No.

BASIC DESIGN STUDY REPORT
ON
THE PROJECT
FOR
SIEM REAP GENERATING FACILITIES
IN
THE KINGDOM OF CAMBODIA

OCTOBER 2001

JAPAN INTERNATIONAL COOPERATION AGENCY
NIPPON KOEI CO., LTD., TOKYO, JAPAN

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PREFACE

In response to a request from the Government of the Kingdom of Cambodia, the Government of Japan decided to conduct a basic design study on the Project for Siem Reap Generating Facilities and entrusted the study to the Japan International Cooperation Agency (JICA).

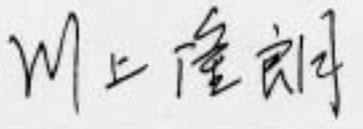
JICA sent to Cambodia a study team from May 15 to June 16, 2001.

The team held discussions with the officials concerned of the Government of Cambodia, and conducted a field study at the study area. After the team returned to Japan, further studies were made. Then, a mission was sent to Cambodia from August 23 to September 1 in order to discuss a draft basic design, and as this result, the present report was finalized.

I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of the Kingdom of Cambodia for their close cooperation extended to the teams.

October, 2001



Takaaki Kawakami
President
Japan International Cooperation Agency

October, 2001

Letter of Transmittal

We are pleased to submit to you the basic design study report on the Project for Siem Reap Generating Facilities in the Kingdom of Cambodia.

This study was conducted by Nippon Koei Co., Ltd, under a contract to JICA, during the period from April, 2001 to October, 2001. In conducting the study, we have examined the feasibility and rationale of the project with due consideration to the present situation of Cambodia and formulated the most appropriate basic design for the project under Japan's grant aid scheme.

Finally, we hope that this report will contribute to further promotion of the project.

Very truly yours,

Yoshikazu Sunagawa

Project manager,
Basic design study team on
The Project for Siem Reap
Generating Facilities

Nippon Koei Co., Ltd.

Location Map of Project Site

New Siem Reap Power Station

Abbreviations

ADB	:	Asian Development Bank
APSARA	:	d'Autorite pour la Protection du Site et L'Amenagement de la Region d'Angkor
BOT	:	Build-Operation-Transfer
EAC	:	Electricity Authority of Cambodia
EdC	:	Electricite du Cambodge
EGAT	:	Electricity Generating Authority of Thailand
CMAC	:	Cambodia Mine Action Center
GMS	:	Greater Mekong Sub-region
GWh	:	Giga watt-hour
JCS	:	Japanese Cable Standard
JICA	:	Japan International Cooperation Agency
IEC	:	International Electrotechnical Committee
JEC	:	Japanese Electromechanical Committee
JIS	:	Japanese Industrial standard
IKL	:	Isokeraunic Level
IPP	:	Independent Power Producer
Km	:	Kilo meter
MIME	:	Ministry of Industry, Mines and Energy
MVA	:	Megavolt-ampere
MW	:	Megawatt
OJT	:	On-the-job Training
WB	:	World Bank

Summary

Summary

The electric power system facilities of Cambodia were severely destroyed during the long civil war period continued since the 1970s, and all the existing major facilities have been constructed after the civil war is ended. Influenced by such a situation, the electrification of the country is far behind the general levels of the Southeast Asian countries. Power is supplied to only 13% of the population of the country and the per capita consumption is 35 kWh; the both are at the lowest level in the region. The Royal Government of Cambodia is wishing to promote the power supply activities and is trying to contribute to balanced development of economy and human lives in the country.

There is no interconnected transmission system in the country, and power is generated individually at each major city and provincial center and delivered through own distribution network. As of the year 2000, the total installed capacity of generating facilities in the EdC system was 129 MW, and out of which 87% is concentrated in Phnom Penh. Recently, EdC is purchasing power from IPPs in Phnom Penh and Kampong Champassak, and in the year 2000 the purchase from the IPPs exceeded the half of the power supply from EdC. The power consumption in the year 2000 of Electricity Siem Reap Unit was 10.3 GWh and accounted for 2.5% of the country. The electrification ratio of Siem Reap was 34.3 in the city area and 17.9% including the surrounding area.

Cambodia consists of twenty four (24) municipalities and provinces including Phnom Penh. The power supply in the capital, Phnom Penh, is being managed by Electricite du Cmabodge (EdC). In addition, the coverage area of EdC has been expanded to the provincial centers in five (5) provinces, Siem Reap, Shihanoukvill, Battam Bang, Kampong Cham and Takeo. In the other provincial centers, the power supply is still being operated by the Ministry of Industry, Mine and Energy and/or private company contracted to the Ministry.

In Cambodia, each power system is operated under the independent profit system and has the independent power tariff system. The power tariffs are cheaper for the larger system. In the year 2000, the average tariff of the Siem Reap system was 23 cents per kWh and that of the Phnom Penh system was 15 cents.

Power demand of the Siem Reap system has been increasing rapidly in the recent years along with the increase in the number of foreign tourists, and in the year 2000 the peak demand was 2,910 kW and the generated energy 12.3 GWh. In Siem Reap, in addition to the supply from EdC there is a considerable amount of consumption by hotels, restaurants, etc., that are now being supplied from with their generators, and such consumption is estimated as considerably larger than the that of EdC.

The generating facilities of EdC in Siem Reap consist of 4 diesel generators (2,160 kW in total capacity) from the former Soviet Union that started operation in 1985 and a secondhand unit (800 kW) from France. As for machines from the Soviet Union, normal maintenance is impossible as spare parts are not obtainable after the collapse of the Soviet regime. The machine from France got trouble and can not operate any more. At present, the maximum available output is 1,100 to 1,200 kW and can be operated

for short duration only. Since 1998, EdC has borrowed skid-base diesel generators of 1,000 kVA (800 kW) capacity from a private firm one by one as the demand requires, and at present 4 sets of lease generators are installed in the power station. At present, the lease generators are operated for normal supply and the Soviet generators are operated at peak time to supplement deficiency in supply. In April 2000, the peak demand of 3,500 kW was recorded and no more addition of supply is possible by the present facilities.

Under such circumstances, in July 2000 the Royal Government of Cambodia submitted an Application for Grant Aid from the Government of Japan for the Siem Reap generating facilities of 10,000 kW capacity and transmission lines to connect the new power station with the existing network.

In response to the request of the Royal Government of Cambodia, the Government of Japan decided to conduct a basic design study on the Project for Siem Reap Generating Facilities and entrusted the study to the Japan International Cooperation Agency (JICA). JICA sent to Cambodia a study team 14 May to 17 June, 2001. The study team held a series of discussions with the officials concerned of the Royal Government of Cambodia and EdC, and conducted field survey at the project site. This Project aims not only to review the necessity and the most appropriate development scale of the project together with its contents, but also to ascertain the effects of the Project and the eligibility for the Grant Aid Program of Japan. After the team returned to Japan, they studied further on the Project. Then, a mission was sent to Cambodia in order to discuss on a draft basic design.

The contents of the Project finally agreed between the Cambodian officials and the basic design team through discussions based on the request from the Royal Government of Cambodia are as mentioned below:

(1) Construction of a new power plant for Siem Reap of about 10,000 kW, which includes civil and building works.
(2) Construction of 22 kV lines to connect the new power plant with the existing distribution network.
(3) Consultant's services including the training of operation and maintenance staff of the new power station.

The following basic review was conducted regarding the contents of the request of Cambodia and the planned facilities:

(1) As the location to construct new diesel power station of 10,000 kW capacity, the location proposed by EdC was selected. The site is along National Road No. 6 about 3.5km to the east from the city center, and 400m to the south of the national road. There are no restrictions from the city planning, no houses within the selected land and land acquisition will be easy as the land is desert land that is not much utilized at the present.

(2) It is judged that there will be no problems in capability of EdC in arranging necessary local fund, construction management, technical levels, etc. considering from their past performances

in power station constructions. They are now operating and maintaining 2 large diesel power stations including C-heavy oil fired plants without serious problems, and they seems to have capability to operate and maintain the supplied generation facilities.

(3) Construction materials, labor forces, etc. economically available in the Cambodian market are to utilized as far as possible.

(4) In Cambodia, especially in the rural area, the technology level is low. In the Electricity Siem Reap Unit, the technology level of the present operation and maintenance staff is low and there are difficulties in conducting proper maintenance. Therefore, the generating facilities of the Project shall be as simple as possible and easy in operation and maintenance. The system composition shall ensure high reliability of operation based on high stability of equipment, and be flexible to future expansion of the power system.

(5) To confirm safety of the power station site, CMAC (Cambodia Mine Action Center) conducted the mine searching operation in the beginning of June 2001, and mines are not detected. If undetectable shells are existing, they lie deep. Cares shall be taken in deep excavation and pilling. CMAC will dispose if shells are found.

(6) The supply and erection of generation facilities and civil and building construction works of the Project will be executed under a turn-key contract to assume overall responsibility as a whole.

As the result of the studies on the contents of the Project mutually agreed by the both parties, the facilities with the following particulars are judged to be most appropriate:

(1) As for the diesel generators the plan to install 3 sets of 3,500 kW units with a lot of manufacturing records was selected as the result of comparison with the alternative to install 4 sets of 2,500 kW units.

(2) As for the type of power station, the normal type power house to arrange normal (open) type machines in line and to have overhead travelling hoist was selected as desired by EdC.

(3) The C-heavy oil fired diesel engines are adopted for this Project as this fuel is much cheaper than the light fuel.

(4) The diesel power facilities will be designed so as to satisfy the environmental standards of the government.

