Year	Demerara System	Berbice System
1988	0.273	0.372
1989	0.256	0.299
1990	0.240	0.240
1991	0.223	0.223
1992	0.208	0.208
1993	0.193	0.193
1994	0.180	0.180
Thereafter	0.180	0.180

(Data supplied by GEC.)

Table 3.2.1 Economic Parameters for Power Demand Forecast

Year	GDP (G$ million)			Electricity price (G$/kWh)			Number of consumers
	Market price	Deflator (1980=100)	1980 price	Current price	C.P.I. (1980=100)	1980 price	
1974	955.0	68	1,400.0	0.13	50.8	0.256	73,514
1975	1,188.0	77	1,546.0	0.19	54.7	0.347	80,088
1976	1,136.0	71	1,591.0	0.21	59.7	0.352	81,014
1977	1,125.0	74	1,515.0	0.24	64.4	0.372	82,478
1978	1,268.0	85	1,489.0	0.24	74.4	0.363	85,840
1979	1,326.0	90	1,479.0	0.27	87.7	0.308	87,266
1980	1,508.0	100	1,508.0	0.37	100.0	0.370	80,900
1981	1,697.0	101	1,576.0	0.58	124.7	0.465	95,152
1982	1,446.0	105	1,380.0	0.59	150.0	0.393	89,758
1983	1,468.0	117	1,259.0	0.59	169.9	0.347	82,876
1984	1,700.0	-	-	0.75	212.7	0.353	86,916
1985	1,964.0	-	-	0.84	-	-	84,770
1986	2,219.0	-	-	0.84	-	-	85,546
1987	-	-	-	-	-	-	101,359

Source: GDP, GDP deflator and C.P.I. (Consumers price index) were taken from International Financial Statistics 1987 (IMF).

Data on average rate per unit sold (Current price) were provided by GEC Planning Department.

3.2.2 Power and Energy Demand/Supply Balance

(1) Reserve Capacity Required

A power system must be provided with a certain amount of reserve capacity to enable the power system to posses a stable power supply capability even when the supply capacity is reduced by periodical inspection or forced shutdown of plants, or the demand on the power system increases more than expected.

There are various rules to determine this amount of reserve capacity, but either of the following methods is generally applied in formulating a demand forecast for a developing nation.

- The sum of the available capacities of the largest and the second largest generating units.

- A certain postulated percentage of the maximum demand (generally from 15 to 20%).

In case of GEC's power system, the reserve capacity has been postulated as the output of one unit having the largest installed capacity, considering the tight supply/demand situation, although the above reserve is far from being sufficient. According to this rule, the reserve capacity to be possessed by each power system are as below.

Power System	Required Reserve Capacity (MW)
Demerara	8.5 (1988 - 92), 13.0 (1993 - 98)
Berbice	5.0
Total	13.5 (1988 - 92), 18.0 (1993 - 98)

(Note) It is expected that No. 1 Unit of Kingston "B" Power Plant is abolished by 1993, and two, new 13.0 MW unit will be installed.

(2) Retirement Schedule

Even if sufficient inspection and maintenance procedures are enforced, the service life of a power plant ends within a certain period of time. The generally accepted service life is statistically 25 to 30 years for a steam power plant, and 15 to 20 years for a diesel power plant. In this study, the life of a steam power plant (Kingston) is assumed to be 30 years, and that of a diesel power plant 20 years. It is expected that the life of each power plant of GEC can be extended to these limits if the current rehabilitation plan is implemented.

The retirement schedule of aged power plants and decrease of capacity is estimated as shown in Table 3.2.2(1).

(3) Demand Projection and Demand/Supply Balance

The demand projection formulated by this study is presented in Table 3.2.2(2) through 3.2.2(5). The energy consumption, energy to be supplied, the maximum power demand, reserve capacity, required plant outputs, outputs of existing power plants, installed capacities to be decommissioned, and the demand/supply balance, for the period from 1988 to 1998, are presented in these tables.

Table 3.2.2(1) Decrease of Capacity by Retirement

Year	Power Plant	Demerara (MW)	Demerara Total	Berbice (MW)	Berbice Total	Anna R./WK. (MW)	Anna R./WK. Total	Bartica (MW)	Bartica Total
1988		-	-	-	-	-	-	-	-
1989		-	-	-	-	-	-	-	-
1990		-	-	-	-	-	-	-	-
1991		-	-	-	-	-	-	-	-
1992	Anna Regina	-	-	-	-	1.1	1.1	-	-
1993	Kingston #1	8.5	8.5	-	-	-	1.1	-	-
1994	Kingston #2	8.5	17.0	-	-	-	1.1	-	-
1995	GOE #2, #4	9.0	26.0	-	-	-	1.1	-	-
1996	GOE #3	5.0	31.0	-	-	-	1.1	-	-
1997	Kingston #3	8.5	39.5	-	-	-	1.1	-	-
1998	Canef'd #3, #4	-	-	9.5	9.5	-	1.1	0.4	0.4
"	Bartica								

Table 3.2.2(2) Load Forecast & Supply Balance
(By Existing Power Plants)

GEC Whole Power System

Year (AD)	Energy sold (GWh)	Energy sent out (GWh)	Peak load (MW)	Reserve margin (MW)	Required capacity (MW)	Existing capacity (MW)	Retire-ment (MW)	Supply balance (MW)
1988	204.5	285.2	53.9	15.2	69.1	42.2	0.0	-26.9
1989	217.6	294.0	55.5	15.2	70.7	58.2	0.0	-12.5
1990	230.6	303.1	57.2	15.2	72.4	58.2	0.0	-14.2
1991	243.1	312.5	59.0	15.2	74.2	58.2	0.0	-16.0
1992	255.5	322.4	60.9	15.2	76.1	58.2	-1.1	-19.0
1993	268.4	332.6	62.8	19.7	82.5	58.2	-9.6	-33.9
1994	281.4	343.1	64.8	19.7	84.5	58.2	-18.1	-44.4
1995	290.4	354.1	66.8	19.7	86.5	58.2	-27.1	-55.4
1996	299.7	365.5	69.0	19.7	88.7	58.2	-32.1	-62.6
1997	309.4	377.3	71.2	19.7	90.9	58.2	-40.6	-73.3
1998	319.4	389.5	73.5	19.7	93.2	58.2	-50.5	-85.5

Note: Overall load factor = 60.7%

Table 3.2.2(3) Load Forecast & Supply Balance
(By Existing Power Plants)

Demerara & Berbice System

Year (AD)	Energy sold (GWh)	Energy sent out (GWh)	Peak load (MW)	Reserve margin (MW)	Required capacity (MW)	Existing capacity (MW)	Retire-ment (MW)	Supply balance (MW)
1988	196.6	274.9	51.3	13.5	64.8	39.2	0.0	-25.6
1989	209.4	283.4	52.9	13.5	66.4	55.2	0.0	-11.2
1990	222.1	292.2	54.5	13.5	68.0	55.2	0.0	-12.8
1991	234.1	301.3	56.2	13.5	69.7	55.2	0.0	-14.5
1992	246.1	310.8	58.0	13.5	71.5	55.2	0.0	-16.3
1993	258.7	320.6	59.8	18.0	77.8	55.2	-8.5	-31.1
1994	271.2	330.8	61.7	18.0	79.7	55.2	-17.0	-41.5
1995	279.9	341.3	63.7	18.0	81.7	55.2	-26.0	-52.5
1996	288.9	352.3	65.7	18.0	83.7	55.2	-31.0	-59.5
1997	298.2	363.6	67.8	18.0	85.8	55.2	-39.5	-70.1
1998	307.9	375.4	70.0	18.0	88.0	55.2	-49.0	-81.8

Note: Overall load factor = 61.4%

Table 3.2.2(4) Load Forecast & Supply Balance
(By Existing Power Plants)

Demerara System

Year (AD)	Energy sold (GWh)	Energy sent out (GWh)	Peak load (MW)	Reserve margin (MW)	Required capacity (MW)	Existing capacity (MW)	Retire-ment (MW)	Supply balance (MW)
1988	175.7	241.7	41.9	8.5	50.4	32.7	0.0	-17.7
1989	185.4	249.2	43.2	8.5	51.7	43.7	0.0	-8.0
1990	195.3	257.0	44.5	8.5	53.0	43.7	0.0	-9.3
1991	206.0	265.1	45.9	8.5	54.4	43.7	0.0	-10.7
1992	216.6	273.5	47.4	8.5	55.9	43.7	0.0	-12.2
1993	227.8	282.2	48.9	13.0	61.9	43.7	-8.5	-26.7
1994	238.8	291.3	50.5	13.0	63.5	43.7	-17.0	-36.8
1995	246.5	300.6	52.1	13.0	65.1	43.7	-26.0	-47.4
1996	254.5	310.4	53.8	13.0	66.8	43.7	-31.0	-54.1
1997	262.8	320.5	55.5	13.0	68.5	43.7	-39.5	-64.3
1998	271.4	330.9	57.3	13.0	70.3	43.7	-39.5	-66.1

Note: Load factor = 65.9%

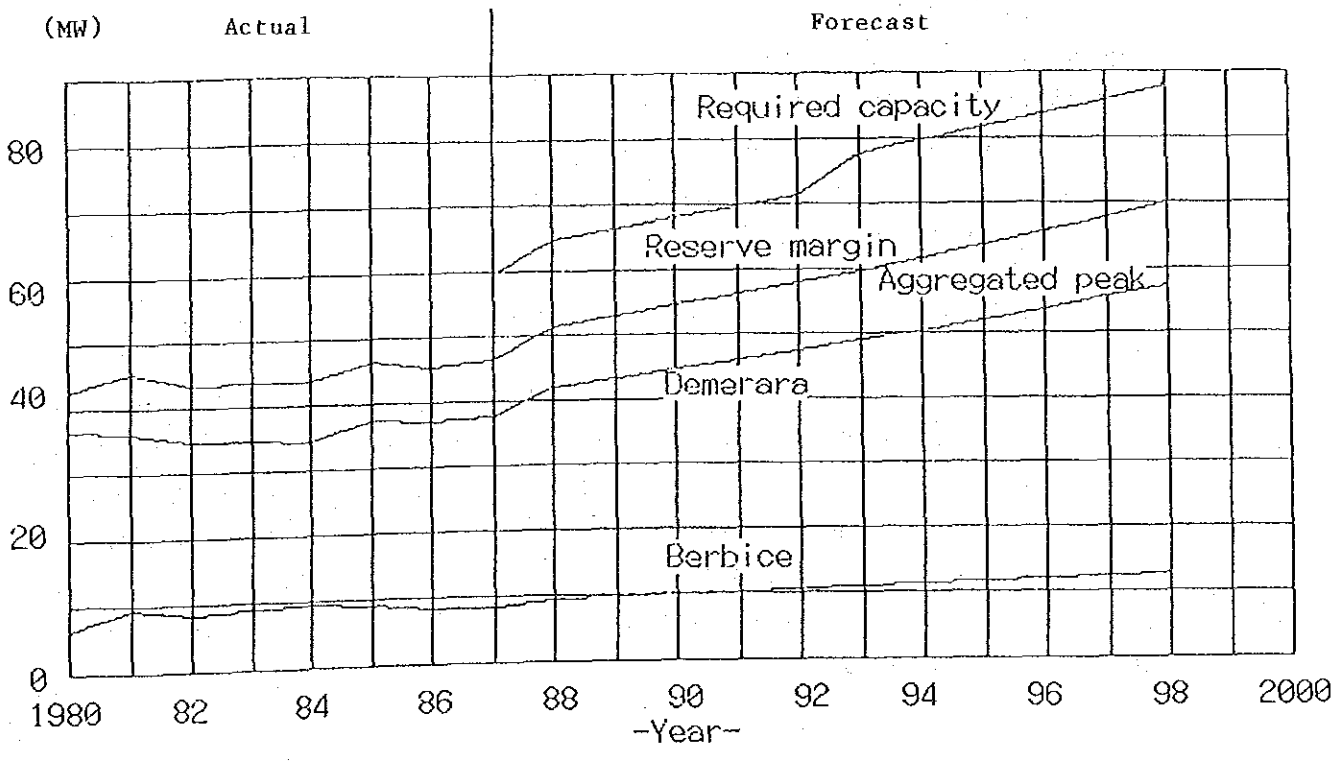
Table 3.2.2(5) Load Forecast & Supply Balance
(By Existing Power Plants)

Berbice System

Year (AD)	Energy sold (GWh)	Energy sent out (GWh)	Peak load (MW)	Reserve margin (MW)	Required capacity (MW)	Existing capacity (MW)	Retire-ment (MW)	Supply balance (MW)
1988	20.9	33.2	9.5	5.0	14.5	6.5	0.0	-8.0
1989	24.0	34.2	9.7	5.0	14.7	11.5	0.0	-3.2
1990	26.7	35.2	10.0	5.0	15.0	11.5	0.0	-3.5
1991	28.1	36.2	10.3	5.0	15.3	11.5	0.0	-3.8
1992	29.5	37.3	10.6	5.0	15.6	11.5	0.0	-4.1
1993	31.0	38.4	10.9	5.0	15.9	11.5	0.0	-4.4
1994	32.4	39.5	11.2	5.0	16.2	11.5	0.0	-4.7
1995	33.4	40.7	11.6	5.0	16.6	11.5	0.0	-5.1
1996	34.4	41.9	11.9	5.0	16.9	11.5	0.0	-5.4
1997	35.4	43.2	12.3	5.0	17.3	11.5	0.0	-5.8
1998	36.5	44.5	12.7	5.0	17.7	11.5	-9.5	-15.7

Note: Load factor = 40.1%

Fig. 3.2.2 Load Forecast for Demerara & Berbice Systems



3.2.3 Necessity of This Project and Its Schedule

If this Project is implemented according to the recommended schedule, the near future demand/supply balance is as summarized in the table below.

