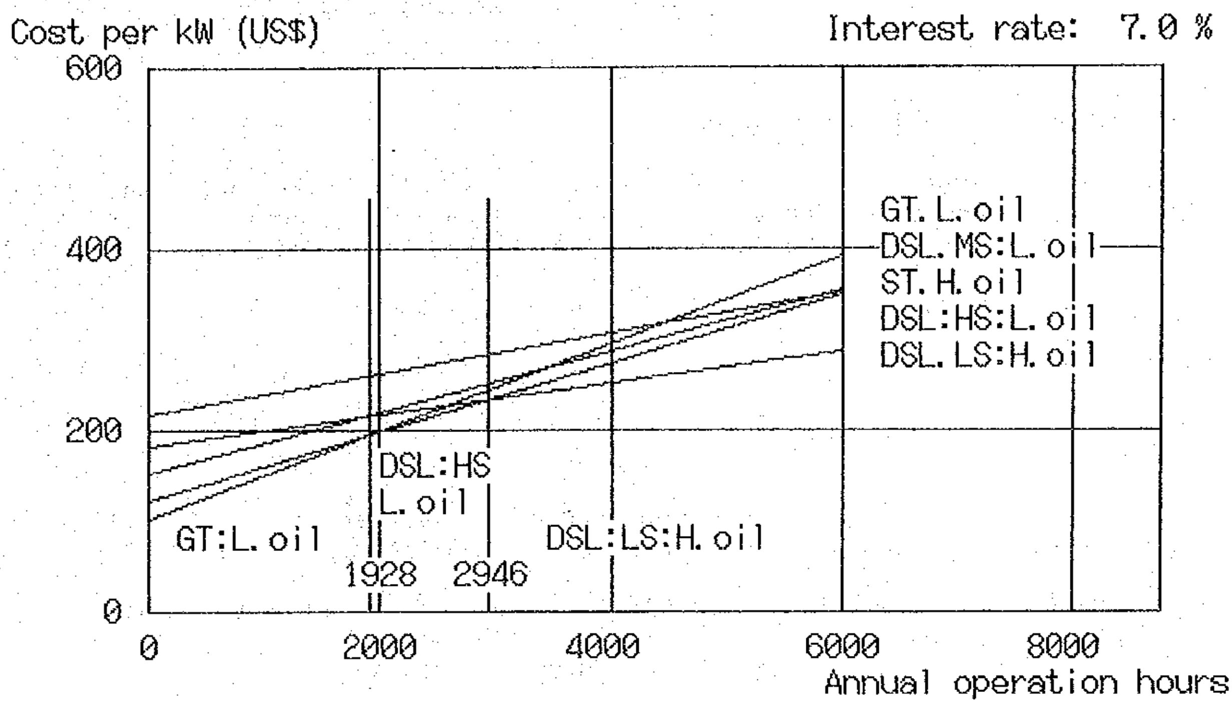


Fig. 12.1.(2) OPTIMUM POWER DEVELOPMENT PROGRAM
-Demerara & Berbice Systems-

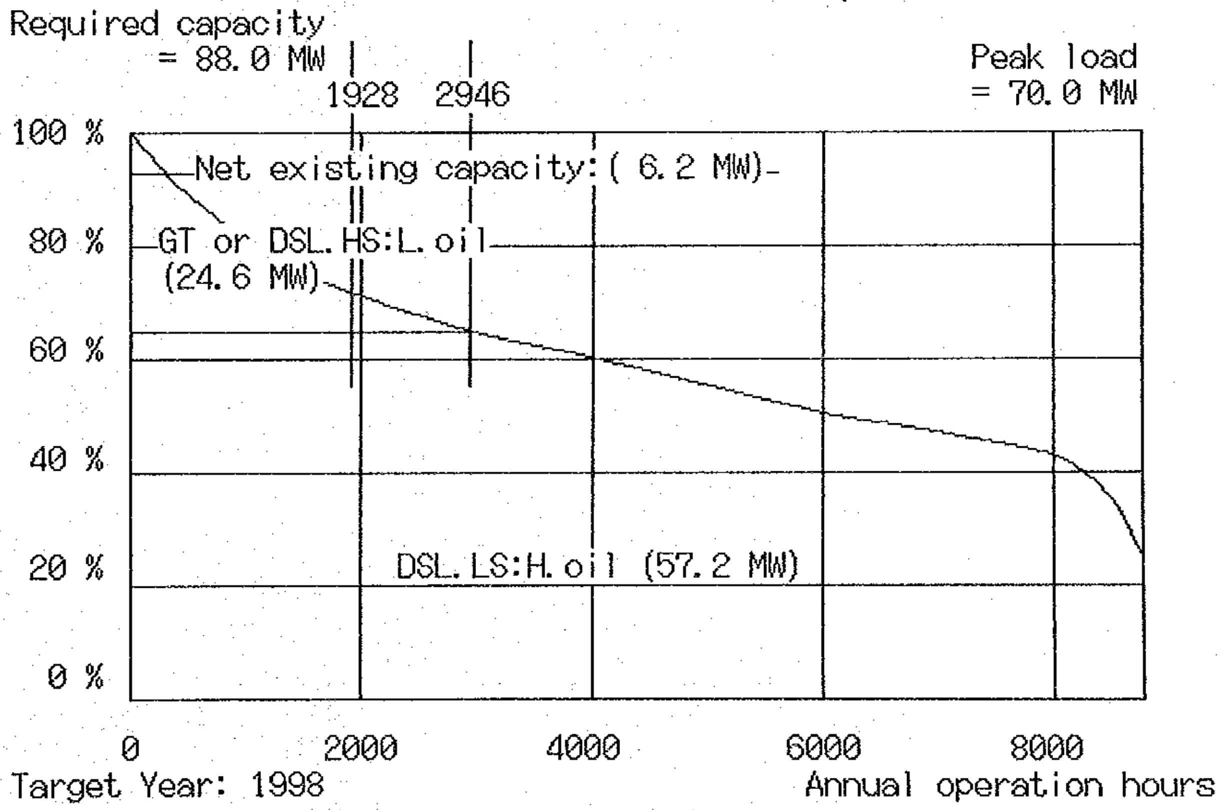


Table 12.2.(2) UNIT GENERATION COST BY TYPE OF POWER PLANT
(Sensitivity Analysis)

Interest Rate: .05
Annual Operation Hours: 6000

Type of P.Plant	Capital cost (US$/kW)	O & M costs (US$/kW)	Fuel cost (US$/kW)	Total costs (US$/kW)	Unit fuel cost (Cent/kWh)	Unit generation cost (Cent/kWh)
DSL:HS:L.oil	80	28	225	333	3.76	5.56
DSL:MS:L.oil	98	35	202	336	3.37	5.60
DSL:LS:H.oil	118	42	104	264	1.73	4.40
GT:L.oil	66	26	290	382	4.83	6.37
ST:H.oil	118	66	135	319	2.25	5.31