(5) Piled foundations will be adopted for the main diesel generators, power station building and fuel storage tanks.

The Project will be completed in 22 months calculated from the conclusion of the Exchange of Notes (E/N) by the both Governments. The Exchange of Note will cover both of detailed design and project implementation. This schedule comrises about 3 months for detailed design including preparation of bidding documents, about 3 months for bidding and conclusion of contract, and 16 months for manufacturing, transport, site construction

and erection works, site tests and transfer of technology.

The execution of this Project will have the following direct and indirect beneficial effects:

Direct Effects

- By the commissioning of a power station of about 10,000 kW, the problem of supply shortage will be solved for some time toward the future and living standards of inhabitant will be improved.

  This power station will meet the general demand of up to around 2009 and the demand including some of hotel loads up to around 2006. The Siem Reap power system is planned to be interconnected with the EGAT system of Thailand in 2008. This interconnecting line will feed a demand more required than the capacity of the new power station after 2009

- By execution of the distribution system reinforcement project under the ADB finance from 2002, the reliability of the system has been much improved and the electrified area of Siem Reap will become wider. By the commissioning of a new power station, more inhabitants will be able to receive the stable and reliable power. The population including the surrounding area of 230,000 will be the object to be benefited.

- The unit generation cost can be reduced by the operation of large diesel generators of C-heavy oil fired, which will result in lowering of the power tariffs. Even if, the present tariff of 23 cent per kWh will be lowered to the similar level of the present Phnom Penh system, being around 15 cent, the financial situation of Electricity Siem Reap Unit will be supported in a sound finance.

Indirect Effects

- Stable power supply will contribute to improve the public utilities and result in advancing the medical facilities and the education.

- The abundant supply of electric power to the Siem Reap area will contribute to promotion of the tourism industry and its associated economic activities. Thus, the project will support the foreign currency earning of the country.

- By lowering of the power tariffs, it will promote the electricity use of the poor population in the area.

The proposed power station site is the desert land almost not utilized at present, and there are no living houses in the site and its vicinity. It is considered that there will not be serious environmental problems in construction of the power station. This plan will be able to be implemented without serious difficulties under a Grant Aid Program from Japan.

The appropriateness for cooperation to a certain parts of implementing this Project under Grant Aid Program from Japan is confirmed, as a lot of effects can be expected from the Project as mentioned above and the Project will much contribute to improvement of the basic living conditions of inhabitants. Concerning the operation and maintenance of the project power station, it is considered that the executing agency of Cambodia has proper organization to arrange necessary staff and fund considered from the present situation of the existing large power stations. In Cambodia especially in local areas away from Phnom Penh, employment of technically capable staff is very difficult. It will not be possible to carry out proper operation and maintenance only by the staff at present in the existing power station of the Electricity Siem Reap Unit. The active involvement of EdC Phnom Penh will be essential. In addition to the on-the-job training during the erection period, the software component will be provided to train the operation and maintenance staff.

If the following arrangements are prepared by the Cambodian agencies without delay, this Project will be implemented smoothly and effectively:

(1) Acquisition of power station land: As the power station land, a land of 155m x 127m (19,685 m^2) is to be acquired at the new power station site selected by EdC.

(2) Construction of access road: An access road of about 220m in length and 7m in width suitable for transport of heavy cargoes is to be constructed between the existing regional road and the power station land.

(3) Joint operation in erection works of diesel generators: The erection works of diesel generators will be executed under joint operation of a Japanese contractor and the Electricity Siem Reap Unit. During this process, the Cambodian workers are to acquire the technology for disassembling and assembling the diesel generators.

Contents

Chapter 1

Background of the Project

Chapter 1 Background of the Project

1-1 General Situation of the Project area

Siem Reap, the objective area of supplying 10 MW diesel generating facilities under a Grant Aid Program from Japan, is the capital city of Siem Reap province of Cambodia. According to the result of the 1998 census, the population of Siem Reap city was approximately 120,000 and that of the whole province was 696,000. The total population including the surrounding area, the beneficiary area of the project, is approximately 230,000.

The mainstay of economy of the province is the agriculture. Based on the numbers of workers, the agriculture is 85%, the fishery 5%, the commerce 7% and the service activities 3%. The most of agriculture population are engaging in the rice cultivation.

Siem Reap city is close to Angkorwat and is the base of sightseeing to the Angkor Complex. For Cambodia, the sightseeing industry is one of the most important sources of earning foreign currency, and is much contributing toward improvement of the financial situation of the country. In addition to the increase in the number of large hotels for foreigners, commercial activities, cottage and handicraft industries, and other related economic activities are becoming active in the recent years reflecting the increase in the number of foreign visitors.

1-2 Current Situation and Problems of the Power Sector

(a) Generating Facilities

Power to the Siem Reap city is being fed from the diesel power station of the Electricity Siem Reap Unit, a regional organization of EdC(Electricite du Cambodge). The generating equipment of this power station comprises 4 sets of diesel generators supplied from the former Soviet Union in 1985 to 1987 and a secondhand set form France supplied in 1996, with particulars as given in Table 1-1 below:

Table 1-1 EdC's Generating Equipment in Siem Reap Power Station

Generating Equipment		Installed Capacity (kW)	Available Output (kW)
1	USSR-1	800	400
2	USSR-2	800	400
3	USSR-3	280	175
4	USSR-4	280	175
5	France Grant	800	0
	Total	2,960	1,150

Source: EdC (Electricite du Cambodge)

The 4 sets from the former Soviet Union are old exceeding the normal economic life and necessary spare parts can not be recruited after the corruption of the Soviet regime in 1991.

Therefore, proper maintenance is not possible and at present equipment can be operated for relatively short time with output of 50 to 60% of the installed capacity. The equipment from France has been damaged to the condition un-repairable at the site during operation and can not be operated any more. The total available output of all the EdC's facilities is 1,100 to 1,200 kW, and this output is far less than the present demand in the area (2,910 kW in 2000).

Due to the insufficiency of technical skill of the maintenance staff, complicated maintenance works such as engine overhaul has not been properly performed.

In 1998, EdC commenced to lease skid-base diesel generators of 1,000 kVA capacity (800 kW) from a private firm, increasing the number of units one by one as the demand required, and at present 4 sets are installed in the existing power station. Currently, the lease generators are operated for normal supply and Soviet generators only for peak time support. The lease money must be paid for the leased generators, but EdC has been continuing the power supply without raising power tariff.

Under such a situation reliability of power supply is low, and inefficient operation under a high fuel consumption rate is obliged.

Up to 1998, the demand of Siem Reap had been suppressed long time due to the shortage in power supply capacity. The load shedding was prevailing and consumers' applications for new connection were suspended. After commencing operation of the lease generating sets and gradual commissioning of the distribution project financed by ADB(Asian Development Bank) in 1999, the power demand increased very rapidly. The peak demand of 2,090 kW in 1998 increased to 2,910 kW in 2000, and in April 2001 the maximum peak of 3,500 kW was recorded. Till now, any increase in generating capacity has been caught up in a short time by increase in demand. The present capacity of generating facilities will not be able to meet further increase of peak demand in the coming years.

(b) Distribution Facilities

The present distribution system of Siem Reap is presented on the System Diagram, Fig. SRD-003, and the Location Map, Fig. SRD-002. The old MV distribution voltage of the Siem Reap system up to 1997 was 6.3 kV. This voltage was graded up to 22 kV by the system improvement executed with the ADB finance in 1997 to 1999. As the result, the old 6.3 kV system had been wholly replaced with the system of 22 kV rating. The summarized particulars of the present distribution facilities is presented in Table 1-2 below:

Table 1-2 Outline of Distribution Facilities of Siem Reap City

1.	Electric System: 22kV Distribution Line 400-230V Distribution Line	 3-phase, 3-wire 3-phase, 4-wire
2.	22kV Overhead Distribution Lines	16.0 km
3.	22kV Underground Distribution Lines	19.6 km
4.	400-230V Overhead Distribution Lines	67.5 km
5.	400-230V Underground Distribution Lines	19.6 km
6.	Distribution Substations	36 sites
7.	Distribution Transformer Capacity	13,550 kVA

Source：Electricity Siem Reap Unit

As clear from the above location drawing, the Siem Reap distribution system covers part of city area only. Even in the urban area, there are wide areas in which the public power supply is not available.

As Siem Reap city is the most important tourist center for Cambodia, the underground cables are installed in the city area so as not to harm the scenic environment of the city.

Due to the raising of system voltage under the ADB project, 6.3 kV to 22 kV, the power transfer capacity of the distribution system was much increased, and the present distribution lines generally have enough capacity to meet increasing demand to the foreseeable future. However, some addition of transformer capacity will be required to consume all power generated by the new 10 MW plant to be installed under the project.

(c) Power Demand and Forecast for the Future

The present power system is supplying power to the city area only, and un-electirfied areas are spreading in and around the city. The electrification ratio of the city at the end of 2000 was 34.3%. The past power demand of the Siem Reap system for the period of 1997 to 2000 is summarized in the Table 1-3 below:

Table 1-3 Summary of Power Demand of Siem Reap (1997 - 2000)

	Item	1997	1998	1999	2000
1.	Generated Energy (MWh)	8,249	9,670	9,370	12,270
2.	Peak Demand (kW)	1,920	2,090	2,440	2,910
3.	Sentout Energy (MWh)	7,836	9,232	9,093	12,160
4.	Consumed Energy (MWh)	4,318	5,009	6,307	10,325
5.	Distribution Loss Factor (%)	44.9	45.3	30.6	15.1
6.	Number of Consumers	5,437	5,888	7,295	7,902

Source: Power station operation records.