(Unit: MW)

Year	Maximum Demand	Reserve Capacity	Supply Capability	(Note 1) Project Implemented		(Note 2) Project not Implemented	
				Available Output	Demand Supply Balance	Available Output	Demand Supply Balance
1991	56.2	13.5	69.7	68.7	-1.0	55.2	-14.5
1992	58.0	13.5	71.5	68.7	-2.8	55.2	-16.5
1993	59.8	13.5	77.8	86.2	8.4	46.7	-13.1

(Note 1) If this Project is implemented: One unit (7.8 MW) is installed at Onverwagt Power Plant in addition to expansion (5.7 MW output) of Garden of Eden Power Plant.

(Note 2) If this Project is not implemented: No new generating units are installed and only existing thermal power plants are rehabilitated.

From the standpoint of demand/supply balance, shortage in power supply capacity increases every year, and immediate capacity addition measures are needed. This shortage will reach 14.5 MW by 1991. To cover this shortage, installation of an additional unit at Onverwagt Power Station by 1991 is recommended in the "The Master Plan Study on Electric Power Development Project in the Coastal Area", and the remaining deficit must be made up with the new 5.7 MW unit of this Project.

3.2.4 Optimal Type and Capacity of Generation Unit

This Project aims at an urgent reinforcement of power supply capacity to mitigate the power supply shortage. For this purpose, the best approach economically is to utilize the existing foundation of the dismantled No. 5 Unit of Garden of Eden, which will enable to shorten the construction period. For this reason, a 5.7 MW medium speed diesel generator has been selected because it is the maximum unit size that can be installed on the existing foundation.

When this Project is implemented and the expansion plan of Onverwagt Power Plant is completed according to schedule by 1991, the scheduled load shedding at that time will be only for 1 to 2 hours during the peak load hours even if one of the existing diesel generator (5.0 MW) plus one steam unit (8.5 MW) of Kingston "B" Power Plant are shut down for inspection or for some other reasons.

3.2.5 Rehabilitation Program for Existing Thermal Power Plants

BEI, a British consulting firm, prepared a rehabilitation program for existing power plants of GEC power systems and submitted a report to GEC in January, 1985.

The following generating facilities are included in this rehabilitation program.

Kingston "B" Power Plant	:	steam power, 10 MW x 3
		gas turbine, 10 MW x 2
Garden of Eden Power Plant	:	diesel, 5.7 MW x 4
Canefield Power Plant	:	diesel, 5.8 MW x 2
Onverwagt Power Plant	:	diesel, 2.5 MW x 1 (new unit)

The Inter-American Development Bank (IDB) agreed to finance this program, and an agreement was signed on November 1, 1985. However, as the appropriation of 16.1 million US$ by IDB was postponed to beyond November, 1987, the rehabilitation program was forced to be changed in March, 1988.

The reasons for the revision of the program were as follows.

1) Price escalation due to two year's delay.
2) Depreciation of U.S. dollars (the loan was on U.S. dollar basis)
3) New spare parts were required due to progressive deterioration of facilities.

By this revision, the power plant facilities included in this rehabilitation program were changed to the following.

Kingston "B" Power Plant : steam power, 10 MW (8.5 MW available capacity) x 3
Garden of Eden Power Plant: diesel, 5.7 MW (3.0 MW available capacity) x 3
Canefield Power Plant : diesel, 5.8 MW (4.5 MW available capacity) x 2
Onverwagt Power Plant : diesel, 2.5 MW (2.0 MW available capacity) x 1
plus 2.5 MW x 1 (New unit)

Purchase orders for repair parts of some of these power plants have been placed, and GEC plans to start the rehabilitation work in October, 1988.

In August, 1988, GEC again reviewed this rehabilitation program, and the generating facilities included in the program were changed to those listed below.

Kingston "B" Power Plant : steam; available capacity; 8.5 MW x 3
(No. 1, No. 2 and No. 3 Units)

Garden of Eden Power Plant: diesel; available capacity;
4.0 MW x 1 (No. 2 Unit)
5.0 MW x 2 (No. 3 and No. 4 Units)
5.0 MW x 1 (No. 5 Unit)
Rehabilitation cancelled

Canefield Power Plant : diesel; available capacity;
4.5 MW x 1 (No. 3 Unit)
5.0 MW x 1 (No. 4 Unit)

Onverwagt Power Plant : diesel; available capacity;
2.0 MW x 1 (No. 5 Unit)
Installation of a new unit of 2.0 MW x 1 cancelled.

The approximate schedule is presented in Figure 3.2.5 "Rehabilitation Work Schedule".

Fig. 3.2.5 REHABILITATION WORK SCHEDULE

Power plant	1988			1989											1990										
	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
Kingston																											
Actual (Expected)																											
#1: 8.5MW (8.5MW)																											
#2: 8.5MW (8.5MW)																											
#3: 8.5MW (8.5MW)																											
Garden of Eden																											
#2: 0 MW (4.0MW)*						4																					
#3: 0 MW (5.0MW)*										5																	
#4: 3.0MW (5.0MW)													2														
Canefield																											
#3: 4.5MW (4.5MW)																											
#4: 0 MW (5.0MW)*																											
Onverwagt																											
#5: 0 MW (2.0MW)*			2																								
Total: 33 MW (51 MW)																											
Increase of capacity																											
- Annual:			2			5			4		5			2													
- Accumulated total			2			7			11		16			18													

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

3.2.6 Selection of Project Site

The desire of GEC is to implement this Project in the premises of existing Garden of Eden Power Plant.

This site is suitable for this Project for the following reasons.

(1) The new diesel generator unit can be installed on the existing foundation from which an superannuated diesel generator unit has been removed.

(2) The fuel system, cooling system and other ancillary systems of the existing power facility can be utilized.

(3) The existing power plant building and the overhead traveling crane can be utilized.

(4) The power generated by this Project can be easily supplied to consumers through the feeders of the power plant, thereby eliminating the need of constructing a new transmission/distribution line.

Voltage	Number of existing Feeders
69 kV	2
13.8 kV	4

3.2.7 Project Operation Plan

GEC has been operating diesel power plants for the past 15 years. The experiences gained on existing diesel power plant can be effectively utilized in operating and maintaining the new diesel generator facility under this Project.

The personnels required for operation and maintenance of this diesel power facility will be approximately 15, and the present organization of Garden of Eden Power Plant can effectively operate and maintain the new unit.

At present, 52 personnels are assigned to Garden of Eden Power Plant under the supervision of the power plant manager to operate and maintain four diesel generator units.

When the new power generation facility under this Project is introduced to the power plant, the number of units remains the same. The duties to

be performed by these 15 personnels for the operation and maintenance of the new unit are to be assigned from the existing 52 personnels.

The fuel supply system for existing Garden of Eden Power Plant is already established, and there should be not problem in appropriating required budget for procurement of fuel for the new generating unit.

3.2.8 Requested Facilities and Materials

The materials and equipments, and the related works required to satisfy the requirements of the requested power generation unit are as listed below.

(1) Major Equipment

1) Diesel Generator (one, 5.7 MW unit)
2) Ancillary Facilities including Fuel System and Cooling System
3) Generator Control System

(2) Construction/Installation Work

1) Preparation of foundations for diesel generator and its ancillary facilities and installation thereof
2) Connecting new facility and ancillary facilities to existing facilities
3) Connecting new electrical systems to existing systems
4) Removing some existing facilities and repairing existing unloading wharf in the power plant premises

(3) Utilization of Existing Facilities

Equipments/materials to be supplied for this Project will have the necessary function as a power generating plant when they are properly interfaced and connected to existing facilities.

The existing systems and facilities to be utilized by the new facility are as listed below.

1) Fuel system
2) Cooling water system
3) Bus and substation electrical systems
4) Overhead traveling crane
5) Power plant building (including control room)

3.2.9 Necessity of Technical Guidance

GEC has more than 15 years of experience in operation and maintenance of diesel power plants. Considering there past experience, there will be no inherent problems in the operation and maintenance of the Project after its completion. However, in order to have the engineering staff of GEC acquire the operation and maintenance technology which is particular to the new power generation facility under this Project, they will be provided with on the job training by the manufacturer's engineers throughout the period from site installation to test operation, so that the necessary technology is transferred to GEC's technical personnel.

In addition, GEC should keep proper level of inventory for equipment spare parts and repair tools which shortage may affect proper operation of the generating plant, and adopt efficient repair procedures to enhance the availability of the generating facility.

3.3 Outline of Project

The outline of the Project formulated based on the study of the content of the request by the Government of Guyana is presented below.

3.3.1 Project Features

The outline of the electric power supply facility of this Project is as below.

(1) Project Site

Inside the power plant building of existing Garden of Eden Power Plant

(2) Power Supply Area

Power supply to consumers in Georgetown and its surrounding areas.

(3) Power Plant parameter

Power Generation system: Diesel engine power generation
Plant Output : 14.7 MW

Unit Output : 3.0 MW (existing generators)
5.7 MW (built under this project)

Number of Units : 4 (3: existing)
(1: built under this Project)

(4) Fuel

"A" fuel oil (also termed diesel oil or gas oil)

3.3.2 Location and Conditions of Project Site

(1) Location

This Project is to be constructed in the power plant building of Garden of Eden Power Plant. The power plant building is equipped with an overhead traveling crane (25/5 ton rating), which can be used for installation work of this Project and maintenance/inspection works after the facility is commissioned.

The circuit of the newly installed generator will be connected to the existing 13.8 kV bus.

The fuel system, cooling system and some other ancillary systems are branched from auxiliary systems of existing equipment.

(2) Harbor and Transportation

1) Georgetown Harbor

Georgetown Harbor, where equipments and materials for this Project will be unloaded, is adjacent to downtown Georgetown. This harbor is used for import of food, general cargo, construction machinery, etc. and export of bauxite. It is the main gateway of Guyana's international trade, and ocean vessels can be directly moored to its piers. The unloading facility of this harbor has 25 tons capacity.

2) Road

The distance of transportation from Georgetown Harbor to Garden of Eden Power Plant is approximately 25 km. They are connected by a two lane, paved road, although the condition is not good. There

will be no problem for transportation of equipment and materials which are not heavier than 25 tons.

3.3.3 Description of Equipments/Materials to be Granted

The equipments and materials to be granted, and their functions are as described below.

(1) Diesel Engine and Its Ancillary Facilities

Item	Quantity	Function
Diesel Engine	1	Generator driving engine.
Fuel System	1 set	Fuel supply to diesel engine.
Lubrication Oil System	1 set	Lubrication of rotating components of the diesel engine.
Cooling Water System	1 set	Supply of cooling water to diesel engine and its auxiliaries.
Start-Up Air System	1 set	Starting-up diesel engine.
Suction/Exhaust System	1 set	Charging air to diesel engine and exhausting combustion gas.
Materials including Steel Piping and Valves	1 set	Connection to various equipment.

(2) Generator and Its Ancillary Facilities

Item	Quantity	Function
Generator	1	Generation of Power.
Generator Control Desk	1 board	Controlling generator at existing control room.
Generator System Control Board	1 board	Operation and control of generator.
Station Service Board	1 set	Control of auxiliary machines.
Relay Board (for generator and station service)	1 set	Protection of generator circuit and station service circuits.