Crossover-point for economic operation (DSL:HS:L.oil/GT:L.oil) 1437
Crossover-point for economic operation (DSL:HS:L.oil/DSL:LS:H.oil) 2573

Note: DSL (Diesel power plant): GT (Gas turbine): ST (Steam power plant)
HS (High speed): MS (Medium speed): LS (Low speed)
L.oil (Diesel oil firing): H.oil (Bunker C firing)

Fig. 12.2.(1) SCREENING CURVES (TIME-COST CURVES)
-Demerara & Berbice Systems-

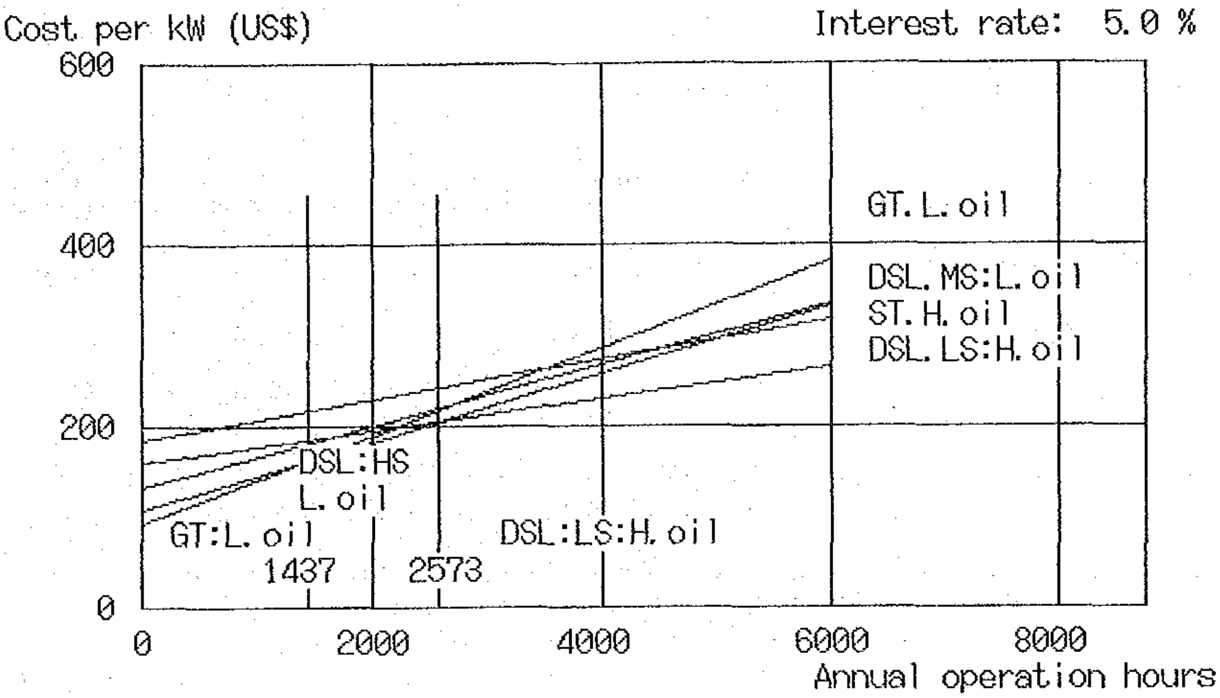


Fig. 12.2.(2) OPTIMUM POWER DEVELOPMENT PROGRAM
-Demerara & Berbice Systems-

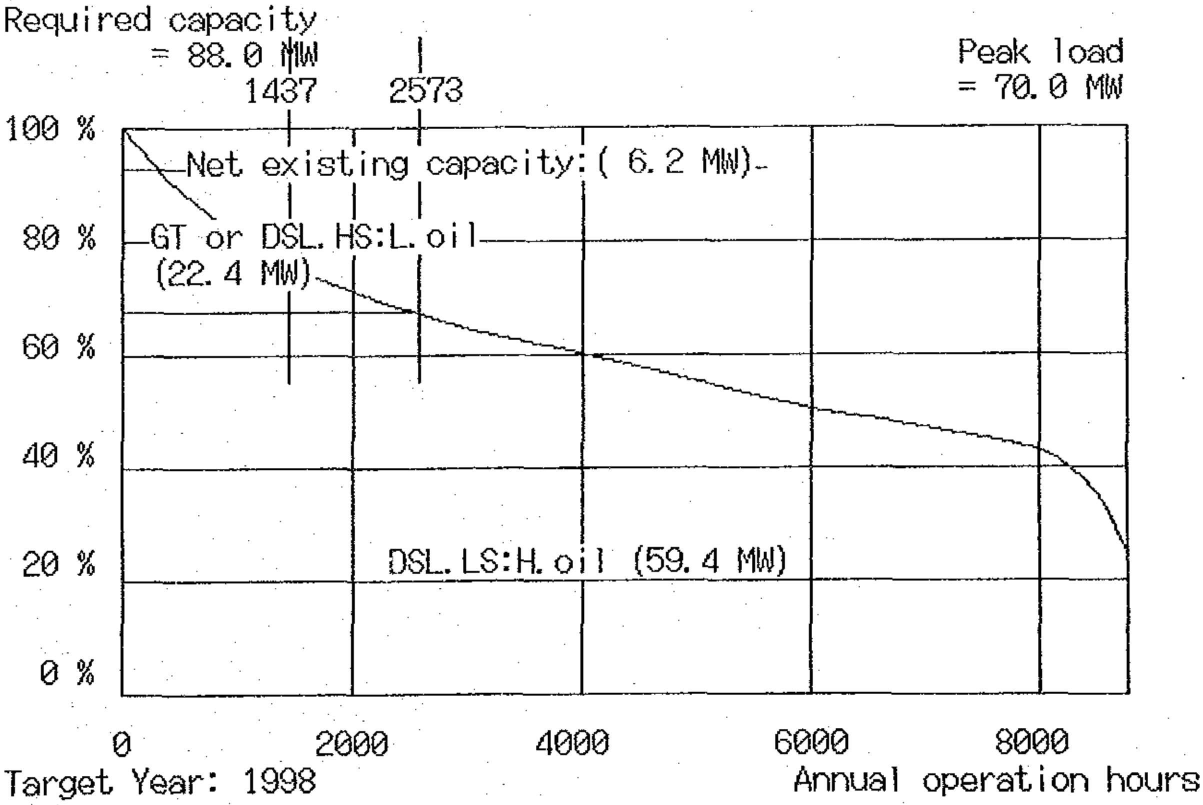


Table 12.2.(3) UNIT GENERATION COST BY TYPE OF POWER PLANT
(Sensitivity Analysis)