Some noted features of the past power demand are mentioned below:

- The power consumption increased much in 1999 and 2000 due to the commencing operation of lease generators and the commissioning of the distribution project financed by ADB. The recent economic boom due to the remarkable increase in the number of foreign tourists would be the most important factor for the rapid demand increase.
- Significant loss reduction in 1999 and 2000 (the distribution loss factor decreased to one third in 2 years, 45% in 1998 to 15% in 2000) was derived from the improvement of distribution system by the distribution project financed from ADB.
- This loss reduction resulted in the increase of consumed (i.e. sold) energy and improvement of the financial situation of the Electricity Siem Reap Unit.
- Though the consumed energy increased steadily, energy generation decreased slightly due to decrease in distribution loss and station service consumption in 1999.
- Up to 1998, the power demand had been suppressed due to insufficiency of supply capacity. Recently, any increase in supply capacity has been soon caught up by the demand. The recent increase of generation capacity due to the operation of lease generators has become full in 2001.

The peak demand of about 3,500 kW was recorded in April 2001, which corresponds to fullest possible output of the existing generating facilities including 4 lease generators.

The peak demand of each load center was roughly forecasted by EdC in their master plan study, and the forecast Siem Reap demand up to 2012 is presented in Table 1-4. This forecast was prepared for the unrestricted demand including hotel demand. The forecasted demand of the year 2000 is 8.38 MW against the actual record of 2.91 MW, and the difference which corresponds to the hotel demand is too much.

The JICA (Japan International Cooperation Agency) Basic Design Study Team forecasted the peak demand of Siem Reap for 2 cases up to the year 2012 taking into account the present situation of the area. One is for the general demand not including demand of hotels, etc. currently met by own generators, and the other is for the case some small to medium hotels are included. The base of the forecast is the actual demand in the year of 2000, and the completion of the 10 MW plant is assumed in the beginning of 2004. The result is summarized in Table 1-4 below in comparison with the above EdC's forecast and details of forecast are included in Table 1-5.

Table 1-4 Forecast Peak Demand of Siem Reap System

Year	2000	2004	2008	2012
EdC Forecast (MW)	8.38	12.58	19.12	27.54
JICA Study (MW): General Demand	2.91	4.25	5.71	7.41
Incl. Hotels	2.91	5.07	9.68	14.47

Table1-5(1) Power Demand Forecast of Siem Reap System

		Unit	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
1	No. of New Domestic Consumers	No.		600	600	720	720	720	720	720	840	840	840	840	840
2	No. of All Domestic Consumers	No.	7,660	8,260	8,860	9,580	10,300	11,020	11,740	12,460	13,300	14,140	14,980	15,820	16,660
3	Domestic Energy Consumption	MWh	5,981	7,059	7,751	8,559	9,563	10,618	11,512	12,433	13,478	14,555	15,663	16,805	17,981
4	Increase of Public & Other Energy	MWh		539	346	404	502	527	447	461	523	538	554	571	588
5	Energy Consumption (General Demand)	MWh	10,325	11,942	12,980	14,193	15,699	17,280	18,622	20,004	21,571	23,186	24,849	26,561	28,326
6	Loss Ratio	%	15.1	14.6	14.1	13.6	13.1	12.6	12.1	11.6	11.1	10.6	10.1	10	10
7	Sent-out Energy	MWh		13,984	15,110	16,427	18,065	19,771	21,185	22,629	24,265	25,935	27,640	29,513	31,473
8	Generated Energy	MWh		14,416	15,578	16,935	18,624	20,382	21,840	23,328	25,015	26,737	28,495	30,426	32,446
9	Annual Load Factor	%		50	50	50	50	50	50	50	50	50	50	50	50
10	Peak Demand (General Demand)	kW	2,910	3,291	3,557	3,866	4,252	4,654	4,986	5,326	5,711	6,104	6,506	6,946	7,408
11	Increase of Hotel & Other Energy	MWh					3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000
12	Energy Consumption (Incl. Hotels)	MWh	10,325	11,942	12,980	14,193	18,699	23,280	27,622	32,004	36,571	41,186	45,849	50,561	55,326
13	Generated Energy (Incl. Hotels)	MWh		14,416	15,578	16,935	22,183	27,460	32,396	37,323	42,410	47,494	52,577	57,917	63,374
14	Peak Demand (Incl. Hotels)	kW	2,910	3,291	3,557	3,866	5,065	6,269	7,396	8,521	9,683	10,843	12,004	13,223	14,469

Applied assumptions in demand forecasting :

a) Number of monthly connection of domestic consumers is assumed as 50 in 2001 and 2002, 60 in 2003 to 2007 and 70 in 2008 and later.

b) Annual energy consumption of newly connected domestic consumers is assumed to be 800 kWh.

c) Annual increase rate of energy consumption connected domestic consumers is assumed at 3% generally, 10% in 2001 and 5% in 2004 and 2005.

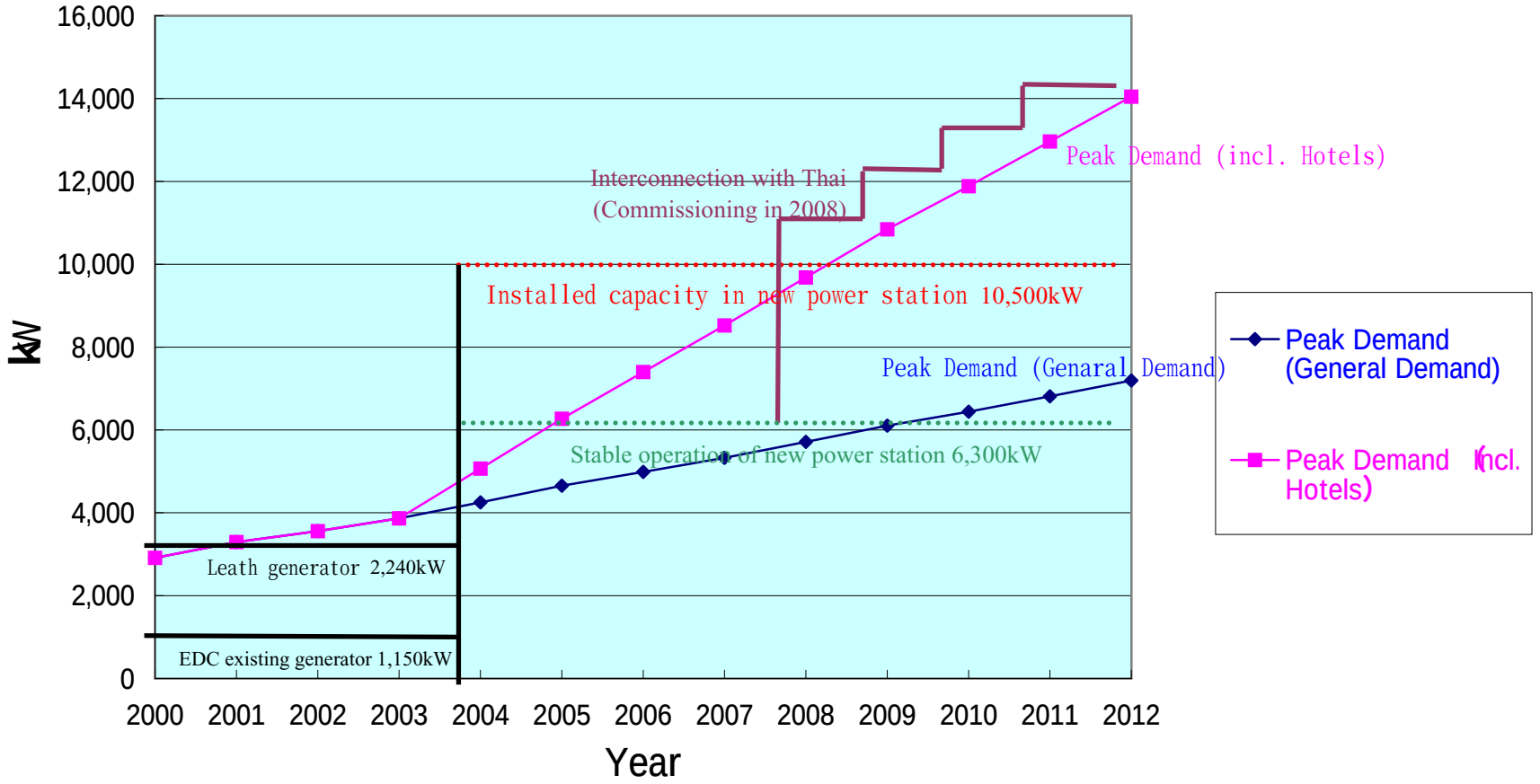
d) Increase of energy consumption for public, commercial, etc. is assumed as 50% of that of domestic category.

e) Connection of large consumers such as hotels, etc. operated with self generation at present is assumeed at 3,000 MWh per annum in 2004 and later.

f) Staion service enrgy is assumed as 3% of generated energy.

g) Annual load factor is assumed as 50% in 2001, and remain un-chaned during firecast period.

Fig. 1-5(2) Power Demand Forecast



(d) Major Problem of the Present Power System

The present power system has various problems to be solved, and out of which the following are urgently needed:

- The existing diesel generating equipment from the former Soviet Union are old and have been considerably deteriorated, but their rehabilitation is not possible.
- Capacity of EdC's generating equipment including lease generators is not sufficient to meet future increasing power demand.
- The coverage of the EdC's distribution system is limited within a part of the city area only, and its extension to the suburban and adjacent rural areas needs to be considered to raise the electrification ratio and to improve the living standard of inhabitants.
- In view of insufficiency in technical capability, power plant operation and maintenance staffs need to be educated and trained.
- Personnel in charge of distribution system also need to be trained.