Generator Circuit Breaker	1 set	Opening and closing of generator circuit (for operation and shutdown of generator).
Excitation System	1	Exciting the generator.
Synchronizing System	1	Synchronization of generator and its connection to power grid.
Neutral Grounding Device	1	Grounding generator neutral.
Surge Absorber	1 set	Protection of generator circuit from lightning.
DC Power Supply	1 set	Supplying DC control power.
Station Service Transformer	1	Supplying AC station service power.
Station Service Transformer Power Fuse	1 set	Opening/closing of station service transformer circuits and protection.
Materials including Cables and Piping	1 set	Connecting electrical equipment.

The equipment/materials are necessary for the proper functioning of the generating plant, and includes spare parts and tools for maintenance and repair of the plant. Spare parts including those for the initial overhaul, are to be furnished for 3 years requirements.

3.3.4 Operation and Maintenance Schedule

(1) Daily Routine Maintenance and Periodic Inspection

In the operation and maintenance of diesel power plants, it is essential to conduct daily routine maintenance and periodic shutdown scheduled inspection according to the operating conditions of the plant. The detailed nature of the inspections to be conducted should be performed according to the manual furnished by the equipment manufacturer.

At GEC the criteria established for maintenance of diesel power plants are inspections and repair conducted after every 500 hours, 1,000 hours, 3,000 hours, 6,000 hours and 12,000 hours of operation, and overhaul after every 24,000 hours of operation.

(2) Personnels Required After Completion of Project

The number of operation and maintenance personnels required after the completion of this Project (one, 5.7 MW unit) will be approximately 15. As this facility will be installed inside the Garden of Eden Power Plant, the operation and maintenance duties can be performed by the current operation/maintenance personnels (52 persons).

The number of personnels required for the new diesel generator plant are as below, although the number may differ somewhat depending on the knowledge and experience of personnels on diesel power plant.

Operating personnel (shift duty) ; 10 (5 mechanical, 5 electrical)
Maintenance personnel (normal duty); 5 (4 mechanical, 1 electrical)
Total ; 15 Persons

(3) Operation and Maintenance Costs

The annual cost of this Project has been calculated based on the capital depreciation during the service life and operation and maintenance costs of the plant.

As the data on the breakdown of generating cost, transmission/distribution cost and overhead expense of GEC are not available, the proportion of these costs for this project has been assumed as below for a 70% load factor of the plant.

Generating cost	70%
Transmission/distribution cost	15%
Overhead expense and others	15%
Total	100%

Annual energy generation = 5.7 MW x 8,760 hours x 0.7 = 34.95 GWh
Generation cost = 0.04616 US$/kWh* x 34.95 GWh = 1,613,292 US$
Transmission/distribution cost = 1,613,292 US$ x 15/70 = 345,705 US$
Overhead expense and other costs = 1,613,292 US$ x 15/70 = 345,705 US$

Total operation and maintenance costs = 2,304,702 US$

(Note: * Refer to Table 3.3.4) (≒ 299 million yen)

The system power loss factor in the future is expected to be 18% and the available energy at the receiving end is:

Receiving end energy = 34.95 GWh x (1 - 0.18) = 28.66 GWh

As presented in Section 2.3.5, the average rate per unit sold of GEC is 0.84 G$ (0.084 US$). Therefore, the expected revenue is:

0.084 US$/kWh x 28.66 GWh = 2,407,440 US$ (≒ 313 million yen)

Therefore, the operation and maintenance costs of the facility under this Project can be recovered by the revenue from electricity sales.

Table 3.3.4 Energy Generation Cost

(1)	Unit installed capacity	kW	5,700	
(2)	Station power consumption	%	3.0	
(3)	Total delivered power	kW	5,529	(1) x (1-0.03)
(4)	Annual operating hours	hrs/Year	6,132	24 x 365 x 0.7
(5)	Annual energy generation	Gwh/Year	33.9	(3) x (4)
(6)	Total construction cost	Million US$	5.77	
(7)	Construction cost per kW	US$	1,012	(6)/(1)
(8)	Depreciation	US$/Year	288,500	(6)/20
(9)	Number of operators and maintenance personnel	Person	15	
(10)	Wages per head	US$/Year	2,640	1G$=0.1US$ 2200G$/monthx12x0.1
(11)	Total wages	US$	39,600	(9) x (10)
(12)	Total fixed cost	US$	328,100	(8) + (11)
(13)	Total fixed cost per kWh	US$/kWh	0.00968	(12)/(5)
(14)	Fuel price per liter	G$/liter	1.33	
(15)	Fuel price per liter	US$/liter	0.133	1G$=0.1US$
(16)	Specific gravity of fuel		0.860	
(17)	Fuel price per kg	US$/kg	0.155	(15)/(16)

(18)	Thermal efficiency	%	43.0	
(19)	Specific heat consumption	Kcal/kWh	2,000	860/(18)
(20)	Calorific value of fuel	Kcal/kg	10,300	
(21)	Specific fuel consumption	kg/kWh	0.194	(19)/(20)
(22)	Fuel cost per kWh	US$/kWh	0.03007	(17) x (21)
(23)	Lub-oil price per liter	G$/liter	18.4	
(24)	Lub-oil price per liter	US$/liter	1.84	1G$=0.1US$
(25)	Specific gravity of lub-oil		0.90	
(26)	Lub-oil price per kg	US$/kg	2.044	(24)/(25)
(27)	Specific lub-oil consumption per kWh	g/kWh	1.25	
(28)	Lub-oil cost per kWh	US$/kWh	0.00256	(26) x (27) x 10^{-3}
(29)	Maintenance cost per kWh	US$/kWh	0.00385	
(30)	Total variable cost per kWh	US$/kWh	0.03648	(22) + (28) + (29)
(31)	Unit cost per kWh	US$/kWh	0.04616	(13) + (30)

Note: 1US$ = 10 G$

3.3.5 Technical Guidance

To operate and maintain the diesel generator facility under this Project, the operation/maintenance experience for a similar facility and a certain level of technical expertise are required. GEC has accumulated such operation/maintenance experience on similar facilities of Garden of Eden Power Plant (commissioned in 1975) for 15 years. Based on this experience, the operation and maintenance personnels of this power facility will be secured and fostered by the following educational program.

On-the-Job Training

The engineers of the contractors will provide the following technical guidance throughout the period of site installation work and test run of the power plant.

(1) Personnels to be Educated

* Personnel having experience in operation and/or maintenance on diesel generators of Garden of Eden or other power plants equipped with similar units.

* Approximately 9 mechanical personnels and 6 electrical personnels.

(2) Content of Guidance

* Structure and characteristics of equipment.
* Equipment operation procedures.
* Equipment test method.
* Inspection procedures and Periodic inspection.

CHAPTER 4

BASIC DESIGN

Chapter 4 BASIC DESIGN

4.1 Design Principle

Since this diesel generator unit is to be installed in order to urgently strengthen the power supply facility, it is planned not to expand the existing power plant building and to utilize the existing facilities as much as possible, so that the Project is economical and its construction schedule is short. To be specific, the existing No. 5 generating unit and its ancillary facilities will be removed, and a new diesel generator unit will be installed inside the power plant building by utilizing the remaining foundation of No. 5 Unit.

The existing units have been manufactured from 1974 to 1976. As their ancillary facilities are very aged, and their specification and standards are different from the new unit to be installed, there could be adverse effect by interference between the old and new systems when there is a fault. Therefore, the auxiliary equipment power supply system, DC control power, and 13.8 kV switchgear for the new generator unit will be installed anew.

The existing facilities that can be utilized for this Project are as below.

(1) Concrete Foundation of Existing Diesel Generator

The existing No. 5 Unit will be removed, and the new diesel generator will be installed on the existing foundation. At present, No. 5 Unit is not included in the rehabilitation program, and its engine has been removed, and the generator is appropriated to No. 4 unit, and only the foundation remains. The condition of the foundation is as described below.

1) During the on-site survey, no defect was found on the foundation by visual inspection, and there has not been any trouble, such as abnormal vibration, that might have affected the foundation.

2) The existing foundation forms a structure which is independent from the power plant building, and its weight is estimated to be approximately 335 tons.

3) The weight of the removed, Crossly Pielstick engine is not recorded on nameplate or drawing, but the weight is estimated to be approximately 100 tons considering its output (7,920 HP), speed (514 rpm) and the date of manufacture (1975).

4) Evaluation of Foundation

It is a general rule that the weight of foundation is more than 3 times the weight of the engine. The foundation weight is approximately 335 tons, while the total weight of the new engine will be approximately 87 tons. Therefore, the weight ratio is 3.9, and this foundation can be utilized for the new engine.

In the actual construction work, the upper surface of the foundation will be chipped, and special concrete will be placed on the chipped surface, anchor bolts will be embedded after the special concrete is cured, and a flat base plane for the engine and generator will be constructed.

(2) Power Plant Building

As the new diesel generator unit will be installed on the foundation from which No. 5 Unit has been removed, the new facility will be placed inside the existing power plant building.

(3) Overhead Traveling Crane

The hoisting capacity of the existing overhead traveling crane is 25 tons for the main hook and 5 tons for the auxiliary hook, being sufficient for overhaul and assembly of the new generating unit.

(4) Fuel Storage Tank

As the diesel engine of the Project utilizes the same diesel oil with the existing units, the fuel to the new unit will be supplied from the existing fuel storage tank through existing piping.

The total storage capacity of the fuel tanks is 2,455 kl (1136.5 kl x 2, 90.9 kl x 2). The fuel consumption for one month will be approximately 3,000 kl after the new unit of this Project is installed and the existing units are rehabilitated to make 4 units operational, assuming that the capacity factor of the units is 80%. This means that the fuel tanks can store 25 days of fuel consumption. According to GEC, the fuel is procured by the Guyana National Energy Authority (GNEA) of the Government from Venezuela, and fuel oil is delivered within 11 to 12 days after an order is placed. Considering this situation, it is deemed that addition of fuel storage tank is not required.

(5) Associated Electrical Facilities

1) Generator Main Circuit

The generator terminals are connected to the 13.8 kV bus through a new generator circuit breaker. But the substation facilities and transmission/distribution facilities beyond this 13.8 kV bus are constituted by utilizing the existing electrical facilities.

2) Station Service Circuit

The dedicated station service circuit (480 V AC) to this generator unit will be secured from the 13.8 kV bus. For this purpose, a new station service transformer (13.8 kV/480 V) will be installed and connected to the 13.8 kV bus.

4.2 Basic Conditions for Basic Design

The design conditions of this diesel generator unit has been determined based on the following conditions.

4.2.1 Meteorological Conditions (Georgetown City)

Temperature	:	annual average of maximum temperature, 30.4°C.
		annual average of minimum temperature, 24.0°C.
Atmospheric Pressure	:	annual average, 1013.6 mbar.
Humidity	:	annual average, 82.5%.

Precipitation : annual maximum, 2744.3 mm
annual average, 2303 mm
monthly maximum, 509.5 mm

There is no need to consider seismic factor in the design of equipment.

4.2.2 Fuel Characteristics

The characteristics the diesel oil currently used by Garden of Eden Power Plant is as given below.

Specific gravity	: 0.8667 at 15°C
Viscosity	: 3.6 mm^2/sec at 40°C
Flash point	: 76°C
Sulfur content	: 0.4 %M
Moisture content	: 0.05% V or less
Sediments	: 0.01% M or less
Cetane	: 46

4.2.3 Cooling Water Characteristics

The result of analysis of the cooling water currently used by Garden of Eden Power Plant is as given below.

	Fresh Water	Raw Water
PH	6.3	5.7
Alkalinity (ppm)	40	12
Electric conductivity (microohm/cm)	90	3700
Chlorides (ppm)	12	1101
Total hardness (ppm)	2.52	106.5
Silica (ppm)	5.17	31.4
Turbidity (ppm)	30	2901

4.2.4 Applicable Standards

The following Japanese standards shall be applied to the performance, material, quality and standard of equipments under this Project.

Japan Industrial Standard (JIS)
The Japanese Electrotechnical Committe (JEC)
The Japan Electrical Manufacturers' Association Standard (JEM)

The Japanese Electrical Wires and Cable Makers' Association Standard (JCS)

4.3 Basic Design

4.3.1 Diesel Power Plant Design Parameters

The performance of the diesel generator unit, operating conditions, and control systems are defined by the following parameters.