Interest Rate: .09
Annual Operation Hours: 6000

Type of P.Plant	Capital cost (US$/kW)	O & M costs (US$/kW)	Fuel cost (US$/kW)	Total costs (US$/kW)	Unit fuel cost (Cent/kWh)	Unit generation cost (Cent/kWh)
DSL:HS:L.oil	112	28	225	366	3.76	6.10
DSL:MS:L.oil	139	35	202	376	3.37	6.27
DSL:LS:H.oil	167	42	104	312	1.73	5.21
GT:L.oil	88	26	290	404	4.83	6.73
ST:H.oil	190	66	135	391	2.25	6.52

Crossover-point for economic operation (DSL:HS:L.oil/GT:L.oil) 2481
Crossover-point for economic operation (DSL:HS:L.oil/DSL:LS:H.oil) 3355

Note: DSL (Diesel power plant): GT (Gas turbine): ST (Steam power plant)
HS (High speed): MS (Medium speed): LS (Low speed)
L.oil (Diesel oil firing): H.oil (Bunker C firing)

Fig. 12.3.(1) SCREENING CURVES (TIME-COST CURVES)
-Demerara & Berbice Systems-

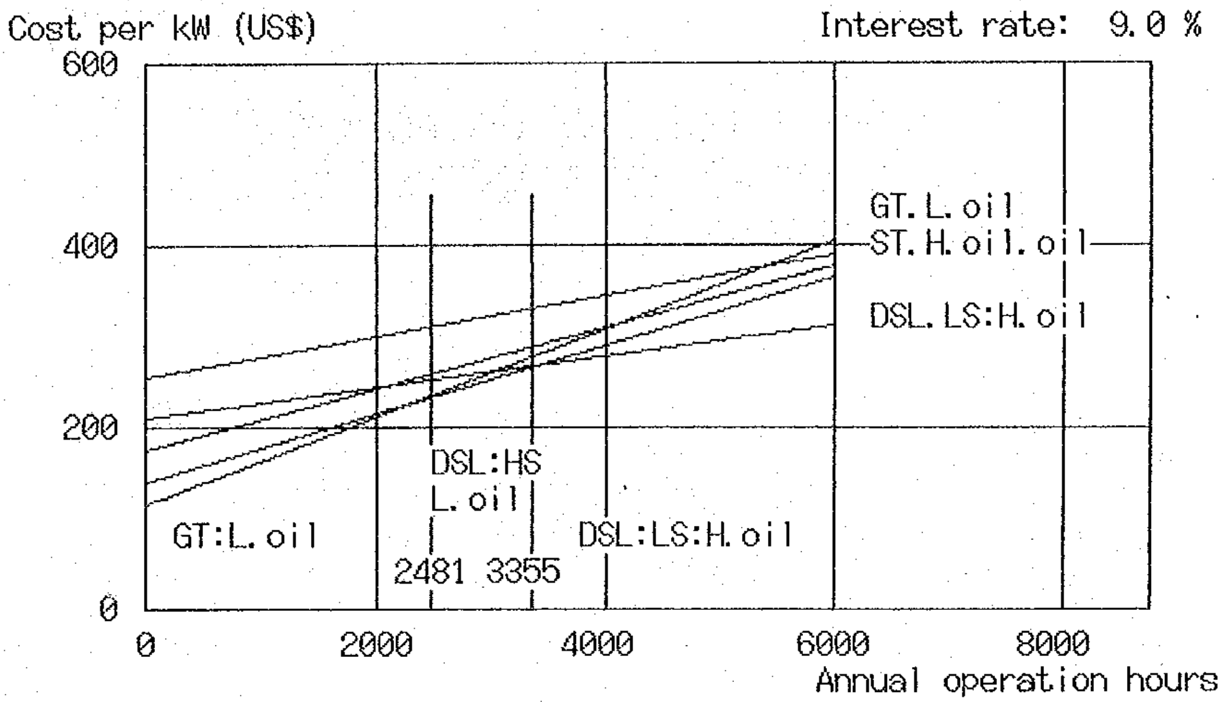
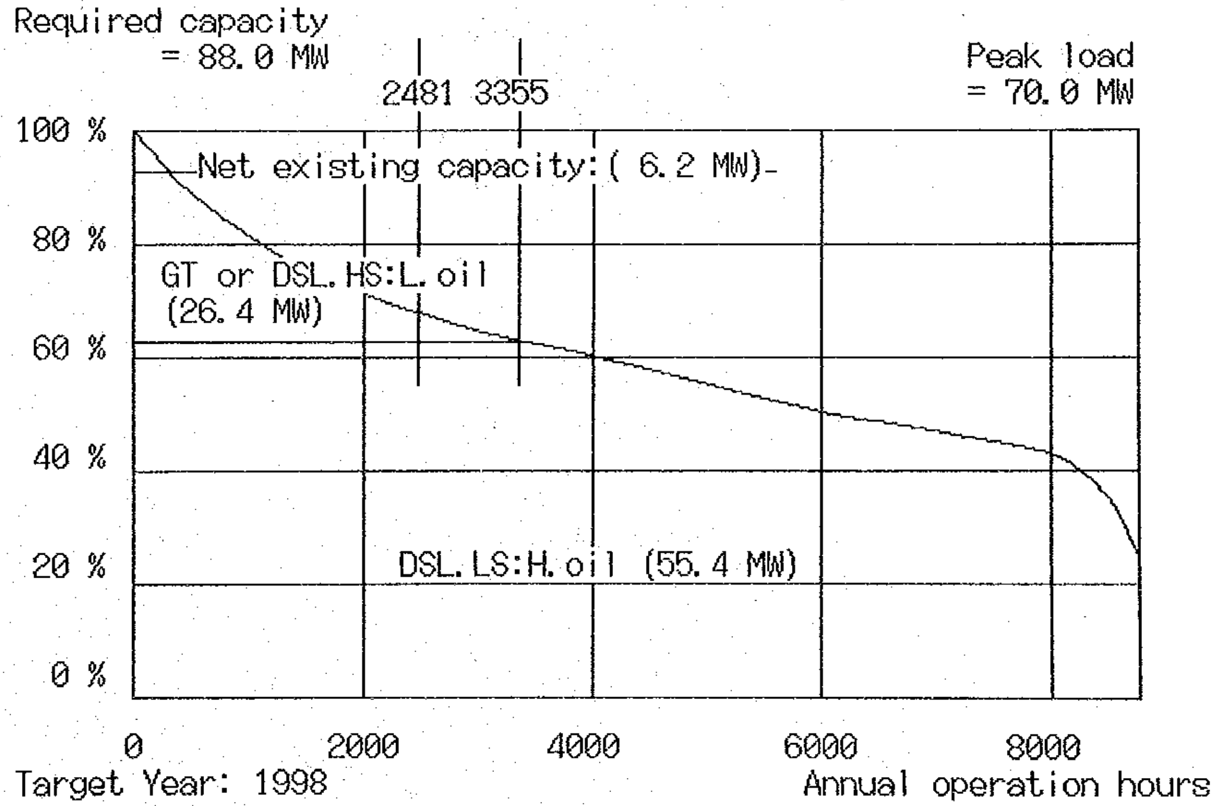
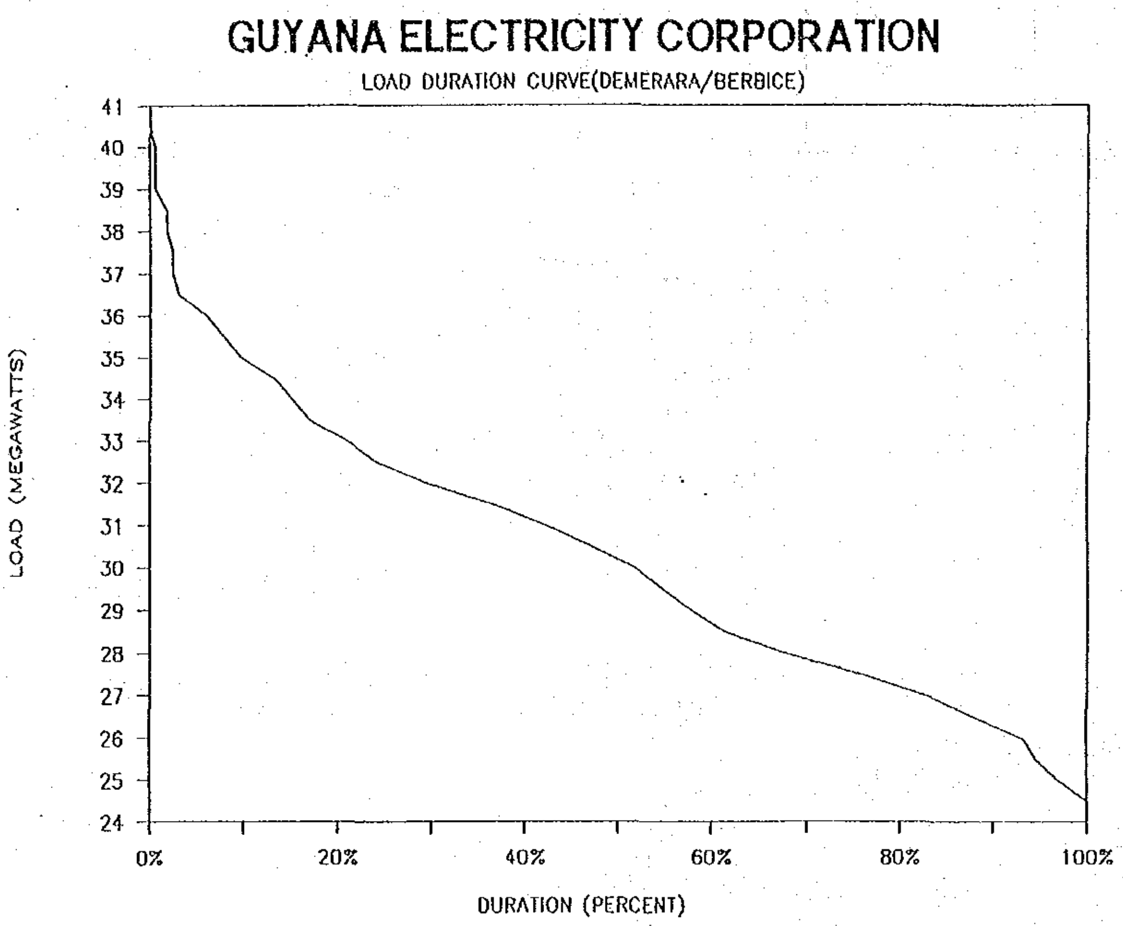