1-3 Past Efforts of EdC Toward Increase of Supply Capacity

In addition to the above-mentioned lease of 4 diesel generators and execution of distribution system improvement under an ADB loan, EdC has made the following efforts to improve the balance of demand and supply.

(a) Master Plan Study by JICA

In the master plan study of JICA conducted in 1993, for the Siem Reap power system the installation of 4,000 kW diesel generators and rehabilitation of the distribution system were proposed. However, 8 years has past since then and the situation has changed much. The demand has increased exceeding the forecast in 1993 due to the recent increase in foreign visitors and other reasons. The generation capacity of 4,000 kW in the master plan is not sufficient to meet the future demand.

(b) IPP Proposal

In 1995, a Malaysian investor submitted an IPP (Independent Power Producer) proposal for generation in Siem Reap. This proposal included request for concessions to various infrastructures and power rate was 13.5 US cents per kWh. The both parties could not conclude negotiations for contract. In 1997, the Government decided to request the supply of generating equipment to the Government of Japan and terminated negotiation on this IPP proposal.

(c) 115 kV Interconnection with Thailand

In accordance with a recommendation in the master plan study for transmission system carried out with World Bank assistance, the Government planned to interconnect the western load centers

of Siem Reap, Battambang and Bantay Meanchey with the Thai power system with a 115 kV single circuit transmission line. The Thai side terminal will be the 115 kV Watthana Nakon substation located 30 km west from the border. The first meeting with EGAT(Electricity Generating Authority of Thailand) of Thailand was held in March 2001. For this project, the transmission facilities within Cambodia are to be constructed by the Cambodian side. However, its financial source has not yet been determined. Prospect for conclusion of negotiation is not known at the present stage. In the World Bank study, the connection of Battambang and Bantay Meanchey is proposed in 2005 and the extension to Siem Reap in 2008.

The present importing power rate from PEA (Provincial Electricity Authority) of Thailand on the MV level is 7.5 US cents per kWh. When the transmission cost is added to this rate, the expected power rate at Siem Reap will be higher than the generation cost of the diesel power plant firing C-heavy oil to be supplied under the project.

The power transmission capacity of the interconnection will not be sufficient to supply all the demand in the area; the length of 115 kV line is too long (distance from the 220 kV substation to Siem Reap is about 260km). However, this interconnection will much improve the system reliability and the power from Thailand will be required mainly for supporting purpose. The 115 kV interconnetion among 3 centers will also be effective in reasonable arrangement of spare generation units. Even after the interconnection, generating equipment will be required at each load center as main power source.

1-4 Outline of the Proposed project

With the background as mentioned above, in July 2000 the Royal Government of Cambodia submitted an Application for Grant Aid from the Government of Japan for the Siem Reap generating facilities with particulars as given bellow:

(1) Diesel generating facilities of 10,000 kW capacity

(2) 22 kV distribution lines of 16 circuit-km to connect the new power station with the existing network

The total construction cost can be reduced if the new generating facilities can be installed in the existing power station. However, available area in the existing station is limited. Therefore, EdC selected open land near the proposed power station site for the conceived IPP project. This site is located in the eastern suburb of Siem Reap along National Route No. 6. There is no constraint related to the city plan of APSARA, and land is expected to be able to be acquired without difficulty.

As for the type of fuel for generation, EdC expressed their desire to supply the type of engines to use C-heavy oil.

Under the ADB project, the 22 kV distribution system was extended to the point close to the new

power station taking into account possibility of connecting with the proposed IPP power plant. The distance between the end of existing distribution network and the proposed power station site is approximately 1km. For connection with the existing system 3 underground cable lines are required.

In addition, EdC wished to construct a 22 kV line from the northern end of Siem Reap city to the airport passing near the main entrance of Angkorwat. This extension was proposed to secure backup power to the airport and to supply lighting up power to Angkorwat, and at the same time to supply to the residential demand along the road between Angkorwat and the airport. This distribution system plan was not accepted by JICA Basic Design Study Team as this project is the generation project and not a distribution project, and this extension will not much contribute to basic human need. Number of houses in the area between Angkorwat and the airport is not many, and the standby power for the airport operation is already available from the existing standby generators.

At the same time, provision of services for training of personnel related to the operation and maintenance of generating facilities was agreed among the both parties.

1-5 Expected Benefits of the Project

By providing new generating facilities as mentioned above, abundant supply of reliable power will become available to the Siem Reap system. This project will contribute to leveling up of inhabitants' lives and also to promotion of regional development with focus on the sightseeing activities. The reduction of power generation cost due to introduction of large generating units burning C-heavy oil will result in lowering of power tariffs and will benefit the power users especially the poor population. The termination of the lease contract for generators will much reduce financial burden of EdC.

Chapter 2

Contents of the Project

Chapter 2 Contents of the Project

2-1 Basic Concept of the Project

(1) Upstream Projects and Objectives of the Project

In the future, the national power system of Cambodia will be operated under nation-wide interconnection among major power stations and load centers with transmission network. The present northwestern area comprises 3 independent small load centers, Battambang, Siem Reap and Banteay Meanchey, with considerable separation among them. In the transmission system master plan prepared by the World Bank, the integration of the northwestern system comprising Siem Reap, Battambang, Banteay Meanchey and the Phnom Penh system is envisaged in the future, after 2010. In the near future, the northwestern system is planned to be interconnected with the EGAT system of Thailand through a single-circuit 115 kV line. According to this plan, Battambang and Banteay Meanchey will be interconnected with the Thai system in 2005, and this systm will be extended to Siem Reap in 2008. In the Battambang area, there are 2 future hydroelectric projects that will be connected to the western system when they are developed. But, these 2 projects have not yet been studied for feasibility.

The interconnecting line with the Thai system is very long (length of 115 kV line is 260km from a 220 kV substation of EGAT to Siem Reap), and therefore this line will not be able to send all necessary power for Siem Reap. This transmission line will feed a part of the necessary power, but will contribute to improvement of reliability of power supply and reasonable arrangement of system reserves. To satisfy the N-1 condition in reliability of power supply (power supply to all consumers shall be possible when one component of power system, either, line, generator, transformer, etc. is out of service), the Siem Reap system needs a considerable amount of own power source even after the system interconnection is attained to support the system even when the interconnection is separated.

Cambodian government needs to solve the power shortage expected in the near future and to construct a base power station in Seam Reap for the increasing power demand. This project is aimed at constructing a diesel power station of approximately 10MW in Seam Reap, and contributing to training the personnel for operation and maintenance.

(2) Summary Description of the Project

The summery of necessary components to attain this project is shown below.

(a) Construction of a new power plant (output of about 10 MW), which includes civil and building works in Siem Reap.
(b) Expansion of 22 kV line to connect the new power plant with the existing system.
(c) Consultant's services including the training of operation and maintenance staff of the

new power plant.

The list of major equipment and materials necessary for the project is shown in Table 2-1.

By completion of this project, the current problem of power shortage in the Siem Reap area will be solved and the people living in the area will be able to receive reliable power of good quality without being worried about power shortage. In addition, the current power tariffs will be lowered significantly (to the level similar to those of the current Phnom Penh system), and the poor people in the area will be able to afford electricity charge. The depreciation amount against the increase of assets because of inclusion of the new power station will be available for investment to distribution facilities. The improvement of technical skill of the operation and maintenance staff due to personnel training will contribute to stable operation of the new power station.

Table 2-1. List of Major Equipment and Materials

	Items	Required	Q'ty	unit	Remarks
Mechanical Materials	Diesel Engine	Power Output 3500kW、Rotations 750～600rpm	3	sets	
	Fuel Oil Circulating System	Cleaning Device, Each Pumps, Oil Filters, Flow Late Measurements	3	nos	
	Lubricating Oil System	Cleaning Device, Cooling Device, Each Pumps, Each Tanks, Filters	3	nos	
	Cooling Water System	Each Pumps, Each Tanks, Soft-Water Device, Radiators	3	nos	
	Starting Air System	Air Compressors, Starting Air Cells	2	sets	
	Ventilation System	Exhaust Silencers, Inhalation Silencers, Exhaust Dukts, Inhalation Dukts, Air Filters	3	nos	
	Sludge Processing System	Each Pumps, Each Tanks, Oil Separation Unit	1	nos	
Electrical Materials	AC Generator	3,500kW、6.6kV、50Hz	3	sets	
	Step-up Transformer	3phase、22kV/6.6kV、50Hz、4500kVA	3	sets	
	Station Service Transformer	3phase、6.6kV/0.4kV、50Hz、1000kVA	2	sets	
	Aut Synchronous Machine		1	set	
	Control Panel for Generators		3	sets	
	Feeder Panel	VCB 22kV	3	sets	
	Circuit Breaker Panel for Generators	VCB 7.2kV、630A、20kA	3	sets	
	Circuit Breaker Panel for secondary of Transformer	VCB 7.2kV、630A、20kA	3	sets	
	Switching Panel for Station Service Transformer	VCB 7.2kV、630A、20kA	2	sets	
	Neutral Grounding Panel	DS 7.2kV、100A	1	sets	
	Surge Absorber Panel		3	sets	
	DC Power Supply Equipment	DC 110V	1	nos	
22kV Connecting Line	12/20kV CV Cable	3C×240mm2	2,604	m	
	12/20kV CV Cable	3C×150mm2	1,302	m	
Civil & Construction Facilities	Power Station Building	Generator Room, Administration Room, Cubicle Room, Ventilation Room	1	nos	
	Administration Office	Storage Room, Administration Room, Manager Room, Engineer Room, Meeting Room	1	nos	
	Guard House		1	nos	
	Fuel Oil Tank	150kL×1, 300kL×2	3	sets	
	Asphalt Road in the Power Station	W7m	1	nos	
	Drain Facilities in the Power Station	Drain Trench, Drain Pit, Oil Separation	1	nos	
	Border Fence	553m(H:2.0m) & Entrance Gate	1	nos	

2-2 Basic Design of the Requested Japanese Assistance

2-2-1 Design Policy

(1) Basic Concept

In preparing basic design of the project, the basic concept of grant aid from Japan is esteemed so that the short-term and long-term effects of the project can be maximized. Taking into account the present situation of Cambodia including the Siem Reap area, the benefited area, the project will be designed so as to produce the maximum benefit by investing minimal cost.