(1)	Diesel generator rated output:	5.7 MW (1 unit)
(2)	Annual load factor:	70%
(3)	Annual energy generation:	34,950 MWh
(4)	Specific fuel consumption :	194 g/kWh
(5)	Thermal efficiency:	43.0%
(6)	Station service factor:	3.0%
(7)	Fuel consumption:	1,290 l/h (at 100% load)
(8)	Lubrication oil consumption:	190 l/day
(9)	Engine startup system:	Air startup system with compressed air.
(10)	Engine startup procedure:	Manual startup by switch operation on control board and manual startup of engine at the site (two procedures available).
(11)	Engine shutdown procedure:	Manual shutdown by switch operation on control board and manual shutdown of engine at site (two procedures available). Plus emergency shutdown by automatic relay protection and remote emergency shutdown from control room.
(12)	Startup/shutdown of auxiliary facilities:	Automatic startup/shutdown by sequencer and startup/shutdown by operation of switches at engine.
(13)	Monitoring system:	Operation and faults are monitored on control board and on control desk in control room.

(14) Speed control system:	Automatic and manual speed control is possible on the control board and at the engine.
(15) Cooling system:	Treated cooling water is used. The engine is cooled by primary cooling water, and the air cooler, lubricant cooler, and clean water cooler are cooled by secondary cooling water. The secondary cooling water is cooled by a cooling tower and recirculated.
(16) Air suction system:	Air is suctioned from outdoors.
(17) Exhaust system:	Exhaust gas is discharged to outdoors through a duct with silencer.

4.3.2 Equipment Layout

The major equipment of the new diesel generator plant will be laid out inside the existing power plant building and the adjacent outdoor ground inside the plant premises.

(1) General Layout

The layout design of the major equipment of this Project is described below.

Equipment Layout

1) Indoor Equipments:

Diesel Engine
Generator
Air Compressor System
Generator Control Desk
Generator System Control Board
Relay Board
Station Service Transformer
Station Service Board
DC Power Supply Board
Fuel Oil System
Lubrication Oil System

2) Outdoor Equipments:

Cooling Water System

Suction/Exhaust System

Fuel Oil Tank

(2) Features of Equipment Layout and Installation Procedure

1) Diesel Generator Foundation

As discussed in Section 4.1, Paragraph (1), "Concrete Foundation of Existing Diesel Generator", the existing foundation is to be utilized for the new diesel generator unit.

2) Layout of Diesel Generator

The position and direction of the new diesel generator unit has been selected to align the new unit with the existing units so that the existing building and overhead traveling crane can be most effectively utilized.

3) Package Base Plate

The new diesel engine and generator are assembled on a package base plate in order to reduce the amount of installation work at site and piping works. The components of fuel oil system, lubrication oil system, and the cooling water system are also installed on this package base plate, and the assembly is shipped with all piping completed.

4) Air Filter

As the air at the plant site is dusty, the dust filter is installed in the suction chamber in order to prevent the dust from entering the engine with the combustion air.

5) Exhaust Gas Pipe

The exhaust gas from engine is silenced by a silencer and discharged to atmosphere through an exhaust gas pipe. The new exhaust gas pipe is aligned with the existing exhaust gas pipes.

4.3.3 Diesel Engine Output and Generator Capacity

The rating of the new generator and the diesel engine driving this generator are described below.

Generator

Rated output	:	5,700 kW
Rated capacity	:	7,125 kVA
Rated power factor	:	0.8 (lag)
Number of unit	:	1

Diesel Engine

Rated output	:	8,070 PS
Number of unit	:	1

The calculations of these ratings are presented below.

(1) Engine Output

The engine output is obtained by the following equation.

$$\text{Engine output: } Pe \geq P/(0.736 \times \eta g) \text{ (PS)}$$

Where:

Generator output: $P = 5,700$ (kW)

Horsepower equivalent: 1 (PS) = 0.736 (kW)

Generator efficiency: $\eta g = 96\%$

$$Pe \geq 5,700/(0.736 \times 0.96) = 8,070 \text{ (PS)}$$

(2) Generator Rated Capacity

The generator rated capacity, Pg (kVA) is obtained by the following equation.

$$Pg = P/p.f = 5,700/0.8 = 7,125 \text{ (kVA)}$$

Where the generator power factor, p.f. = 0.8 (lag).

4.3.4 Capacity of Station Service Transformer

A 13.8 kV/480 V station service transformer is to be installed to supply the auxiliary power from 13.8 kV bus. The capacity of this transformer will be 250 kVA. The rated capacity is calculated by the following method.

The consumption by auxiliaries by the new diesel power plant will be approximately 3.0% of the diesel generator output.

Auxiliary power = 5,700 (kW) x 0.03 = 171 (kW)
Capacity of station service transformer = 171 (kW) ÷ 0.80
= 214 (kVA) ≒ 250 kVA
Where 0.8 is the power factor of auxiliary power.

The capacity of 250 kVA has been selected by taking into account some fluctuation of load.

4.3.5 Operation and Control System

An operation and control system for this diesel generator is required so that this unit is operated in good coordination with other generators in the same power system. The description of various control systems (or control boards) and their functions are described below.

(1) Generator Control Desk

This system is used to remotely operate the diesel generator unit at the existing control room. The generator output is controlled by the command from the control room according to the demand of power system.

(2) Generator System Control Board

This system is used to directly operate and control the diesel generator at the generator room. The test run and runs for inspection are performed in the generator room.

(3) Relay Board

The relay board is a protection system to operate the diesel generator set stably, to prevent electrical failure and to reduce the effect of failure should it occur.

(4) Station Service Power Board

This board controls the AC power supply for operation of auxiliary equipment. The voltage and rating of this board is selected to match the existing system, that is, 3-phase, 3-wire 480 V.

(5) Battery and DC Power Supply Board

This board is provided for control of DC power supply (battery system) and DC circuits for operation and control of diesel generator unit and its auxiliary equipment. The DC voltage is selected at 130 V to match the existing DC system.

4.3.6 Circuit Breaker

This circuit breaker is the main switching device provided in the 13.8 kV generator circuit to connect or disconnect the diesel generator unit to and from the power grid. The vacuum circuit breaker (VCB), which is easy for maintenance work and which has high reliability, as well as high economy, is used.

4.3.7 Equipment/Material Plan

The outline specifications and number of items of major equipment/materials required for the implementation of this Project are presented below.

(1) Plant Equipment/Materials

Item	Outline Specification
Diesel Engine	Number : 1
	Type : 4-cycle, stationary type, power generation duty.
	Output : Approximately 8,070 PS, continuous.
	Speed : 720 rpm.
	Cooling system: Circulating water, with cooling tower.
	Fuel : Diesel oil.
Generator	Number : 1
	Type : 3-phase AC, horizontal shaft, synchronous generator.
	Rated output : 5,700 kW.
	Rated capacity : 7,125 kVA.
	Rated voltage : 13.8 kV.
	Rated current : 298 A.
	Power factor : 0.8 (lag).

	Frequency : 60 Hz.
	Number of poles : 10.
	Insulation class : Class F.
	Excitation system: Brushless.
	Cooling system : Open air cooled.
Station Service Transformer	Number : 1
	Type : Indoor, 3-phase, dry type.
	Rated capacity : 250 kVA.
	Rated voltage : Primary; 13.8 kV, secondary; 480 V.
	Frequency : 60 Hz.
	Connection : Primary; delta, secondary; star.
	Neutral : Directly grounded.
Control Boards (Monitoring, control, protection and station service)	Type: Indoor, enclosed, self-standing type.
	Use : Control and protection.
	(a) Generator control desk: 1 set.
	(b) Generator system control board: 1 set.
	(c) Relay board: 1 set.
	(d) Neutral grounding resistor board: 1 set.
	(e) Station service board: 1 set.
	(f) DC power supply board: 1 set. (Charger, alkali battery, DC control)
Circuit Breaker Board	Number: 1
	Type : Indoor, enclosed, self-standing type.
	Circuit breaker: Vacuum circuit breaker.
	Rated voltage: 13.8 kV.
	Rated current: 600 A.
Power Cable	Type: Cross-linked polyethylene insulated power cable.
	Voltage: 13.8 kV.
	Conductor cross section: 150 mm2.

(2) Maintenance Materials and Tools

What is needed to maintain the performance of this diesel generator unit for a long period is the technical expertise for plant operation and maintenance to be possessed by the personnels who attend the power plant, and a proper inventory of spare parts and consumables for

repair and replacement of parts, which will eventually be worn out, aged or break down in proportion to the duration of service.

The level of operation and maintenance expertise has been discussed in Section 3.2.9, and it is deemed to be sufficient. The following concerns the requirement of spare parts, consumables and maintenance tools, as well as the amounts to be stocked.

1) Requirement

a) It is necessary to keep a certain level of inventory of spare parts as determined by the construction of equipments, because prompt action is needed to satisfy the need of power supply should an equipment fail.

b) Due to the geographical conditions of this Project Site, prompt procurement of required items is difficult under an urgent circumstance.

c) It is difficult to store a large amount of spare parts, consumables and tools on the day of commissioning when the economic burden on the owner of this facility is considered.

2) Major Items and Their Numbers

a) Main and Auxiliary Equipments
The inventory of materials and spare parts for routine maintenance of the main and auxiliary equipments must be at least equivalent to 3 years of requirement, including those needed for the first overhaul.

b) The type and number of materials and spare parts which must be stocked for routine maintenance of control boards, switches and transformer depends on whether it is related to stationary parts or moving parts. The amounts of spare parts needed for routine maintenance work (fuses, pilot lamps, etc.) must be sufficient for 3 years of consumption. Concerning relays, magnetic contactor coils, contacts, machine parts that wear or age such as bearings, and items that can not be repaired at the plant site such as thermometers and switches, at least one unit of each item must be possessed by the power plant.

4.3.8 Basic Design Drawings

The following basic design drawings for equipment layout and electric circuit design are included in this report.