Fig. 12.3.(2) OPTIMUM POWER DEVELOPMENT PROGRAM
-Demerara & Berbice Systems-



REFERENCE



GUYANA ELECTRICITY CORPORATION
LOAD DURATION CURVE(DEMERARA/BERBICE)
LOAD (MEGAWATTS)
41
40
39
38
37
36
35
34
33
32
31
30
29
28
27
26
25
24
0%
20%
40%
60%
80%
100%
DURATION (PERCENT)

Table 12.3.(1) OPTIMUM SEQUENCE OF POWER DEVELOPMENT
(Operation for entire service life)

DISCOUNT RATE: 7.0%

Item	DISCOUNTED TOTAL COSTS (US$ THOUSAND) Plan I	Plan II	Plan III
Investment cost	61556.5	64032.0	62963.9
Operation & maintenance cost	19685.8	20477.5	20136.0
Fuel cost	83379.4	76673.8	77245.8
Total cost	164622.0	161183.0	160346.0

Note: A plant factor of 60% is used.

Table 12.3.(2) OPTIMUM SEQUENCE OF POWER DEVELOPMENT (Operation for entire service life)

DISCOUNT RATE: 5.0%

Item	DISCOUNTED TOTAL COSTS (US$ THOUSAND) Plan I	Plan II	Plan III
Investment cost	67827.8	70348.0	69438.4
Operation & maintenance cost	25475.2	26421.7	26080.1
Fuel cost	108056.0	98766.1	99333.9
Total cost	201359.0	195536.0	194852.0

Note: A plant factor of 60% is used.

Table 12.3.(3) OPTIMUM SEQUENCE OF POWER DEVELOPMENT (Operation for entire service life)

DISCOUNT RATE: 9.0%

Item	DISCOUNTED TOTAL COSTS (US$ THOUSAND) Plan I	Plan II	Plan III
Investment cost	56076.6	58485.9	57312.9
Operation & maintenance cost	15475.9	16140.9	15817.2
Fuel cost	65503.1	60587.3	61125.2
Total cost	137056.0	135214.0	134255.0

Note: A plant factor of 60% is used.

CHAPTER 13

RECOMMENDATIONS FOR IMPROVEMENT OF OPERATION, MAINTENANCE AND SUPERVISION

CHAPTER 13 RECOMMENDATIONS FOR IMPROVEMENT OF OPERATION, MAINTENANCE AND SUPERVISION

Stable supply of electric power is the very duty imposed on the electric utility. All resources of an electric utility must be mobilized to assure continuity of power supply and prevention of blackout.