It is required to prepare a plan so as to meet the requirements of the site taking into account the present situation of EdC as a whole and of the Siem Reap area. Special attention must be paid to easiness of operation and maintenance.

Due attentions have to be paid in order not to cause severe environmental influences to inhabitants in the surrounding area

As the location to construct new diesel power station of about 10,000 kW capacity, two alternative ideas are conceived; in the existing power station and at the new site selected by EdC. The location selected by EdC is along National Road No. 6 about 3.5km to the east from the city center, and 400m to the south of the national road. In 1995, a site on the northern side of the national road was selected as the candidate site of an IPP power station. However, later this area was assigned as forest reserve in the area classification of the city planning, and therefore the new power station site was shifted to the southern side of the national road. The area in the belt within 250m on the both sides of the national road is assigned as 'protection zone' in which construction of factory, tall structures exceeding 8m in height, etc. is restricted; therefore the area outside this belt was selected as the power station site.

Locations of the existing power station and the newly selected site are illustrated in Fig. SRD-002.

The power station construction plans in the existing power station and in the new site are compared in the following Table 2-2.

Table 2-2 Comparison of Power Station Sites

Comparison Item	Construction in existing power station		Construction at new site	
City Planning	Existing power station site is classified in the city plan as 'Protected Zone' in which construction of factory, etc. is restricted. This site has vested rights but there may be some problems in actual execution.		The site is classified in the city plan as 'Future Development Zone', and there will be no restriction in actual execution.	0
Equipment Layout Plan	In constructing the existing power station, future expansion was not taken into account. Therefore, narrow spaces are scattered and functional layout of facilities is not possible. Especially, there are problems in construction of oil fencing dikes against oil leakage.		Most appropriate layout can be planned taking into account future extension.	0
Interconnection with the existing distribution system	Only connection to existing 22 kV bus in the power station.	0	To connect with the existing 22 kV network, 3 circuits of interconnecting line of about 1km are required.	
Expandability	115 kV substation and load dispatching center for western system are planned in the existing power station premises by EdC. New site is to be sought if existing site is not available.		Future extension as planned by EdC is possible.	0
Civil works	No problems	0	Site is low lying and soil fill of around 1m will be required to avoid land flooding.	
Building works	New construction and removal of existing structures are required for cooling water pump house, inspection house and distribution department office.		Office, store, etc. are to be newly constructed.	0
Equipment erection works	Land is narrow and use of construction machines is difficult and parallel operation of civil works, building construction, equipment erection, etc. is not possible.		Large construction machines can be easily brought in and parallel operation of various activities is possible. Construction period can be shortened.	0
Operation and maintenance of facilities	Due to dispersed layout of equipment, process of operation and maintenance become complicated. Equipment layout is restricted by available space, and maintenance and repairing works become complicated.		Systematic O&M is possible under most appropriate layout of facilities. Equipment layout taking into account easiness in maintenance and repairing can be designed.	0

Environmental protection	In recent years, many houses have been constructed around the existing power station. There were many complaints at the time of oil leakage from power station and contamination of surrounding residential area in October 1999. The noise problem due to operation of large machine may create problems. Future problems related to environmental protection may be created from old facilities.		The site is desert land without houses. Normal countermeasures will be required for environmental protection.	0
Number of '0' marks		2		7

Although the construction of new power station in the existing power station premises may result in a little lower cost, there are many problems and the plan involves many unknown factors. It is considered better to determine the site for new power station at the site selected by EdC.

Although the new generation plant of 10,000 MW is installed under the project, the future capacity expansion will be required in several years after the completion. In deciding the land area for acquisition, the area for future extension needs to be taken into account.

The selected land is in private land, but it is mostly sandy desert and not much utilized at present. The soil of this land seems not fertile, but rice is planted partly. Although there are several landowners in the proposed land, not many difficulties are anticipated in acquiring necessary area of the land.

To ensure safety of the proposed power station site, CMAC (Cambodia Mine Action Center) carried out land mine searching operation in the beginning of June 2001. Land mines were not detected at that time, and only several fragments of bullets were found in the area. Thus safety of the proposed site has been confirmed.

(2) Weather Conditions

The power station site is in the tropical region with high temperature and high humidity environment. The air temperature is high throughout the year, but the temperature seldom exceeds 40°C. The annual rainfall is around 1,400 mm. There is clear distinction between wet season (June to October) and dry season (November to May), and there is almost no rain fall in dry season. The relative humidity is high throughout the year; in rainy season the humidity is around 80% and 65% in dry season. Wind is generally mild, and according to available meteorological data there is a record of up to around 26 m/s.

The following criteria will be applied for design of facilities of this project:

- Minimum ambient temperature: 15 ºC
- Maximum water temperature: 28 ºC
- Altitude: 20 m
- Highest relative humidity: 87 %
- Maximum wind velocity 30 m/s
- Frequency of thunderstorm: IKL of around 60 is taken into account
- Seismic intensity: 0.05G

(3) Design Standards

In Cambodia, the international standards, IEC, are adopted as standards for electrical facilities. However, standards of advanced countries are also accepted in case of foreign aid provided that they are comparable to the international standards. In case of the supply from Japan under grant aid program, the Japanese standards such as JIS, JEC, JEM, JCS, etc. can be applied to facilities to be supplied. Recently, such Japanese standards are equivalent to or almost same as IEC and there are no remarkable differences.

(4) Construction Environment in Cambodia

In Cambodia, construction contractors have not yet been well matured. Except small contractors, there are no capable civil and building constructors available. Available construction forces will be laborers only. There are not enough construction markets, and usually there are no difficulties in employing necessary number of laborers.

Available contractors for electrical works are mostly engaged in small distribution works, and there are no contractors with experiences of erection for large diesel generators. Therefore, Cambodian contractors can be employed only for supporting works.

In case that a foreign contractor carries out construction works in Cambodia, such contractor usually recruits foremen from neighboring countries such as Thailand, Malaysia, the Philippines, etc. and necessary number of laborers in Cambodia for carrying out construction and erection works.

As for construction materials, there are not available for many items in Cambodia. Steel reinforcing bars, cement, etc. can be obtained in the Cambodian market. Among concrete aggregates, sand can be collected from rivers in the Siem Reap area, and coarse aggregate can be obtained in the Sisophon area, about 100km west of Siem Reap. In Siem Reap, there is a concrete batch mixing plant of sufficient capacity operated with Thai finance. This plant will be available for construction works of the project.

(5) Capabilities of Executing Agencies

The final executing agency of the project will be EdC. It is judged that there will be no problems in capability of EdC in arranging necessary local fund, construction management,

technical level, etc. considering their past performances. They completed the Phnom Penh No. 5 power station (2 x 5,000 kW) in 1996 under the Project for Rehabilitation and Upgrading of Electricity Supply Facilities of Phnom Penh, First Stage, under a Grant Aid from Japan. Outside Phnom Penh, the Siahnoukville power station (2 x 3,000 kW) was completed in 1999 with ADB loan. The both projects were successfully completed under management of EdC.

The study team visited the Phnom Penh No. 5 power station (light fuel fired) and No. 6 power station (heavy fuel fired, 3 x 6,300 kW) to inspect present operating conditions, and found that these power stations are now being operated by EdC without serious problems. It is reported that the Sihanoukville power station is also operated smoothly under assistance of the Phnom Penh head office.

(6) Establishment of Grades of Facilities and Equipment

In Cambodia, especially in the rural area, the technology level is low. The number of education facilities on technology subjects is limited in Phnom Penh only and recruitment of staff with technical knowledge is very difficult. In the Electricity Siem Reap Unit, the technology level of the present operation and maintenance staff is low and proper maintenance is not possible. Most of present operation and maintenance staff for engine-generators graduated from middle school or primary school, and they do not understand difficult technology.

Therefore, the generating facilities of the project shall be as simple as possible and easy in operation and maintenance. The high-class computer control is easy for operation, but its repairing is very difficult when some troubles occur. It is better not to adopt the modern technology that is difficult to understand for local staffs who are not well educated.

The system composition shall ensure high reliability of operation based on high stability of equipment, and be flexible to future expansion of the power system.

(7) Methods of Purchase and Implementation Period

(a) Method of Purchase

The supply including erection of generation facilities and construction works under the project will be implemented by the following manufacturers and constructors:

Diesel generation facilities		
Diesel generators	:	Diesel engine/electric apparatus manufacturer
Electric facilities	:	Electric apparatus manufacturer
Civil and building structures	:	Construction contractor

It is a usual practice that a diesel engine manufacturer deals with complete diesel generator sets including electrical apparatus.