Figure 4.3.8 (1) Garden of Eden Power Station General Layout

Figure 4.3.8 (2) Garden of Eden Power Station Layout of Power House

Figure 4.3.8 (3) Garden of Eden Power Station Sectional Outline of Power House

Figure 4.3.8 (4) Single Line Diagram of Garden of Eden Power Station

Figure 4.3.8 (5) Single Line Diagram of Diesel Engine Generator

Figure 4.3.8 (6) Garden of Eden Power Station Fuel Oil Supply System

Figure 4.3.8 (7) Garden of Eden Power Station Cooling Water Supply System

Figure 4.3.8 (8) Garden of Eden Power Station Starting Air System

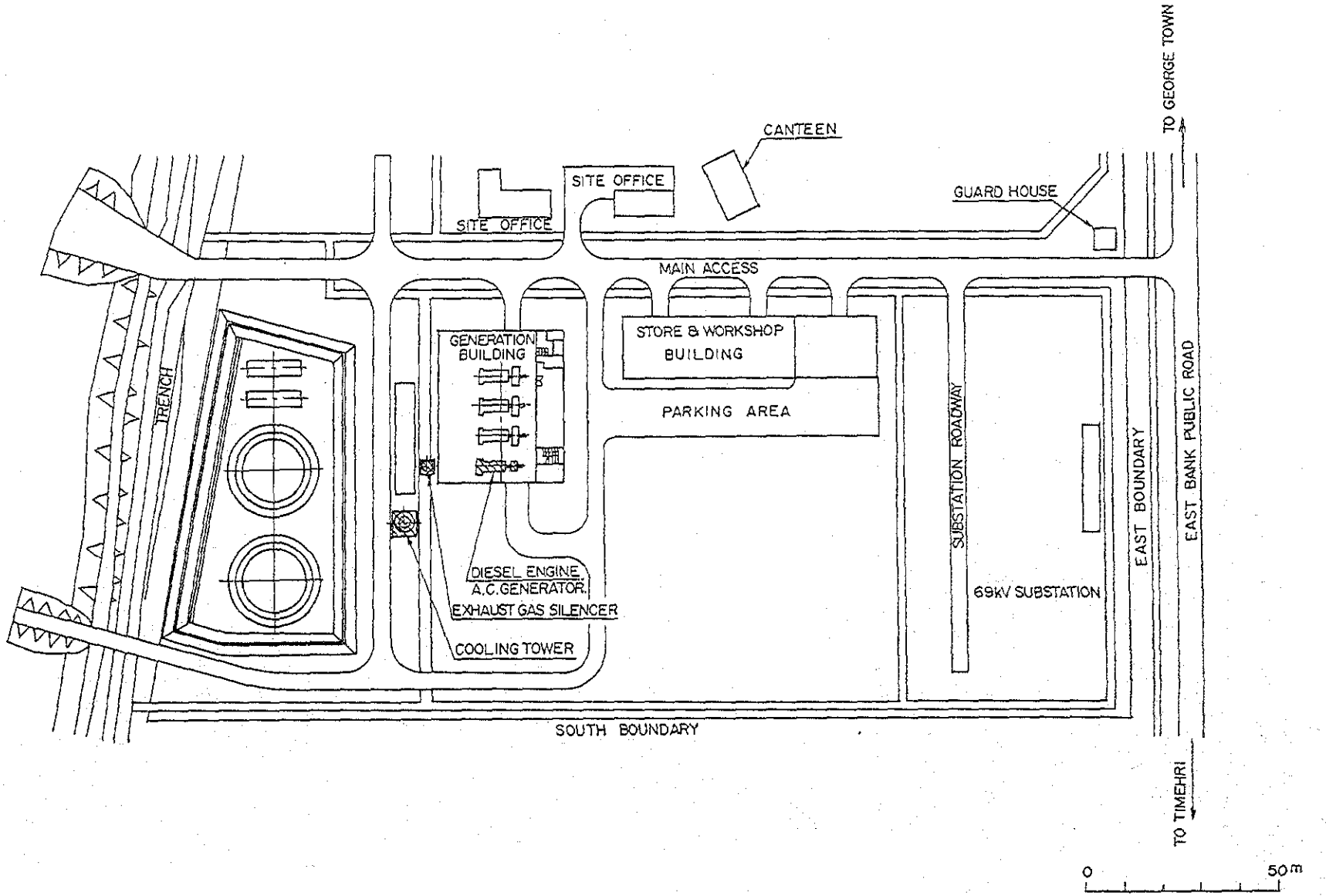


Fig. 4.3.8.(1) GARDEN OF EDEN POWER STATION
GENERAL LAYOUT

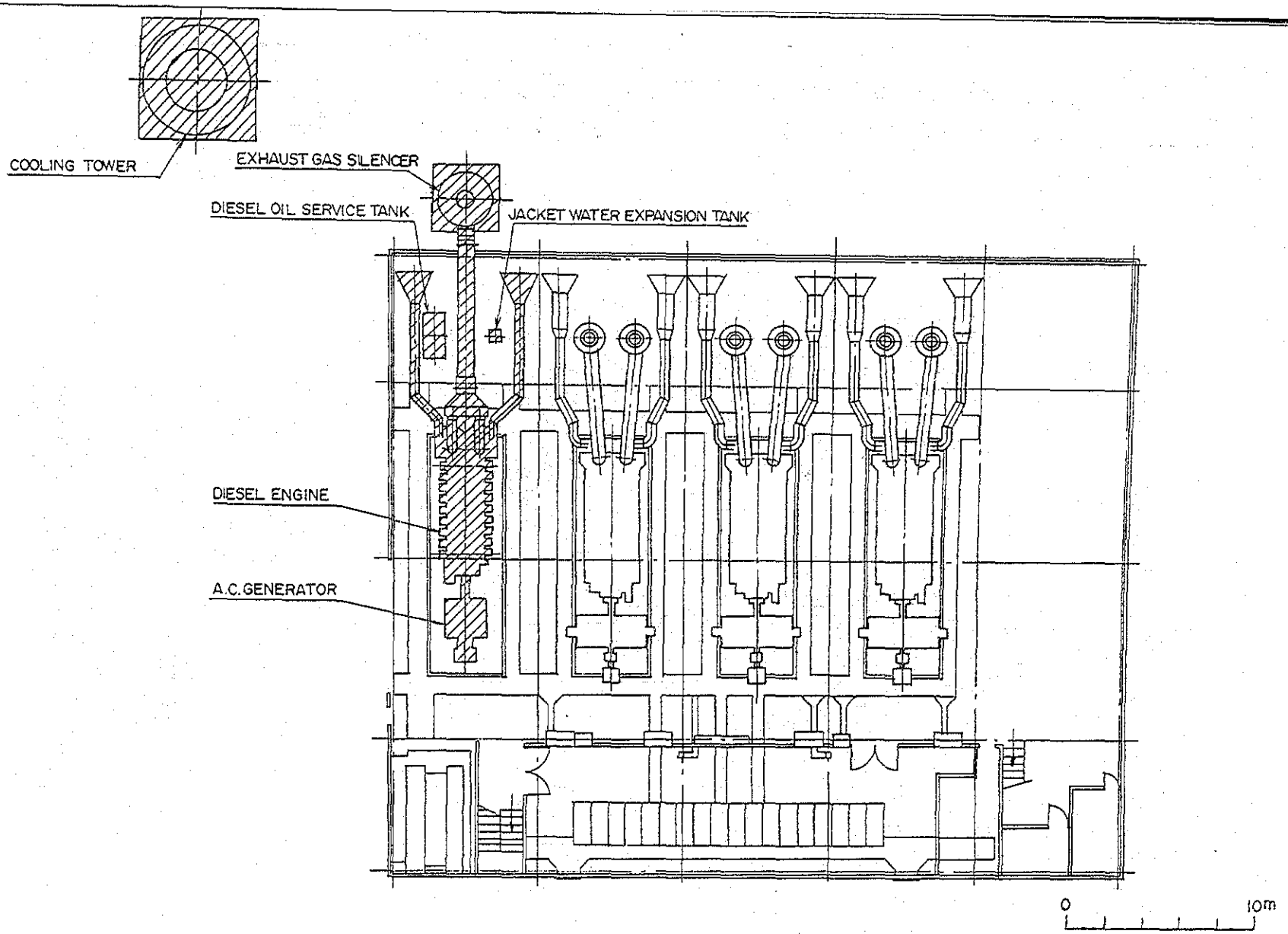


Fig. 4.3.8.(2) GARDEN OF EDEN POWER STATION
LAYOUT OF POWER HOUSE

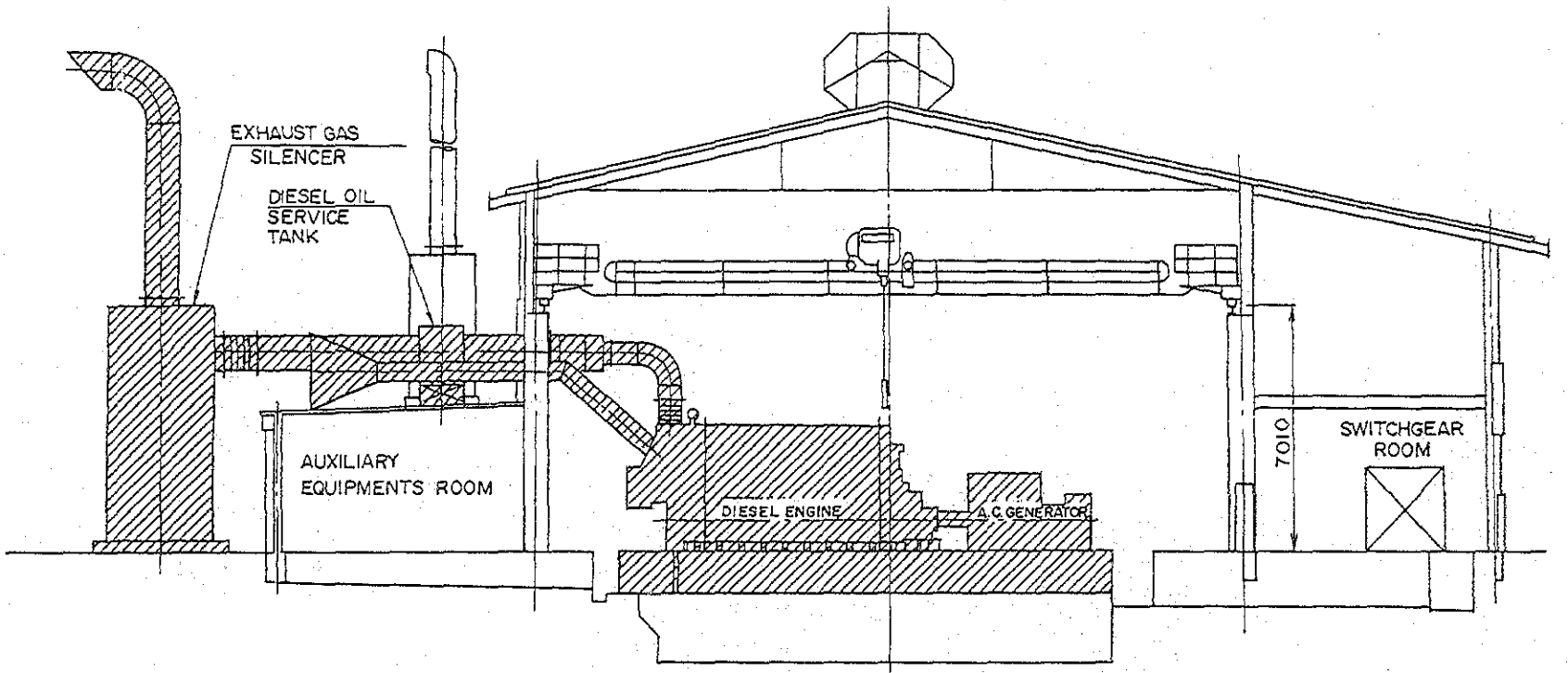


Fig. 4.3.8.(3) GARDEN OF EDEN POWER STATION
SECTIONAL OUTLINE OF POWER HOUSE

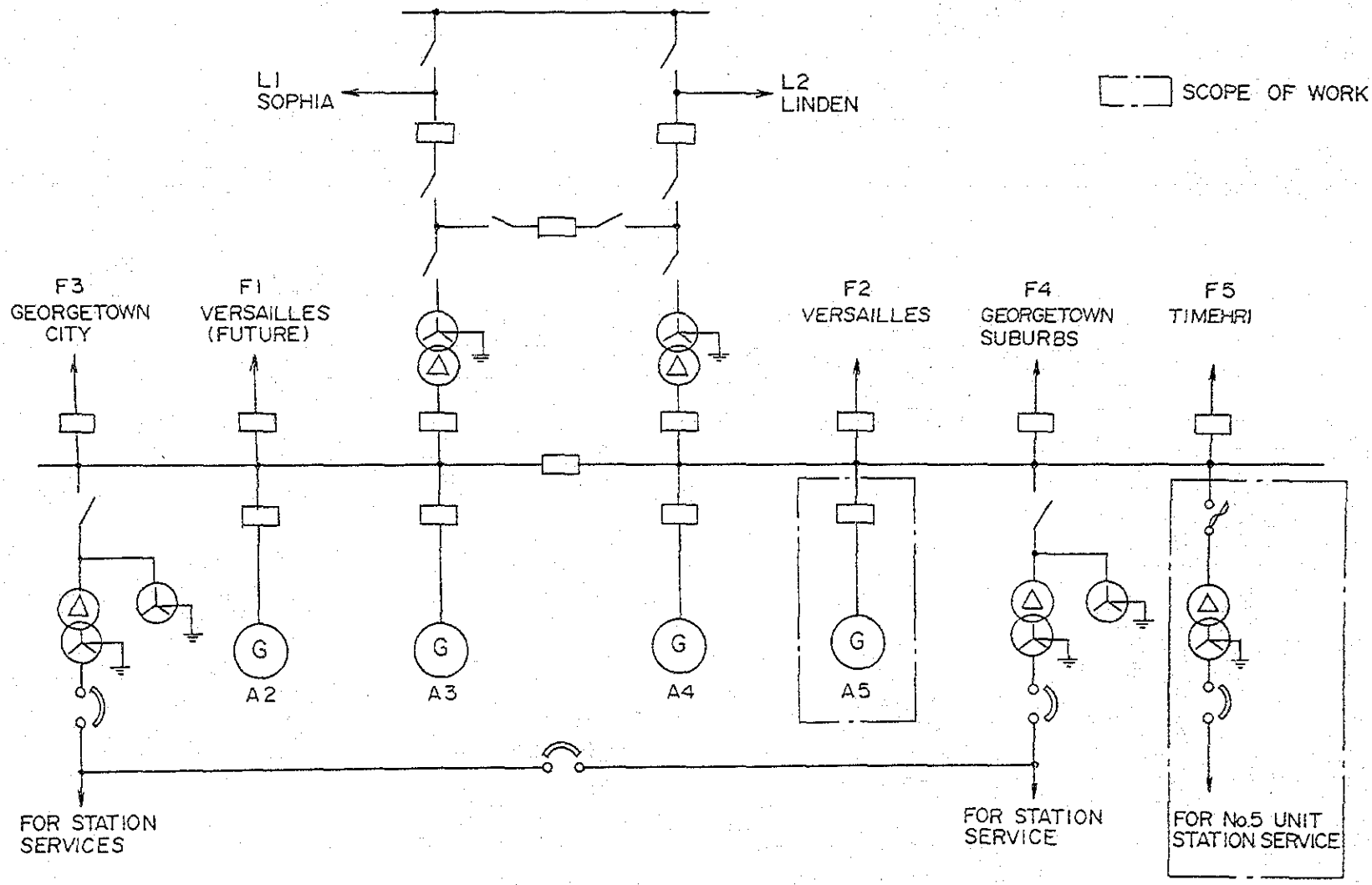


Fig.4.3.8.(4) SINGLE LINE DIAGRAM
OF GARDEN OF EDEN POWER STATION

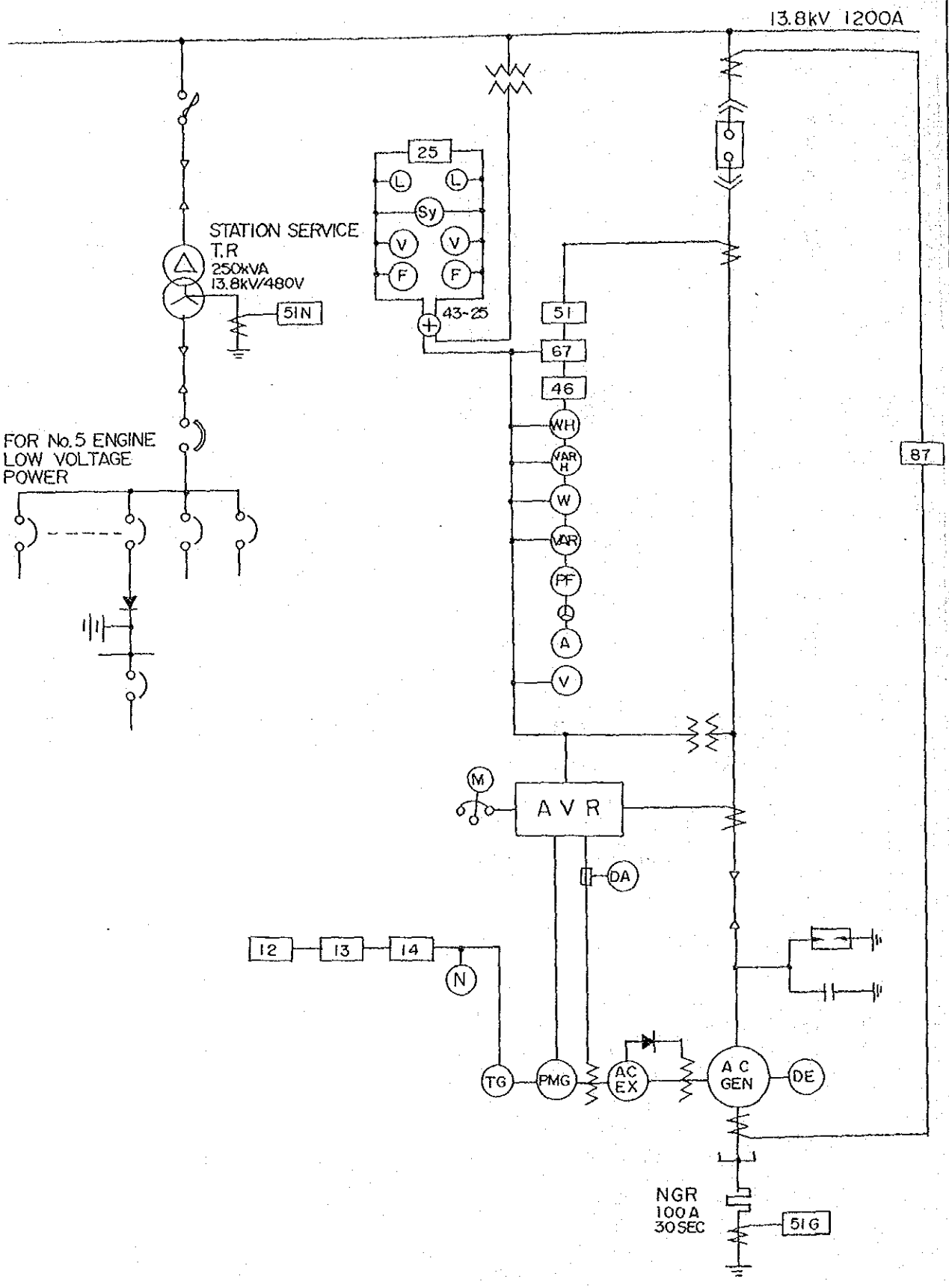


Fig.4.3.8.(5) SINGLE LINE DIAGRAM OF DIESEL ENGINE GENERATOR

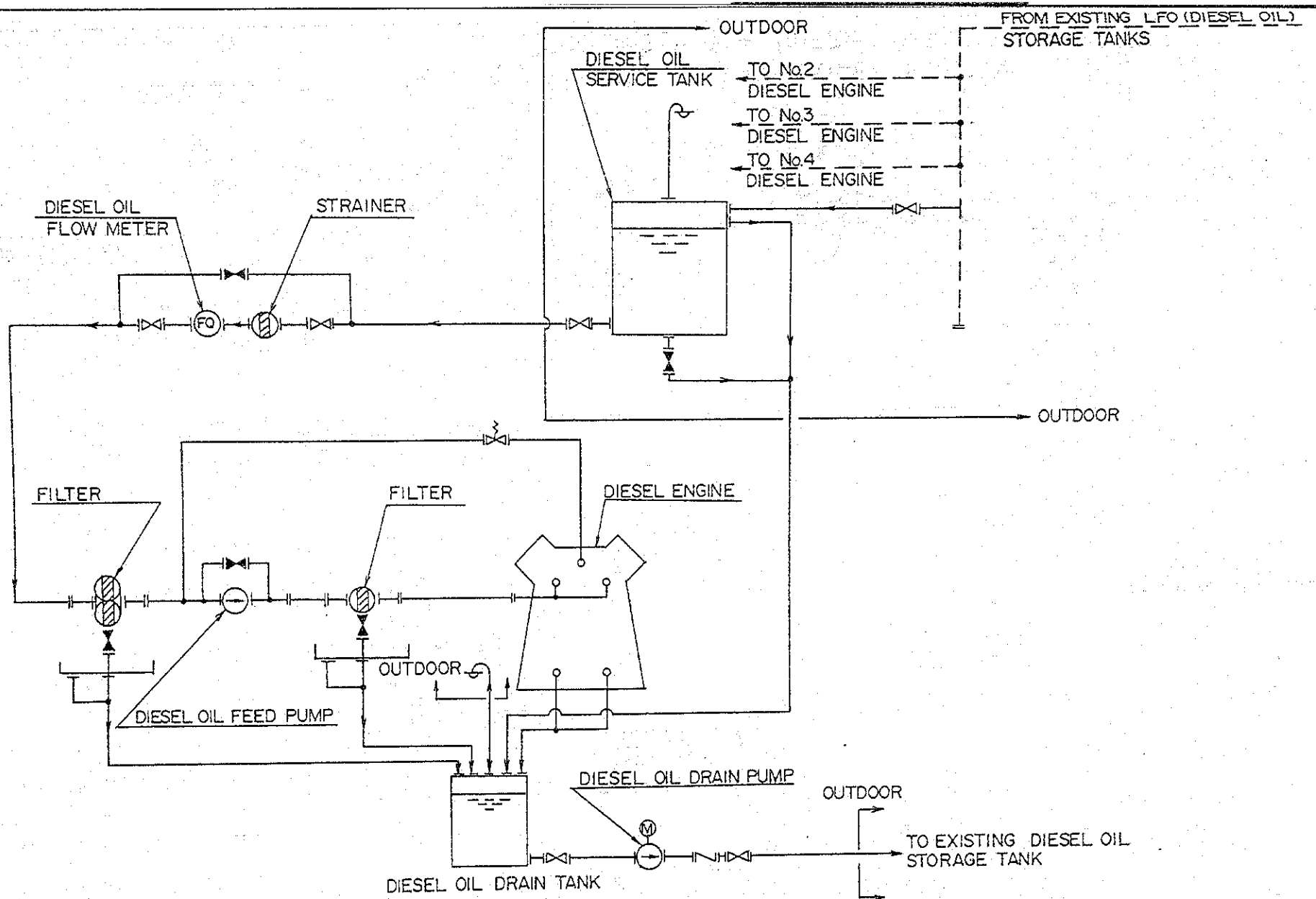


Fig. 4.3.8.(6) GARDEN OF EDEN POWER STATION
FUEL OIL SUPPLY SYSTEM

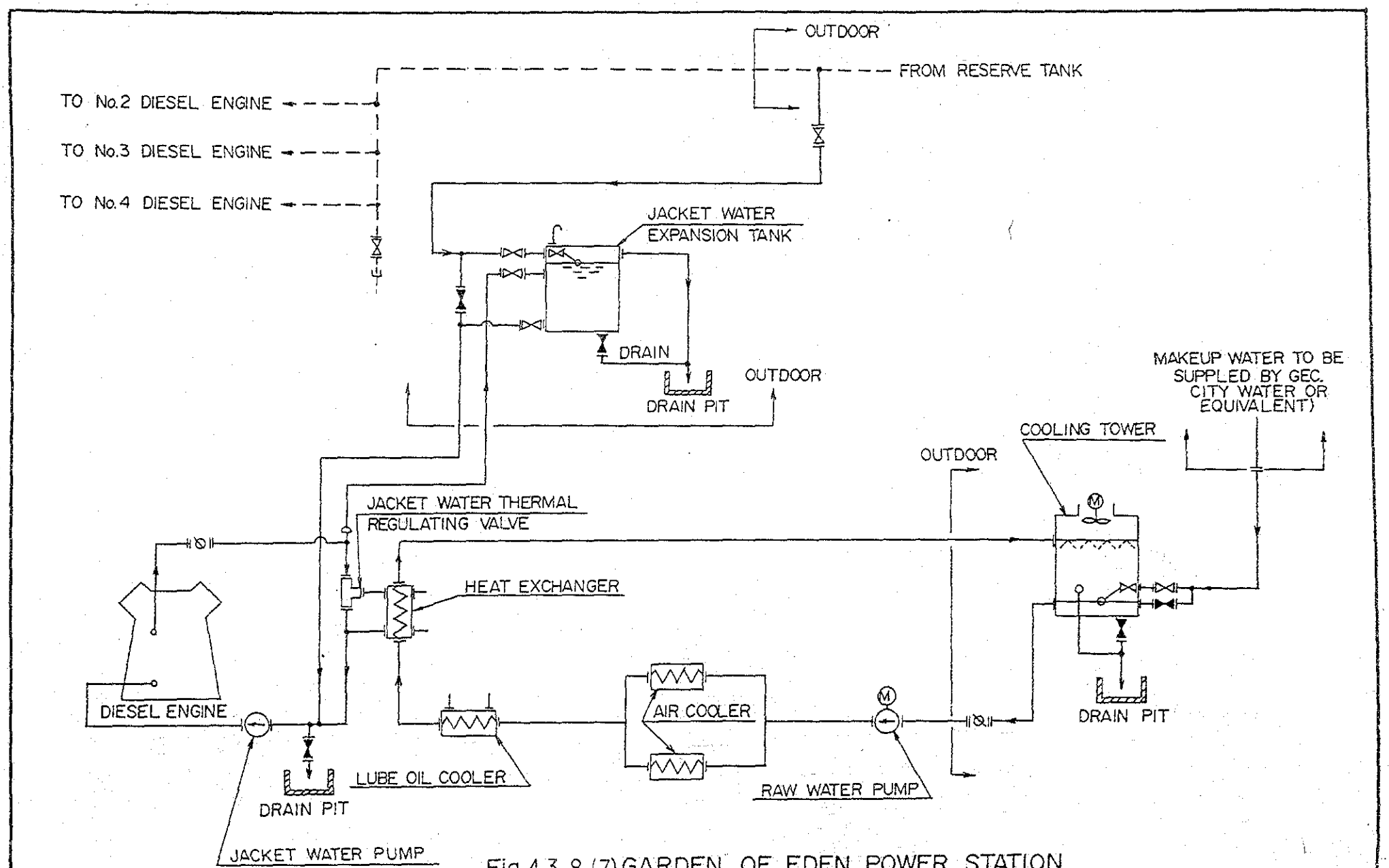


Fig.4.3.8.(7) GARDEN OF EDEN POWER STATION
COOLING WATER SUPPLY SYSTEM

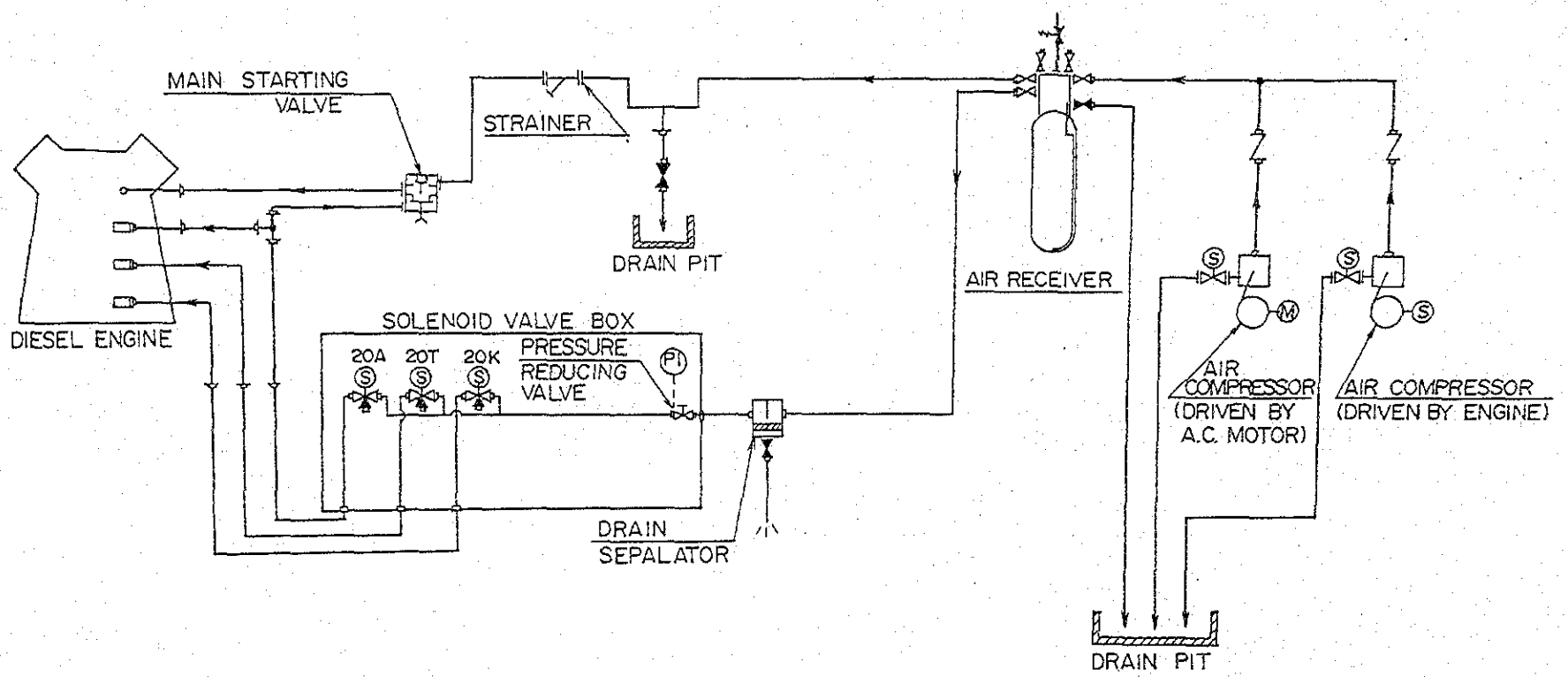


Fig. 4.3.8.(8) GARDEN OF EDEN POWER STATION
STARTING AIR SYSTEM

CHAPTER 5

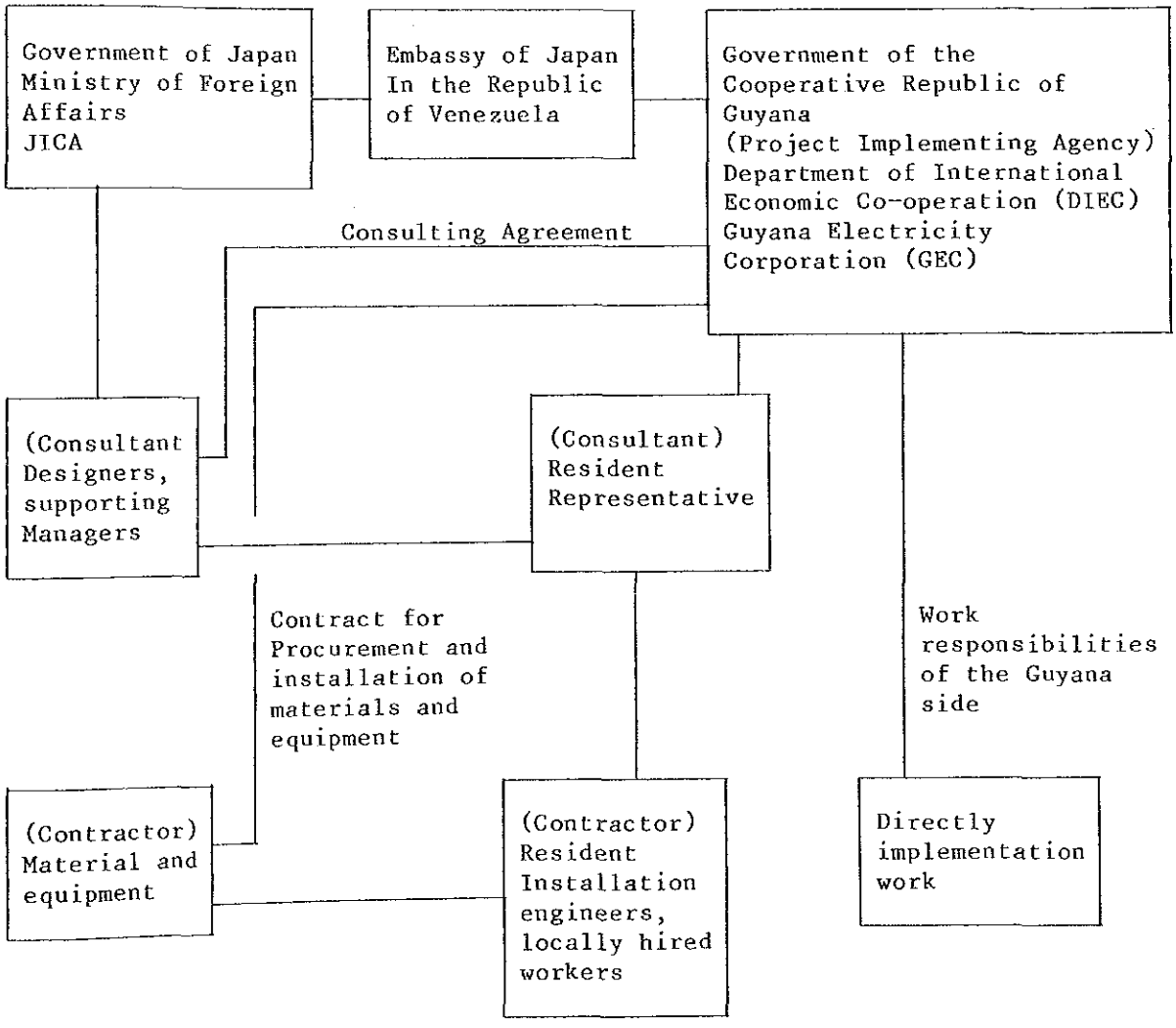
PROJECT IMPLEMENTATION PLAN

Chapter 5 PROJECT IMPLEMENTATION PLAN

5.1 Implementation Organization

In implementing this Project under a grant of the Government of Japan, the following organizational structure and the implementation method are necessary. The organizational structure for implementation of the Project is given in Figure 5.1.

Fig. 5.1 Project Implementation Organization



5.1.1 Scope of Work on the Guyanan Side

In implementing this Project, the Department of International Economic Co-operation (DIEC), in the Office of President shall have the sole responsibility for formalities and negotiations between the Government of Guyana and the Government of Japan. GEC shall be responsible for the detail, design and the installation work.

The major works to be implemented by the Guyanan side are as set forth below.

(1) Award of contracts to Japanese consultant and suppliers.

(2) Supervising the Project, and providing the necessary services to the consultant and suppliers.

(3) Operation and maintenance of the completed Project.

(4) Securing budget allocations for the construction works to be implemented by the Guyanan side.