In addition to the personnel engaged in power generation, transmission and distribution who must take all engineering and supervisory measures for perfect operation of power supply facilities, the supporting staff, such as those in material procurement, accounting and service activities for the customers must also be aware of the importance of keeping supply facilities in perfect condition.

In addition, the senior officials of an utility must understand the importance of the cost to be borne for maintenance of facilities, and make proper effort in securing the necessary budget for proper operation, maintenance and supervision of power supply facilities.

The following recommendations are presented in this context.

13.1 ENGINEERING MEASURES

13.1.1 Operation, maintenance and supervision of power generation and substation facilities

(1) Operation of power generation and substation facilities

1) Monitoring operating performance

Abnormal conditions of power generation and substation facilities can be detected at their early stages if the operating performance of equipment is carefully monitored all the time. Patrol inspections conducted on equipment can lead to detection of failures before the related phenomena are indicated on instruments by finding such symptoms as noise, odor, overheat and small leakage. In finding out such symptoms, the personnel in charge must have sufficient knowledge on the range of equipment's parameters under normal operation. For this purpose, the following practices can be recommendable.

* Making the normal range of instrument indications.

* Writing down the normal indication values into logs and equipment check lists.

* Keep the nameplates on equipment and control boards in proper conditions.

2) Proper handling and operation of equipment

Various operations on switches and valves, such as opening, closing and control, are required in starting up and shutting down the main unit or in changing load. Careful operation based on correct judgment not only prevents tripping by faulty operation but reduces the abnormal burdens placed on equipment.

Some practices to be observed in attaining correct and reliable operation are presented below.

* Preparing proper operation manuals: The manuals for correct operational procedures in startup and shutdown must be prepared, and the actual operations must be exercised strictly according to these manuals.

* Reciting verbal confirmations: When the operator is given command from his superior, he must recite what he heard, and recite what he is about to do before acting, in such a way as "Throwing in No. X Switch". This practice is very effective in preventing mistaken actions.

* Practicing drills: The startup drill and emergency action drills must be performed routinely on simulated situations, so that the operators can get accustomed the proper sequence of actions.

* Other practices: The equipment shut down by failure or for inspection must have their power supply cut off, and the related switches and valves must be identified with safety tags. Important switches must be covered with protectors by shift supervisors, so that no one can touch them accidentally.

3) Improvement of working environment for operators

* Separation of control room from main equipment room: In Versailles Power Plant, a separation wall should be installed between the control room and the main equipment room, so that the operators are protected from the noise of main units.

* Improvement of lighting facilities:

(2) Maintenance of power generation and substation facilities

1) Maintenance plan

In formulating a maintenance plan, various factors such as power generation schedule, budgetary constraint, etc. have to be taken into consideration. From the point of view of fault prevention, the plan must be formulated with due considerations on the past records of failures, trends in occurrence of faults and the findings in periodical inspections. In particular, it is recommended to study the following points.

* Strengthening periodical inspection practices in accordance with the aging of equipments: After equipment are in service for more than several years, aging of material and wearing of parts progress to some degree. The periodical inspection practices must be strengthened to deal with these phenomena. Faulty parts must be either repaired or replaced with new parts.

* Modifications for improvement during shutdown for periodical inspection: When it is found that improvements are needed due to insufficient design and manufacturing, modifications must be implemented as far as practicable during the shutdown for periodical inspection. Such information should be supplied to similar facilities in order to prevent failures, or fed back to the manufacturer's department in charge of design for future improvement.

* Repairs with emphasis placed on items where frequent faults are observed: The records of repairs conducted in routine maintenance and their natures must be carefully analyzed, and maintenance plan must be formulated with emphasis on these items. If failures are repeated due to improper repair method, the status must be examined and improvement measure must be worked out.

* Evaluation of measures taken in the past: The measures taken in the past, as well as the policies of repair work must be evaluated and reflected in the future repair plans.

* Spending effective repair funds: The past plant performance versus repair costs must be compared and evaluated comprehensively, and decommissioning of old facility should be recommended as appropriate.

2) Strengthening maintenance systems

The following measures must be observed when one wishes to establish effective maintenance systems.

* Exercising proper inspection practices: The check lists describing the inspection items for daily, weekly and annual periodical inspections must be developed for each equipment, and inspection works must be performed strictly according to these lists.

* Assuring reliability of overhaul and assembly works: If one wishes to assure high reliability in overhaul and assembly works, the following documents must be maintained.
  Drawings.
  Work manuals.
  Work check lists.

* Education on safety measures and procedures: Negligence of safety in maintenance and repair work not only endangers equipment but also human life. In particular, when a part of equipment is to be repaired while the plant is in operation, sufficient communication with the department in charge of operation must be established, and safety of men and machines must be confirmed before work is started.

* Fostering of capable engineers/technicians: Skilled personnels for maintenance and repair works can not be developed quickly. The utilities officials must perform constant and continued efforts for fostering of such personnels.

* Replenishment and maintenance of tools:

Special tools: The places of storage must be specified and all related personnels must be kept informed.

General tools: One person must be assigned in charge of maintenance of tools, and tools must be replaced when any is lost.

13.1.2 Maintenance and supervision of transmission and distribution facilities

As transmission and distribution lines run through various terrains, they are subjected to all kinds of threat created by natural phenomena.

There are variety of measures that can be applied to both facilities and operation practices for prevention of accidents. In terms of operation, the following measures are effective.

(1) Rationalized patrol and inspection practices

The patrol and inspection missions must be planned in such a manner that they are suitably adjusted to the changing conditions and environment of line routes. The targets of inspection and target areas should be specified and patrols conducted effectively with emphasis on such targets (such as growing trees, bird nests, kite, etc.).

(2) Public relations

The following public relations activities must be encouraged in order to reduce line faults, electrical accidents and gathering information on line route.

1) Relations with general public

The importance of power line failures and accidents must be informed to the public. For this purpose, warnings concerning collecting timbers, bird nests and kite flying must be publicised by distribution of pamphlets through citizens groups and schools, and signs must be provided and newspapers used as appropriate.

2) Request for supply of information

Good relations with the public must be established so that faults on lines are reported to the utility as soon as possible.

13.2 ORGANIZATION IMPROVEMENTS

13.2.1 Securing and executing repair budgets

(1) Repair budget

The department in charge of engineering must formulate the budget plan for the repair schedule of the next fiscal year, and submit to the department in charge of finance.

(2) Securing budget

The utility company must evaluate the appropriateness of the repair budget plan, and must request the governmental authority to provide the necessary budget.