As for construction materials, civil and architectural materials should be procured as much

as possible in Cambodia.

(b) Principle for Implementation Schedule

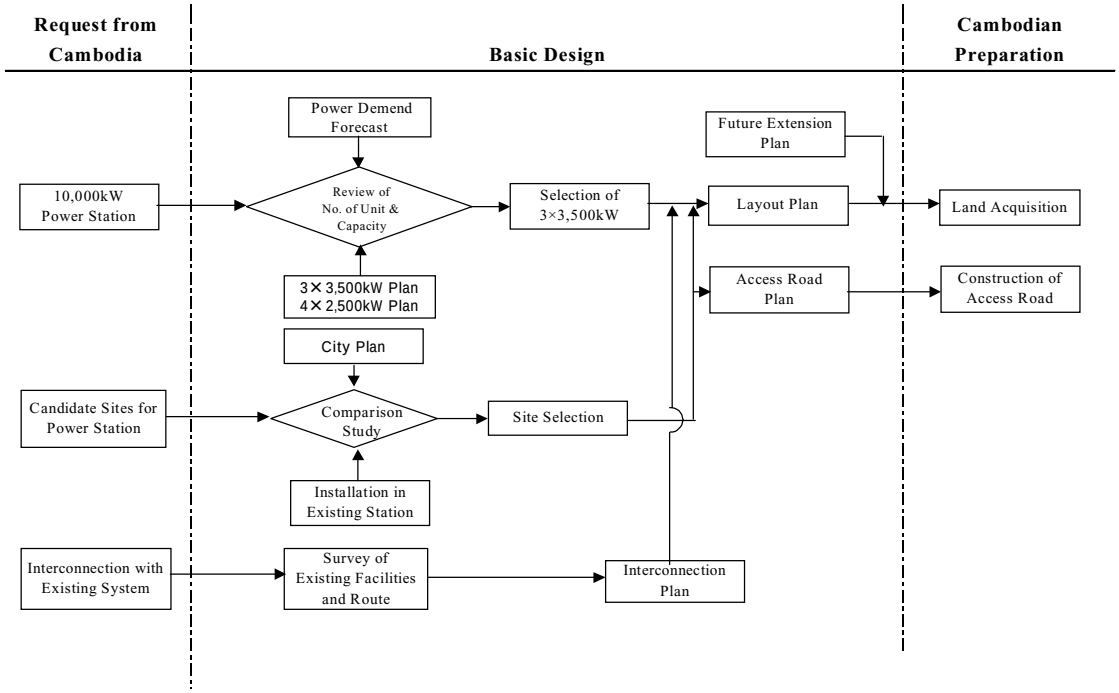
The necessary period for implementation of this project covering design and manufacture, transport, site construction, site tests and transfer of technology, and civil and building construction, requires 16 months from the conclusion of the contract up to completion.

It is not possible to complete the entire works within the period of single year budget. Therefore, it is planned to execute the project with budget of 2 fiscal years of 2002 and 2003; with one Exchange of Note covering both for detailed design including preparation of bidding documents and for project execution.

2-2-2 Basic Plan (Facilities Plan/Equipment Plan)

The flow chart of the Basic Design Study, which was carried out to confirm and justify the contents of Request for Grand Aid for a generation project, is shown in Fig. 2-1 below.

Fig. 2-1 Flow Chart of Basic Design Study



2-2-2-1 Generating Facilities

In preparing basic design of the project, technical properties of generating facilities are designed with utmost attentions to easiness in operation and maintenance and as well as economy in overall operation cost. Equipment and accessories are designed with due consideration to weather conditions in the tropical monsoon region.

(1) Appropriateness of Power Station Capacity

The appropriateness of the diesel power station capacity of 10,000 kW in the Application for Grant Aid from Japan from the Government of Cambodia was reviewed as mentioned below.

The demand forecast for the Siem Reap system up to the year 2012 was prepared by the study team as mentioned in Clause 1-2, (c). The result is shown in Table 1-5(1). The forecast results are graphically shown on Fig.1-5(2) in comparison with the reliable output of the new power station under the project. The reliable output of the diesel generators under the project (3 x 3,500 kW) is 85% output of two generators; i.e. 5,950 kW. The available output of the existing Siem Reap power station after returning lease generators is around 1,100 kW during peak time at present, however after 2004 this availability will not be able to be expected. The new facilities will meet the general demand only of up to around 2009 and up to 2005 in case some connection of hotels is taken into account. Thus, the new generation capacity of 10,000 kW is judged appropriate.

The actual power demand of the whole Siem Reap system including hotel demand is considerably large (estimated as 10,000 kW in installation and 4,000 kW in peak demand). When the EdC power tariffs are much lowered, there will be many applications of hotels and the number of connections to be granted will be an issue. The supply to general consumers shall be executed with priority. In case that power is supplied to hotel consumers having own generation facilities, the supply contracts are recommended to include conditions to cooperate with EdC by operating their facilities during the peak period when EdC's supply capacity will become short.

(2) Number of Units and Unit Capacity

It is planned that the power station under the project will be operated as a power station for normal power supply. In general, the overall construction cost of power station with the same installed capacity can be minimized by selecting unit capacity larger and reducing the number of units. However, by taking into account security of supply, necessity of spare unit for inspection and maintenance, etc., the appropriate number of units will be 3 or 4. Taking into account the series of unit capacities of Japanese engine manufacturers, the 2 alternatives, 3 x 3,500 kW and 4 x 2,500 kW, are compared as mentioned below:

- Taking into account an EdC's request, medium-speed machines of 750/600 rpm are selected, as these equipment are widely operated in Cambodia and EdC's workers are accustomed to handling these machines.
- Regarding the C-heavy oil fired diesel engines, many Japanese firms can manufacture and have supply records for 3,500 kW machines. However, as for the 2,500 kW machines only 2 manufacturers have records for only a few units.
- The operation and maintenance of 3 unit power plant is easier than that of 4 unit plant; both consist of diesel engines including auxiliary facilities - generators - electric facilities.

- The maximum reliable operating output (assumed as 85% of rated output when one unit is out of service) under normal operation is 5,950 kW for the case of 3 x 3,500 kW and 6,375 kW for the case of 4 x 2,500 kW. The latter is 425 kW larger.
- The maximum transporting weight is about 30 tons for 3,500 kW machine and about 20 tons for 2,500 kW machine. However, there will be no problem in transport of either machine, and no fundamental difference is found.
- The total cost of generating facilities is slightly lower for the 3 x 3,500 kW case.
- The fuel consumption rate is a little less for the 3,500 kW machine.
- There is no remarkable difference in both size of power station building and equipment erection period.

The most fundamental problem is difference in records of manufacture and supply, and it is judged appropriate to adopt a plan to install 3 sets of 3,500 kW diesel generators, to which many makers can participate in bidding and fair competition can be expected. The 3 x 3,500 kW alternative will be more reliable in operation and be easier in operation and maintenance.

(3) Type of Power Station

As for the type of power station, the normal type power house to arrange all normal (open) type machines in line and to have overhead travelling hoist was selected as desired by EdC. Heavy items to be lifted by the hoist are cylinders and turbo chargers and the required hoisting capacity is 3 tons.

(4) C-Heavy Oil Fired Diesel engines

The 2 kinds of heavy oil, A-heavy oil and C-heavy oil, are used to drive diesel engines. The market price of C-heavy oil is about 60% of that of A-heavy oil, and any power utility usually wish to use cheap C-heavy oil as far as possible. There is not much difference in construction of engines themselves using both fuels, however viscosity of C-heavy oil is high and to fire C-heavy oil pre-treatment is required to raise liquidity of the fuel. The C-heavy oil is widely used for large machines with unit capacity of 3,500 kW and above. The C-heavy oil fired engines required by EdC are planned for this project.

In Cambodia, C-heavy oil fired machines are adopted in the recent Phnom Penh No. 6 and Sihanuokville power stations. The fuel system needs to be so composed to enable changeover of 2 kinds of fuel, C-heavy oil and A-heavy oil.

The minimum stable operating output of C-heavy oil fired diesel engines is around 40% of the rated output; 1,400 kW for 3,500 kW machine. In case of the Siem Reap power system, 1,400 kW will almost correspond to the lowest demand in relatively cool season in the year 2004 when the power station will commence operation.

The power station will have 2 systems of fuel tank; for both C-heavy oil and A-heavy oil. A-

heavy oil is fired during 30 minutes each after machine starting and before stopping. Even under normal operation, the fuel system is required to have an automatic mechanism to changeover from C-heavy oil to A-heavy oil when operating output goes down below 40% of the rated output.

Fuel Storage Tanks

2 kinds of fuel tanks, for C-heavy oil as main fuel and for A-heavy oil as auxiliary fuel, are required. The selected storage capacities are 2 x 300 kl for C-heavy oil and 1 x 150 kl for A-heavy oil. The capacity for C-heavy oil is enough for continuous operation under generation of 30,000 MWh per annum for around 1 month.

(5) Equipment Layout

The equipment layout of diesel generators, control boards, auxiliary facilities, etc. in the power station building must be designed taking into account easiness of operation and space for maintenance. At the time of overhaul of engine-generators, engines will be completely disassembled and space for placing all disassembled component parts and for necessary works is required. Diesel generators, control boards, auxiliary facilities, etc. are connected each other with electric wiring and piping. Therefore, systematic arrangement of all items are to be planned taking into account safety, economy and easiness in operation and maintenance.