5.1.2 Scope of the Consultant's Work

After the grant cooperation for this Project is approved by the Cabinet of the Japanese Government, Exchange of Note (E/N) will be made between the two Governments, and a consultant agreement for this Project will be concluded between a Japanese consulting firm and the Government of Guyana. The Japanese consultant shall perform the following works according to this consultant agreement to support the works to be performed by the Guyanan side.

(1) Detailed Design
(2) Inviting bid for selection of suppliers.
(3) Study and review of approval drawings.
(4) Witnessing shop tests.
(5) Construction supervision at Project site.
(6) Reporting progress of work.

5.1.3 Scope of the Contractor's Work

The suppliers shall conclude a contract with the Guyanan side for supply and installation of granted equipments, and shall perform the following works according to the contract.

(1) Production of Shop Drawings

The suppliers shall produce shop drawings for manufacture of granted equipments and shall have the drawings approved by the consultant.

(2) Manufacture of Granted Equipments

The suppliers shall manufacture the granted equipments according to the approved drawings.

(3) Transportation

The suppliers shall ship the granted equipments from ports in Japan to Georgetown Harbor of the Cooperative Republic of Guyana, unload the cargo at Georgetown Harbor, have the cargoes clear custom, and transport them to the premises of Garden of Eden Power Plant.

(4) Installation Works

The suppliers shall prepare the foundation for the granted equipments, and perform the installation works for the granted equipments including electrical connections to the existing power circuits, piping work for connection to the existing fuel supply system, and piping work for connection to the existing cooling water system.

(5) Test Run for Acceptance

After the installation works are completed, the suppliers shall perform test runs as stipulated in the applicable standards in order to verify the performance of the diesel generator.

(6) On-the-Job Training

The suppliers shall provide on-the-job training to GEC personnels in charge of operation and maintenance of the granted equipments throughout the period of installation works and test runs of such equipments. (The method and content of such training are described in Section 3.5.5)

5.2 Scope of Work

The scope of work to be performed by the Governemt of Japan and the Government of the Cooperative Republic of Guyana shall be as set forth below.

5.2.1 Scope of Work to be Performed by the Government of Japan