(3) Distribution of authorized budget

The budget which the governmental authority has authorized for the repair work must be distributed among the executive branches of the company, and these branches must execute the budget effectively.

13.2.2 Improvements on supervision of spare parts

(1) Improvements on supervision of spare parts

The spare parts of each diesel power plant, except for daily consumables, are stored in Garden of Eden Power Plant and Canefield Power Plant in a centralized manner. This centralized supervision make the responsibility of each power plant ambiguous, and inventory controls are insufficiently implemented. If these spare parts are stored and a spare part supervisor is assigned in each plant, the shortage of spare parts inventory can be identified all the time, and parts can be procured more quickly when a failure occurs.

(2) Improvements on facilities and organization

* Increase in number of inventory control staff.
* Replacement of warehouse at each power plant.

APPENDIX

APPENDIX 1

Key Personnel with whom Survey Team Met Authorities Concerned of Guyana

(1) Embassy of Japan in Venezuela

His Excellency Kunio Muraoka	Ambassador to Venezuela
Mr. Akira Urabe	Minister
Mr. Junichi Hatano	First Secretary
Mr. Naomasa Hiraishi	Third Secretary

(2) Department of International Economic Co-operation (DIEC)

Dr. Cecil Rajana	Head
Mr. Desmond Bollers	Head of Section
Mr. Keenan Elliot	Desk Officer

(3) Ministry of Public Utilities (MOPU)

Mr. Robert H.O. Corbin	Deputy Prime Minister (Public Utilities)
Mr. E.M. Downer	Technical Specialist
Mr. Kenneth Nariaine	Permanent Secretary

(4) Guyana Electricity Corporation (GEC)

Mr. Narvon Persaud	General Manager
Mr. Wilfred Leander	Deputy General Manager
Mr. David Gomes	Program Coordinator
Miss Verlyn Klass	Strategic Planning Manager
Mr. Kenneth Klass	Diesel Generation Manager
Mr. F. Cumdermack	Turbine Generation Manager, Kingston
Mr. Stanhope Dathorne	Transmission and Distribution Manager
Mr. V. Forsythe	System Control Manager, Sophia

Mr. A.M. Donald	Maintenance Manager
Mr. Ashton T. Jairam	Training Manager, Sophia
Mr. H. Howard	Diesel Generation Engineer, Garden of Eden
Mr. R. Drepaul Saul	Diesel Generation Engineer, Canefield
Mr. R. Grant	Diesel Generation Engineer, Onverwagt
Mr. K. Somwaru	Assistant Diesel Generation Engineer, Verssailles
Miss E. Dodson	System Operation Engineer, Sophia
Mr. E. Adams	Transmission and Distribution Engineer, West Demerara
Mr. A. Bacchos	Diesel Generation Engineer, Anna Regina

(5) Guyana Natural Resources Agency (GNRA)

Mr. Winston N. King	Chairman
Mr. Barton A. Scotland	Deputy Chairman
Mr. M. Veecock	Director, Hydropower Unit
Mr. Eldon Ralph	Director, Project Development Unit
Mr. K. Boodram	Special Project Officer
Mr. M. Jackson	Engineer, Hydropower Unit

(6) Department of Lands and Surveys Ministry of Agriculture

Mr. Leon Rutherford	Assistant Commissioner (Survey)

(7) Guyana Geology and Mines

Mr. Woolford	Chief Mines Officer, Deputy Commissioner

(8) Technical Consultant to the Minister of Communications and Works

Mr. J. Holder	Technical Specialist

(9) Guyana Mining Enterprise Limited (GUYMINE)

Mr. S.G. Bovell	General Manager, Linden
Mr. J. Lewins	General Manager, Everton

(10) Guyana Sugar Corporation (GUYSUCO)

Mr. K. Wilkie	Factory Manager, Alaion Estate
Mr. Aleen Hafiz	Factory Manager, Blairmont Estate

(11) Counterpart Personnel of GEC

Miss Verlyn Klass	Strategic Planning Manager
Mr. Kenneth Klass	Diesel Generation Manager
Mr. Munaf Hussein	Asst. Planning & Development Engr.
Mr. Abraham Perry	Diesel Project Superintendent
Mr. Jai Persaud	Planning Assistant
Mr. Frank Cumbermack	Turbine Generation manager

(12) Counterpart Personnel of GNRA

Mr. M. Jackson	Engineer Hydropower Unit
Mr. Raymond Dumdee	Engineer Hydropower Unit

APPENDIX 2

Study Team

The study team, headed by Masashi KOIKE of EPDC International, Ltd., was composed of two groups of general planning and detailed investigation. The studies, including field investigation and discussions with related authorities of Guyana, were conducted from July 11 to August 8, 1988 for general planning and from August 4 to September 26, 1988 for detailed investigation. The members of study team were as follows:

Name	Profession	Member's company
Masashi KOIKE	Project Manager	EPDC International, Ltd.
Akio MASUKI	Thermal Power Generating Planning	"
Noriyuki KOHORI	Power Generating Plant Design (Thermal & Hydro)	"
Kunio KURODA	Power System Planning	"
Minaichi TAKEOKA	Hydro Power Generating Planning (Civil)	"
Kaname SOBUE	Geologist	"
Tetsurou KOBAYASHI	Economist	"
Shozo YUZAWA	Hydro Power Generating Planning (in Japan)	"

Itinerary (1) Planning Team

	Date	Description
1	July 11th (Mon)	Tokyo (Lv. 12:00 JL 006) New York (Ar. 11:25) New York (Lv. 15:00 VA 801) Caracas (Ar. 19:35)
2	July 12th (Tue)	Courtesy visit to Embassy of Japan in Venezuela (Explanation of Inception Report and Acquire visas for Guyana) Caracas (Lv. 23: 20 PA 217)
3	July 13th (Wed)	Port of Spain (Ar. 00:30) Port of Spain (Lv. 11:30 BW 463) Georgetown (Ar. 13:30)
4	July 14th (Thu)	Courtesy visit to concerned Government Authorities Meeting with DIEC, GEC and GNRA (Explanation of Inception Report and submit Questionnaire)
5	July 15th (Fri)	Investigation of Kingston P.S. and Sophia Frequency Conveter Station
6	July 16th (Sat)	Investigation of Georgetown
7	July 17th (Sun)	Arrangement of collected data
8	July 18th (Mon)	Investigation of Versailles P.S. and West Demerara Area
9	July 19th (Tue)	Investigation of Garden of Eden P.S.
10	July 20th (Wed)	Investigation of No. 53 Corentyn S.S., Canefield P.S. and Everton P.S.
11	July 21st (Thu)	Investigation of Onverwagt P.S. and Factory of GUYSCO (Albion, Blairmont)