Equipment layout of the new Siem Reap power station is shown in Fig. SRD-006.

(6) Operation System

The normal operation of diesel generating equipment will be executed with the "Manual One Man Control System"; the operation covering starting, stopping, switching of load, etc. is possible from the control board by one operator. The diesel engines are started with air-starting equipment and protective machine stopping devices and other protective and alarming apparatus are provided. Thus, stable operation by one attended operator is possible.

The diesel generating equipment will be provided with the following protection items:

i) Speed rise of diesel engine
ii) Stop of water flow and temperature rise of cooling water for diesel engine
iii) Abnormal drop of lubricating oil pressure for diesel engine
iv) Voltage rise and overcurrent of generator

When such protective apparatus detected an abnormality, the circuit breaker of generator circuit is opened automatically and diesel engine stop operation, and fault is informed to operators with visual indication and audible alarm on control boards.

(7) Diesel Engines

Major technical particulars of the diesel engines are mentioned in the following Table 2-3:

Table 2-3 Major Technical Particulars of Diesel engines

(a)	Engine type	:	4 stroke, supercharged, water cooled, medium speed, diesel engine with radiator cooling system
(b)	Unit capacity	:	3,500 kW
(c)	Number of unit	:	3 units
(d)	Engine output	:	4,759 PS
(e)	Rotation speed	:	750 rpm and lower
(f)	Overload output	:	110% for 1 hour
(g)	Lubrication System	:	Manual oil feeding system
(h)	Fuel system	:	Automatic fuel feeding system, manual supply
(i)	Cooling system	:	Air cooled radiator cooling system
(j)	Starting system	:	Compressed air starting system
(k)	Intake air system	:	Oil bath type
(l)	Exhaust gas system	:	Silencer type
(m)	Kind of fuel	:	C-heavy oil, light oil (ASTM No. 2)
(n)	Governor system	:	Electronic type or hydraulic type

Major particulars of auxiliary facilities of diesel engines are mentioned below:

(i) Speed Governor

The speed governor will be of hydraulic type or electronic type, and the governor will have speed adjusting range of plus and minus 5% of the rated speed at no-load condition.

The following characteristics shall be guaranteed:

(a) When 100% load is suddenly separated

Variation of rotating speed	within 15%
Time for reinstatement	within 15 seconds

The speed droop will be adjustable during operation in the range of 0 to 6%.

(ii) Compressed Air System

The compressed air system for starting engine generator will consist of an air compressor, an air reservoir, a pressure reducing valve, a safety valve, pressure gauges, pressure switches, magnetic valves, drains and all piping works necessary for operation of the system. The maximum operating pressure of this system will not exceed 2.5 Mpa.

Details of air compressor equipment and air piping system are presented in Fig. SRD-008.

(a) Air Compressor

The air compressor will be driven by AC motor (7.5 kW), air-cooled with a cooling fan. Reciprocal air compressor of 2-stage compressing type will be adopted.

(b) Operating System

The air compressor will be installed in the power station building, and be provided with automatic operating device to feed air to the pressure tank up to a pre-set pressure.

(c) Installation Method

The air compressor and driving motor will be mounted on a common base plate, and the driving belt will have construction to adjust driving tension.

(d) Air Filling

The delivery rate of air compressor will be determined to fully charge the compressed reservoir up to the maximum working pressure within one hour.

(e) Air Reservoir

The welded portions of air reservoir will conform to requirements of JIS standard and be certified by the Japan Boiler Association. The reservoir capacity will not be less than 1,200 litter x 2.5 Mpa, which shall be sufficient to start the engine generator not less than 3 times without recharging. The air reservoir will be provided with a safety valve and a drain valve for condensed water.

(iii) Fuel Oil System

The diesel engine is normally operated with C-heavy oil. However, due to specific features of the diesel engine it needs operation with light fuel during 30 minutes each after starting and before stopping the engine.

The fuel oil system will consist of facilities in the following Table 2-4. The complete fuel system diagram is presented in Fig. SRD-009.

Table 2-4 Fuel Oil Supply Facilities

	Light Fuel System	C-Heavy Fuel System
Oil storage tank	150 kl with level gauge	2 x 300 kl with level gauge
Buffer tank	---	2,000 l with level gauge and electric heater
Transfer pump	Gear pump, 3.7 kW	Gear pump, 3.7 kW
Service tank	2,000 l with level switch	2,000 l with level alarm and electric heater
Purifier unit	---	2,570 l/hr, 7.5 kW
Unloading pump	40 m^3/hr x 1.5 kW	40 m^3/hr x 1.5 kW
Fuel oil filter	Single - automatic cleaning – cartridge system, A-C mixer and changeover valve	
Fuel oil heater	Electric system	
Fuel oil draining facilities	300 l tank, gear pump of 0.75 kW	

In addition fuel oil flow meters, pressure adjusting valves, etc. will be included.

(iv) Lubricating Oil Feeding Equipment

The lubricating oil feeding equipment will consist of facilities in the following Table 2-5. The lubricating oil system diagram is presented in Fig. SRD-010.

Table 2-5 Lubricating Oil Facilities

Lubricating oil tank	5,000 l with level switch
Lubricating oil priming pump	Gear pump, 20 m^3/hr x 5.5 kW
Lubricating oil cooler	Plate, or shell & tube system
Lubricating oil filter	Automatic reverse flow washing system
Lubricating oil cleaning unit	1,679 l, 5.5 kW, automatic sludge discharging type, with level switch
Turbocharger lub. Oil tank	350 l, with level switch
Turbocharger lub. oil pump	Gear pump, 6 m^3/hr x 3.7 kW
Turbocharger lub. oil cooler	Plate, or shell & tube system
Turbocharger lub. oil filter	Duplex

(v) Cooling System Equipment

The cooling water system of diesel engine will basically consist of 2 systems; engine cooling water system and heat exchanger cooling system. The cooling system will consist of facilities the following Table 2-6. The cooling system diagram is presented in Fig. SRD-011.

Table 2-6 Engine Cooling System Facilities

Cooling system	Air-cooling radiator system
Prime water pump	1 m^3/hr
High temp. side cooling water tank	1,000 l
Low temp. side cooling water tank	1,000 l
High temp. side cooling water pump	Volute pump, 100 m^3/hr x 15 kW
Water softening system	1 m^3/hr
Low temp. side cooling water system	Volute pump, 110 m^3/hr x 18.5 kW
Radiator	Air cooled, 2-stage heat exchanger

(vi) Sludge Treating System

The sludge processing system will consist of facilities in the following Table 2-7.

Table 2-7 Sludge Treatment Facilities

Sludge transfer pump	1 m^3/hr
Sludge separating tank	3 m^3, with electric heater
Oil - water separator	Capacity : 1 m^3/hr, not higher than 50 ppm
Oily water transfer pump	Screw pump, 1 m^3/hr
Waste oil pump	Screw pump, 1 m^3/hr
Sludge collecting tank	1,000 l, with level gauge and switch

(vii) Air Intake and Exhaust System

Air Intake System

The engine air intake system will consist of an oil bath air filter of wet type, a turbo-blower supercharged, a charge air cooler and an intake air silencer. Outdoor air will be extracted to obtain lower air temperature compared with air in the power house.

Exhaust Gas System

The engine exhaust gasses will be released to the atmosphere through an exhaust pipe with a silencer at its end. The engine will be provided with an exhaust pipe leading to the outside of the power house wall and fitted with an exhaust silencer. The silencer will be of floor mounting type.

All exhaust piping in the power house will be wrapped with thermal insulating materials. The exhaust piping will be provided with a flexible section or an expansion joint and all be sloped to a drain pocket with a drain cock outside the building.

(8) Generators

Major technical particulars of generators are as given in the following Table 2-8:

Table 2-8 Technical Particulars of Generators

(a)	Generator type	:	Horizontal shaft, revolving field, air cooled, compound winding, 3-phase AC synchronous generator
(b)	Unit capacity	:	4,375 kVA
(c)	Number of units	:	3 sets
(d)	Installed location	:	Indoor generator room
(e)	Electric system	:	3-phase, 3-wire system
(f)	Generator voltage	:	6.6 kV
(g)	Frequency	:	50 Hz
(h)	Power factor	:	0.8
(i)	Exciter type	:	Brush-less system
(j)	Cooling system	:	Self-ventilating air-cooled system
(k)	Number of poles	:	8 poles or more
(l)	Insulation class	:	F class

(i) Limit of Temperature Rise

The temperature rise of generator under the full-load condition shall not exceed the following limit values:

Stator windings:	100 ºC	(embedded thermometer)
Rotor windings:	110 ºC	(resistance)
Bearings:	75 ºC	(thermometer)

(ii) Voltage Variation Rate

The inherent voltage variation rate shall not exceed the following values:

When full load with 0.8 power factor is suddenly separated	40%
When full load with 1.0 power factor is suddenly separated	30%

(iii) Allowable Over Speed

The generator shall mechanically withstand to operation at 120% of the rated speed for one minute under no-load and no-excitation condition.

(iv) Insulation Strength

The commercial frequency insulation strength of the generator shall be as follows:

Stator winding:	2 x (rated voltage) + 1,000V	1 minute
Rotor winding:	10 x (exciting voltage)	1 minute

(v) Protective Relays

The following protective relays will be mounted on the generator control board:

- Generator differential relays
- Generator overvoltage relays
- Emergency stop switch
- Generator loss of excitation relays
- Generator earth overvoltage relays
- Main transformer differential relays

When the above protective relays operate with faults, the circuit breakers of generator circuits will automatically open and diesel engines be stopped, and at the same time occurrence of faults is informed to operators with indications on the control board and audible alarm.