(1) Manufacture of equipments/materials listed in Section 3.3.3.

(2) Marine and inland transportation of equipments/materials of Paragraph (1) above.

(3) Foundation works required for installation of equipments/materials of Paragraph (1) above.

(4) Installation and test run of equipments/materials of Paragraph (1) above.

(5) Consulting services for detailed design, bidding and construction supervision for the equipments/materials of Paragraph (1) above.

5.2.2 Scope of Work to be performed by the Government of Guyana

(1) Preparation and making available site for the equipment by removing existing facilities,

(2) Rehabilitation of existing unloading wharf for transportation of heavy items of equipments/materials set forth in Section 5.2.1, Paragraph (1) which exceeds 25 tons in weight, to the power plant site.

(3) Supply of cooling water (city water).

(4) Repair of damaged parts of power plant building.

(5) Making available space required for the construction work (for temporary storage of equipment/materials, and temporary office of the Cntractor).

(6) Supply of water and electricity for construction work and fuel and lubrication oil for test runs.

(7) Other work and services not provided by the grant-aid.

5.3 Procurement, Transportation and Construction Schedules

5.3.1 Procurement Schedules for Equipments/Materials

Products which meets the specific needs of this Project are essentially not available in the Cooperative Republic of Guyana, and practically all items have to be imported from Japan. Classification of procurement of major equipments/materials related to this Project is listed below.

Procurement Classification

Procured in Japan	Procured in Guyana
(Diesel Engine and Related Items)	
Diesel Engine	Sand
Diesel Engine Accessories	Gravel
Fuel Oil System	Timber
Lubrication Oil System	
Cooling Water System	
Compressed Air System	
Suction/Exhaust System	
Piping Materials	
Construction Materials	
(Generator and Related Items)	
AC Generator	
Generator Control Desk	
Generator System Control Board	
Relay Board	
Station-Service Board	
Generator Circuit Breaker	
Exciter Board	
Synchronizing Device	

Neutral Grounding Resistor Board

Surge Absorber

DC Power Supply System

Station Service Transformer

Station Service Transformer
Power Fuse

Power Cable

Control cable including rack,
conduits and other accessories

In procuring equipments/materials of this Project, the procurement must be conducted according to a comprehensive schedule which is based on the required time and timing of transportation, acceptance at the construction site, foundation works and installation works.