	Date	Description
12	July 22nd (Fri)	Arrangement of collected data
13	July 23th (Sat)	Ditto
14	July 24th (Sun)	Ditto
15	July 25th (Mon)	Ditto, meeting of team
16	July 26th (Tue)	Linden S.S. and Linden P.S. (Survey facilities and discussion with GUYMINE Staff)
17	July 27th (Wed)	Investigation of Hydro Power Project Sites
18	July 28th (Thu)	Examine and analysis for collected data
19	July 29th (Fri)	Discussion with GEC
20	July 30th (Sat)	Examine and analysis for collected data
21	July 31th (Sun)	Ditto
22	August 1st (Mon)	Ditto
23	August 2nd (Tue)	Discussion with GURA Investigation of Ruimvelt P.S.
24	August 3rd (Wed)	Discussion with concerned Government Authorities and its Interim Reporting Visit to Mr. Robert H.O. Corbin, Deputy Prime Minister
25	August 4th (Thu)	Georgetown (Lv. 7:30 GY 702) Port of Spain (Ar. 7:30)

	Date	Description
26	August 5th (Fri)	Port of Spain (Lv. 7:40 PA 218) Caracas (Ar. 8:55) Interim Reporting to Embassy of Japan in Venezuela
27	August 6th (Sat)	Caracas (Lv. 8:15 PA 442) Los Angeles (Ar. 16:40)
28	August 7th (Sun)	Los Angeles (Lv. 12:00 JL 065)
29	August 8th (Mon)	Tokyo (Ar. 15:20)

Itinerary (2) Investigation Team

	Date	Description
25	August 4th (Thu)	<u>Planning Team</u> Examine and analysis for Collected data
26	August 5th (Fri)	<u>Planning Team</u> Investigation of Anna Regina P.S. and Wakenaan P.S.
27	August 6th (Sat)	<u>Planning Team</u> Examine and analysis for collected data
28	August 7th (Sun)	<u>Investigation Team</u> Tokyo (Lv. 12:00 JL006) New York (Ar. 11:25) New York (Lv. 15:00 VA801) Caracas (Ar. 19:35) <u>Planning Team</u> Examine and analysis for collected data
29	August 8th (Mon)	<u>Planning Team</u> Investigation of Bartica P.S. <u>Investigation Team</u> Acquire visas for Guyana Caracas (Lv. 23:20 PA217) Port of Spain (Ar. 0:30)
30	August 9th (Tue)	<u>Planning Team</u> Examine and analysis for collected data <u>Investigation Team</u> Port of Spain (Lv. 9:00 BW459) Georgetown (Ar. 11:00) Joining both teams and meeting
31	August 10th (Wed)	Visit to concerned Government Authorities
32	August 11th (Thu)	Meeting with DIEC, GEC and GNRA (Investigation method of Hydro Power Project Sites)

	Date	Description
33	August 12th (Fri)	Previous investigation for Hydropower Project Sites Survey Examine and analysis for collected data
34	August 13th (Sat)	Previous investigation for Hydropower Project Sites Survey Investigation of Ge^r etown
35	August 14th (Sun)	Previous investigation for Hydropower Project Sites Survey Meeting of the team
36	August 15th (Mon)	(a) Civil Engineer Collecting data for Hydropower site (b) Electrical Engineer Investigation of Sophia F/C Station
37	August 16th (Tue)	(a) Ditto (b) Investigation of Versailles P.S. and West Demerara Area
38	August 17th (Wed)	(a) For Linden (b) Investigation of Linden Sub-station
39	August 18th (Thu)	(a) Investigation of Hydropower Project site (b) Investigation of Garden of Eden P.S. (S.S.)
40	August 19th (Fri)	(a) Ditto (b) Investigation of Kingston "B" P.S.
41	August 20th (Sat)	(a) Ditto (b) Arrangement of collected data

	Date	Description
42	August 21th (Sun)	(a) Ditto (b) Ditto
43	August 22th (Mon)	(a) Investigation of Hydropower Project sites (b) Ditto
44	August 23th (Tue)	(a) Ditto, return to Georgetown (b) Investigation of Canefield P.S. and Onverwagt P.S.
45	August 24th (Wed)	(a) Ditto (b) Arrangement of collected data
46	August 25th (Thu)	(a) Meeting with GNRA (b) Ditto
47	August 26th (Fri)	(a) Arrangement of collected data (b) Investigation of secondary S.S. in Georgetown
48	August 27th (Sat)	Examine and analysis for collected data
49	August 28th (Sun)	Ditto
50	August 29th (Mon)	Ditto
51	August 30th (Tue)	Examine and analysis for collected data
52	August 31th (Wed)	Discussion with GEC

	Date	Description
53	September 1st (Thu)	(a) Remain member Examine and analysis for collected data (b) Power System Planning Engineer and Ge^ ogical Engineer return to Japan. Georgetown (Lv. 14:45 GY-702) Port of Spain (Ar. 14:45)
54	September 2nd (Fri)	(a) Investigation of Garden of Eden P.S. (b) Port of Spain (Lv. 7:40 PA-218) Caracas (Ar. 8:55)
55	September 3rd (Sat)	(a) Examine and analysis for collected data (b) Caracas (Lv. 8:15 PA-442) Los Angeles (Ar. 16:40)
56	September 4th (Sun)	(a) Ditto (b) Los Angeles (Lv. 12:00 JL-065)
57	September 5th (Mon)	(a) Ditto (b) Tokyo (Ar. 15:20)
58	September 6th (Tue)	(a) Electrical Engineer Investigation of Canefield P.S. and New Amsterdam S.S. (b) Civil Engineer Examine and analysis for collected data
59	September 7th (Wed)	(a) Examine and analysis for collected data (b) Investigation of construction machine
60	September 8th (Thu)	(a) Ditto (b) Investigation of Hydropower Project Sites (Anarika)

	Date	Description
61	S^ptember 9th (Fri)	Examine and analysis for collected data
62	September 10th (Sat)	Ditto
63	September 11th (Sun)	Ditto
64	September 12th (Mon)	Ditto
65	September 13th (Tue)	Ditto
66	September 14th (Wed)	Ditto
67	September 15th (Thu)	Preparation of Progress Report Examine and analysis for collected data
68	September 16th (Fri)	Ditto
69	September 17th (Sat)	Ditto
70	September 18th (Sun)	Ditto
71	September 19th (Mon)	Ditto
72	September 20th (Tue)	Ditto
73	September 21th (Wed)	Final meeting with concerned Government Authorities and submit Progress Report
74	September 22th (Thu)	Georgetown (Lv. 14:45 GY 702) Port of Spain (Ar. 14:45)
75	September 23th (Fri)	Port of Spain (Lv. 7:40 PA 218) Caracas (Ar. 8:55) Progress Reporting to Embassy of Japan in Venezuela