Equipments/materials that arrive at Georgetown Harbor according to such schedule are then assembled and installed as mechanical component and electrical component, and the completed diesel generator plant is subjected to the test run, and then transferred to the Government of Guyana as a completed power plant.

Considering all procedures and works involved, as well as the situations to be encountered in marine and land transportation, the granted equipments/materials must be shipped at least 7 months before the date of transfer of the power plant. Therefore, manufacture, shop inspection, packing and transportation must proceed to meet this shipment deadline.

When the major equipments contain items which are vulnerable to shock, humidity or high temperature, these items must be properly handled so that they are not damaged during transportation.

Control boards, which contain a large number of instruments that are vulnerable to shock, must be firmly fixed to the base board of the packing box. The generator stator and rotor, which are easily damaged by humidity, must be vacuum packed. Painting, etc., which is sensitive to high temperature, must be so crated that they do not catch fire. All packing must be prepared to with stand marine transportation, and each items must be inspected carefully before shipment.

5.3.2 Transportation Plan

The diesel generator unit is assembled and its performance tested at manufacturer's shop, and then shipped to the Project site in the minimum number of pieces. With this method, assembly and installation work required at Project site, where skilled labor is scarce and working environment is unfavorable, can be simplified, the time required for the test run is reduced, and the initial troubles after commissioning can be minimized.

The base plate of diesel generator is common for the engine unit and the generator unit, which will be split to three parts, the diesel engine unit, generator unit and common base plate. The item having the largest dimension and heaviest weight is the diesel engine unit, and its maximum weight will be 60 tons.

Currently, cargo vessel service from Japan to Georgetown is only once a month, and it takes 60 days to reach Georgetown. This vessel does not sail regularly to Georgetown, because the amount of cargoes loaded or unloaded at Georgetown Harbor is not large.

The unloading facility of Georgetown Harbor has a capacity of 25 tons. As there are heavy items to be shipped for this Project, a vessel having a heavy derrick may be needed. In such case, early arrangement must be made to have a vessel to meet this requirement.

The largest trailer in Guyana is 30 tons in capacity. Any item heavier than this value (or more than 25 tons, for the sake of safety), must be loaded on a barge, taken up the Demerara River, and unloaded at the existing wharf at Garden of Eden Power Plant. (Refer to Section 3.2.2 for harbor conditions.)

There are only few transporters who handle heavy items in Georgetown. Heavy transportation equipment will have to be borrowed from a governmental organization of Guyana (For example, the Ministry of Transport or GUYMINE), and have these equipment used by the local transporters under supervision of the supplier's personnels dispatched from Japan.

5.3.3 Construction Plan

As soon as the Exchange of Note for this Project are executed between the two Governments, the consultant service agreement between the Guyanan side and the consultant must be signed, so that the consultant can start with the detailed designs according to the basic design, explain the designs to the Guyanan side in detail, and work out schedule of specific duties of the Guyanan side for the Project. In particular, among the works to be implemented by the Guyanan side under Section 5.2.2, the removal of existing facility and rehabilitation of wharf facility have to be completed before the installation work of granted equipment is started by the Japanese suppliers. This is a decisive point that controls the overall construction schedule. The starting dates and completion dates for the work to be performed by Guyanan side, the installation work of granted equipment, and arrival of equipments/materials at the power plant, must be carefully coordinated based on a comprehensive schedule, so that all works involved in the Project proceed in good coordination.

As this Project is located in a power plant which is in service, the circuits of new equipment have to be connected into the existing circuits. This work will be performed by the Japanese supplier. The Japanese supplier and GEC must discuss this connection work and prepare coordinated schedules. In order to perform this complicated work, timely response and effort on the side of GEC is indispensable.

There are local contractors of civil engineering, architecture, electrical and mechanical construction works in Georgetown City, and they have experience in the foundation work and diesel engine installation works of sizes equivalent to this Project. Their ability in construction supervision is not adequate, and they can perform the work under supervisors dispatched from Japanese suppliers.

5.4 Implementation Schedule

To implement this Project, it is expected to take 4 months for the detailed design, and 13 month for manufacture, installation and test run.

The implementation schedule is presented in Figure 5.2.

5.5 Estimated Project Cost

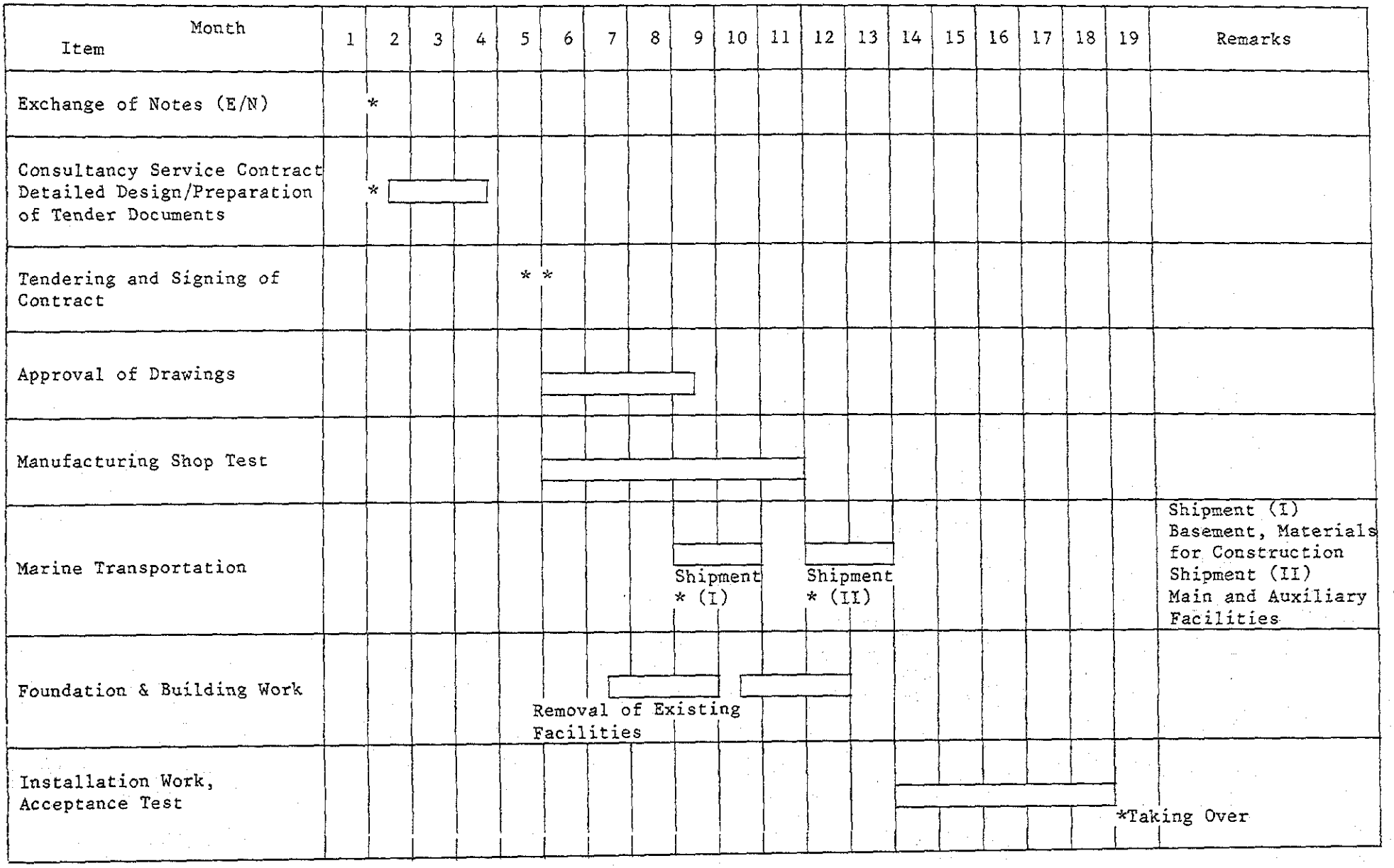
The following costs shall be borne by the Japanese and Guyana Governments respectively for implementation of this Project

(1) Project Cost Borne by the Government of Japan -

(2) Project Cost Borne by the Government of Guyana

	(G$1,000)
. Removing existing facilities	133
. Rehabilitation of existing unloading wharf	674
. Fuel and lubrication oil for test runs	756
. Repair of Power Plant building	85
Total	1,648

Fig. 5.2 Implementation Schedule of the Project for the Improvement of the Garden of Eden Power Station



CHAPTER 6

PROJECT EVALUATION

Chapter 6 PROJECT EVALUATION

6.1 Effect of Project

6.1.1 Direct Effect

The implementation of this Project will increase the power supply capability and mitigate the current stringent demand/supply balance of electric power. This project will make it possible to reduce the hours of scheduled load shedding, from a few hours to 1 to 2 hours, and enable power facilities to be shutdown for inspection and repair, thereby enhancing the reliability of generating equipment.

The annual energy generation from this project is estimated approximately 35,000 MWh (with load factor of 70%), which corresponds to the electricity consumption by 12% of the population in the Demerara/Berbice Systems, and the revenue from the sale of electricity of this Project is expected about 24 million G$. In addition, as the thermal efficiency of the new power generation facility is 43%, which higher than 26.2% of existing facilities, annual saving of fuel, as compared to existing facilities, will amount to approximately 6.7 million G$.

6.1.2 Indirect Effect

The new diesel generator can be operated at high load factor, thereby securing stable supply of power which will contribute greatly to the betterment of the livelihood and to the vitalization of local industries.

6.2 Justification of Project

6.2.1 Technical Justification

This Project is designed to have one unit of 5.7 MW, diesel power generator. This unit capacity is optimum because it will provide the required reserve capacity and can cope with the current power supply shortage. This generating unit is planned to be installed in an existing power plant, so that the facilities of this power plant (such as building, crane, fuel system and cooling water system) are effectively utilized.

6.2.2 Justification from the Standpoint of Operation and Maintenance

GEC's operation/maintenance personnels can understand the characteristics of the new diesel generator unit by receiving on-the-job training while the manufacturer's engineers are engaged in the installation and test run of the new unit. Adequate supervisory system will be established by defining the assignment and responsibility of each division of the organization of the power plant.

6.2.3 Justification from the Standpoint of Organization and Personnel

The new unit can be operated and maintained by the personnels currently stationed at the existing Garden of Eden Power Plant without modifying the power plant organization structure.

CHAPTER 7

CONCLUSION AND RECOMMENDATION

Chapter 7 Conclusion and Recommendation

7.1 Conclusion

Reliable supply of electric power is indispensable for the stable livelihood of the people and development of industry.

The Project has been studied in views of power supply situation, and technical and economic aspects, and facilities are designed to relieve the capital areas of the Cooperative Republic of Guyana from the serious power supply shortage.

Through this study, it has been confirmed that the Project will contribute to enhancement of people's livelihood and vitalization of local industries.

GEC has the competence as an organization to implement this Project, and is capable of providing adequate operation and maintenance activities with the required personnels for the Project. Therefore, it is judged that this Project is applicable for grant cooperation program by the Government of Japan.

7.2 Recommendation

It is essential that GEC has as many staff as possible participated in the installation and test runs, performed at Garden of Eden Power Plant, to learn and acquire the operation and maintenance technique for the new unit. It is recommended that GEC has its personnels strictly understood the inspection and repair standards stipulated in the manuals which will be supplied by the Japanese side on implementation of the project, and GEC must secure appropriate amount of budget for procurement of necessary repair parts and fuels for the proper operation of the new unit.

APPENDIX

Member List of the Basic Design Study Team, JICA

Name	Profession	Member's Company
Mr. Akio Masuki	Power System Planning (Project Manager)	EPDC International Limited (EPDCI)
Mr. Itsuo Ichinose	Mechanical Planning	EPDC International Limited (EPDCI)
Mr. Toshiro Wakamori	Electrical Planning	EPDC International Limited (EPDCI)

List of Received Data and Information

No.	Title	Author/Publisher	Date Published	Remarks
1	The Cooperative Republic of Guyana The Master Plan Study on Electric Power Development Project in The Coastal Area	JICA	May, 1989	Report
2	Refurbishment of Major Plant in The Guyana Electricity Corporation System	British Electricity International Ltd. (BEI)	Jan. 1985	Report