	Date	Description
76	September 24th (Sat)	Caracas (Lv. 8:15 PA 442) Los Angeles (Ar. 16:40)
77	September 25th (Sun)	Los Angeles (Lv. 12:00 JL 065)
78	September 26th (Mon)	Tokyo (Ar. 15:20)

APPENDIX 4

List of Received Data and Information

No.	Title	Author/Publisher	Date Published	Remarks
1.	Administrative map Co-Operative Republic of Guyana (1:100,000)		1988	Map
2.	Geological Map of Guyana	Geological survey and Mines, Guyana	1987	Map
3.	The 1986 geological map of Guyana	- do -	1986	Map
4.	Topo Maps, Tiger Hill site (1:50,000)	Department of Lands and Surveys		Map
5.	City of Georgetown (1:20,000)	Department of Lands and Surveys	1987	Map
6.	Demographic Data (1984)	GEC	Jul. 1988	Data
7.	National Holiday (1988)	GEC	-	Data
8.	Meteological Data (1966 - 1988)	Ministry of Works and Transport	-	Data
9.	Quarterly Statistical Digest (1985)	Statistical Bureau Ministry of Economic Planning Georgetown	1986	Map
10.	Guyana Electricity Corporation Historical Background	GEC	Aug. 1988	Report
11.	GEC's Management Structure 1988	GEC	Feb. 1988	Drawing
12.	GEC's Single Line Digram Interconnected System	GEC	Jul. 1988	Drawing
13.	GEC's Inpedance and Switchgear data of Interconnected System to End of Stage 1 Extension	GEC	Mar. 1978	Drawing
14.	GEC's System Map	GEC	Aug. 1988	Map
15.	Report of Audit Garden of Eden	Gibbs & Hill/Dravo Services, Inc.	May 1988	Report

No.	Title	Author/Publisher	Date Published	Remarks
16.	Report of Audit Canefield Power Station, New Amsterdam	Gibbs & Hill/Dravo Service, INC.	Jul. 1988	Report
17.	Executive Summary (Rehabilitation Program)	GEC	Aug. 1988	Report
18.	Drawing of Garden of Eden Power Station			
18-1	Site Building and Major Equipment Layout	GEC, Shawinigan Eng.	Mar. 1973	
18-2	Generatig Building Foundation Layout	- do -	Jan. 1974	
18-3	Generating Building Section	- do -	Jun. 1974	
18-4	Fresh Water Flow Diagram	- do -	Aug. 1974	
18-5	Raw Water Flow Diagram	- do -	Aug. 1974	
18-6	Fire Hydrant and Yard Piping Layout	- do -	Aug. 1974	
18-7	Ground Floor SW'GR & MCC Area Cabling Details	- do -	Dec. 1974	
18-8	Developed Plan of Control Desk	- do -	Mar. 1974	
18-9	Generating Building General Arrangement Plan	- do -	Jun. 1974	
18-10	Main One Line Diagram	do -	Jul. 1973	
18-11	Auxiliary One Line Diagram	do -	Sep. 1974	

No.	Title	Author/Publisher	Date Published	Remarks
18-12	Oil System Schematic for Commissioning Purposes	GEC, Shawinigan Eng.	-	
18-13	Raw Water System	GEC, Crossley Premier Eng.	-	
18-14	Compressed Air System	- do -	-	
18-15	Fuel Oil Diagram	- do -	-	
18-16	Lubricating Oil System	- do -	-	
19.	Drawing of Canefield Power Station			Drawing
19-1	Modification to H.F.O./ L.F.O. Pipework System	GEC, Shawinigan Eng.	Oct. 1977	
19-2	Fresh Water Flow Diagram	- do -	Feb. 1974	
19-3	Raw Water Flow Diagram	- do -	Feb. 1974	
19-4	Fuel Oil Flow Diagram	- do -	Feb. 1974	
19-5	Main Line Line Diagram	- do -	Jul. 1974	
19-6	Auxiliary One Line Diagram	- do -	Oct. 1974	
20.	Kingston Power Stations 'A' & 'B' Georgetown Site Plan	GEC	Nov. 1970	Drawing
21.	Refurbishment of Major Plant in the G.E.C. System	BEI	Jan. 1985	
22.	Greater Georgetown 11 kV System & Proposed 13.8 kV Distrubution	GEC, Shawinigan Eng.	Jul. 1973	Drawing
23.	GEC 11 kV & 13.8 kV Distribution System (Georgetown)	- do -	Feb. 1976	Drawing
24.	GEC 4 kV Distribution System (Georgetown)	- do -	Feb. 1976	Drawing

No.	Title	Author/Publisher	Date Published	Remarks
25.	Georgetown 11kV 50 Hz Overall Distribution Diagram	GEC	Aug. 1984	Drawing
26.	Garden of Eden 69 kV Substation Plan	GEC, Shawinigan Eng.	May 1974	Drawing
27.	Linden 69 kV Substation Site Equipment Layout	- do -	Mar. 1974	Drawing
28.	Main Causes of Faults on T&D System	GEC	-	Data
29.	Certificate of Analysis of Water at Great Falls G/S	Government Analysis Department	Dec. 1986	Data
30.	Analysis of Water of Tiger Hill Site Demerara River	Institute of ASAT	Aug. 1988	Data
31.	River Discharge at Saka G/S	Ministry of Works and Hydraulics	1976	Data
32.	River Discharge Great Falls	Ministry of Works and Hydraulics	1986	Data
33.	Location of Potential Hydropower Site	GNRA		Drawing
34.	Demerara River Hydro-electric Investigations Volume I, II, III, V	GNRA, Aluminium Laboratories Ltd.	Jul. 1957	Report
35.	Guyana Power Study Draft Final Report Volume 2, Future Facilities, Hydropower Development	SWECO	Oct. 1982	Report
36.	Guyana Power Study Final Report Volume 3, Future Facilities, Plates and Appendices	SWECO	Feb. 1983	Report
37.	Detailed Topo Map of Anarika	GNRA		Map
38.	Discharge Hydrograph at Anarika	GNRA		Drawing

No.	Title	Author/Publisher	Date Published	Remarks
39.	Hydroeletric Power Survey of Guyana Final Report Volume 2 Appendices 1, 2, 3, 4, 5	MONENCO	Apr. 1976	Report
40.	Preliminary Report, Power Development Survey in Guyana for United Nations	Shawinigan Eng.	Jul. 1967	Report