(9) Electric Facilities

The 6.6 kV generator circuits will be stepped up to 22 kV with the main transformers and connected with the existing distribution network. Unit system is adopted for the main circuits from generators to main transformers in view of easiness in operation and maintenance, and in future expansion of circuits and interconnection with other systems. The single line diagram of the power station is shown on Fig. SRD-012.

(i) Main Transformers

Major particulars of the main transformers are as given in the following Table 2-9:

Table 2-9 Technical Particulars of Main Transformers

Type	:	3-phase, outdoor oil-immersed transformer with off-load tap changer
Rated capacity	:	4,500 kVA
Rated voltage	:	Primary 6.6 kV Secondary 22 kV
Vector group	:	Dyn 11
Cooling system	:	Oil-immersed self-cooling
Number of units	:	3 sets

(a) Limits of Temperature Rise

The temperature rise of main transformer shall not exceed the following limits under full-load condition:

Transformer windings:	65°C	(resistance method)
Transformer oil:	60°C	(temperature method)

(b) Tap Changer

The tap changer will be installed on the secondary side, and its changeover step will be 2.5%.

(c) Protective Apparatus

The following relays will be installed on the main control board:

- Buchholtz relays
- Temperature relays
- Overcurrent relays
- Main transformer differential relays

(ii) Station Service Transformers

The station service transformers will supply power to lighting in the power house, auxiliary equipment, etc. Particulars of the station service transformers are as given in the following Table 2-10:

Table 2-10 Technical Particulars of Station Service Transformers

Type	:	3-phase, outdoor oil-immersed transformer with off-load tap changer
Rated capacity	:	1,000 kVA
Rated voltage	:	Primary 6.6 kV Secondary 400 - 230 V
Vector group	:	Dyn 11
Cooling system	:	Oil-immersed self-cooling
Number of units	:	2 sets

The tap changer will be installed on the primary side, and its changeover step will be 2.5%.

The temperature rise alarming apparatus and overcurrent relays will be installed on the main control boards.

(iii) Switchgear and Control Boards

The switchgear and control boards will be of enclosed, self-standing and vertical panels, and will be provided in the powerhouse for the following circuits:

- 22 kV circuits
- 6.6 kV circuits
- Generator circuits
- Other circuits

The required number of panels for the above circuits is mentioned below.

(a) 22 kV circuits

- Main transformer secondary circuits	3 panels
- 22 kV feeder circuits	3 panels

(b) 6.6 kV circuits

- Generator circuits	3 panels
- Station service transformers	2 panels

(c) Other circuits

- Low tension circuit	1 panel
- DC source circuit	1 panel
- Synchroscope panel	1 panel
- Diesel generator operating panels	3 panels

(10) Environmental Considerations

The major environmental considerations for the power station are mentioned below.

Countermeasures Against Noise and Vibration

The best method to reduce influence of noise and vibration derived from the operation of diesel generators is to separate engines from surrounding houses as far as possible. The proposed power station site is selected with enough separation from the national road and regional road. Also, in the power station premises the location of main building is to be selected with separation from the boundary walls. In deciding power station layout greenbelt areas to plant trees are taken into account. For the new power station, the levels will be limited within the specified regulation limits.

Countermeasures Against SOx and NOx

Environmentally harmful SOx and NOx gases are generated due to burning of oil. The gas concentrations in atmosphere will be within the specified limits according to the calculation results.

Protection from Oil

Oil protecting dikes with sufficient capacity will be constructed surrounding the 3 oil tanks to minimize influence to the surrounding area to the minimum even when oil leakage due to failures of oil tank occurs.

Countermeasures Against Waste Oil

Regarding waste oil generated due to the use of C-heavy fuel, oil reservoir of large capacity will be constructed in the power house and accumulated oil will be pumped out when required. Such waste oil include considerable amount of sulfur. EdC is treat such waste oil in manners that will not affect the surrounding environment in the area. There are some power stations that are selling such oil as fuel for small scale burning.

2-2-2-2 22 kV Interconnecting Facilities

To interconnect the new power station with the existing Siem Reap distribution network, 22 kV underground power cables will be installed from the 22 kV feeder cubicles in the power house to the end point of the existing network.

The interconnecting underground cables will have the same particulars as the existing cables to be connected:

Underground power cables: 22 kV cross-linked polyethylene insulated, vinyl sheathed cables (CV cables) with aluminum conductors

3-core x 240 mm^2	2 circuits
3-core x 150 mm^2	1 circuit

The underground power cables will be buried directly in the ground along road or under the pavement. Road crossing underground cables will be protected with vinyl pipes or concrete ducts so as to withstand the assumed maximum traffic load. The overall system connection and burying method are shown on Fig. SRD-013.

2-2-2-3 Civil and Building Structures

(1) Soil Conditions at the Proposed Power Station Site

The study team carried out standard penetration tests at the power station site in 2 bored holes up to the depth of 20m to estimate the rough soil bearing capacity of the subsoil during the basic design study. The results are presented in Appendix 6-1. Up to around 10m from the ground

surface, soil is silty sand with the N-value in the range of 5 to 10. This soil is not suitable to support large foundation loads. The sandy soil below 10m become coarser in particle and stronger in bearing strength with depth. Considerable bearing capacity can be obtained as friction piles by driving piles to around 20m. The ground water level at the time of site investigation was 4.5m below the ground level, but it is supposed that the water level goes up to 1m below the ground level in rainy season.

Referring to the results of the above-mentioned site tests, piles are considered for major foundations such as diesel generators, power station building and fuel storage tanks. Piles will be cast at site using proper forms. Details of piles are shown on Fig. SRD-014.

(2) Power Station Land

The power station land necessary for arranging diesel generating facilities of 3 x 3,500 kW capacity is 127m x 155m (19,685m^2). The entire land will be filled with soil of about 1m thickness to avoid flooding during rainy season, and the green belt of 20m in width will be arranged around the power station.

The layout of generating facilities, buildings, roads, drain ditches, treatment facilities for waste oil and sludge, fuel storage tanks, etc. is shown on Fig. SRD-015.

(3) Foundations of Diesel Generators

The foundations for diesel generators must withstand the machine weight and unbalanced inertia and vibrating forces caused by the operation of diesel engines, and vibration derived from engine operation shall not badly affect other equipment and buildings.

There is no established method to theoretically estimate the sizes of foundations, and the following empirical formula was applied:

$$Wf = 0.2W\sqrt{N}$$

Wf : Weight of foundation (tons)
W : Weight of diesel generator; assumed at 60 tons
N : Revolution speed of engine; 750 rpm

From the above formula, the weight of foundation is obtained as 328 tons. Then the volume of foundation concrete is calculated as about 149 m^3 by assuming specific weight of 2.2.

(4) Buildings of Power Station

The power station is used for normal continuous operation of 3 diesel engine generators and therefore a powerhouse building of exclusive use is planned. The area of building is to be determined with due consideration to space to install diesel generating equipment, auxiliary equipment (starting air system, fuel transfer pumps, C-heavy oil pre-treatment facilities, etc.), supplemental facilities (fuel service tanks, air tanks, etc.), electric facilities, etc., and space

necessary for normal operation and inspection (including overhaul) and maintenance.

The building will be constructed with reinforced concrete columns and block walls, and the ceiling will be supported with steel frame. For the ceiling, micro-fiber glass-wool heat insulating materials will be installed and corrugated steel will be plated.

An overhead travelling hoist of 3 ton capacity will be provided for engine maintenance purpose, and the steel structure shall have strength to support the load of hoist. The building shall be of fire-resistant construction as fuel oil and lubricant are treated normally in the building.

Sufficient ventilation must be provided to avoid temperature rise and from hygienic consideration for operators. In this plan, both of the natural ventilation through windows and galleries and the forced ventilation with blowers will be applied.

The plan and section of the power station building are shown in Figs. SRD-016 and SRD-017.

The office building with a store room will be of concrete columns and brick walls. For the ceiling, micro-fiber glass-wool heat insulating materials will be installed and corrugated steel will be plated. Plan and section of the office building are presented on Fig. SRD-018.

2-2-3 Basic Design Drawings

Basic design drawings of the project are shown below:

No.	Figure Number	Figure Title
1	SRD-001	Equipment Layout in Existing Power Plant
2	SRD-002	Location of Power Plants 20kV Line Route
3	SRD-003	20kV Distribution System
4	SRD-004	Layout of New Generating Facilities in Existing Power Station
5	SRD-005	Area Map of New Site
6	SRD-006	Layout of Generating Equipment in Power Station
7	SRD-007	Arrangement of Fuel Storage Tank
8	SRD-008	Starting Air System Diagram
9	SRD-009	Fuel Oil System Diagram
10	SRD-010	Lubricating Oil System Diagram
11	SRD-011	Cooling Water System Diagram
12	SRD-012	Single-Line Connection Diagram
13	SRD-013	22 kV Underground Cable Laying Plan
14	SRD-014	Construction of Concrete Piles
15	SRD-015	Layout of Generating Facilities in Power Station Land
16	SRD-016	Power Station Building Plan
17	SRD-017	Power Station Building Section
18	SRD-018	Office Plan

2-2-4 Implementation Plan

2-2-4-1 Implementation Policy

Work items of the implementation stage of the project are as follows:

a) Civil construction works comprising land filling and leveling, roads in the premises, drain ditches, various foundations, etc.
b) Building construction works for power station building, an office and store, etc.
c) Supply, erection, test and taking over of diesel generating facilities including auxiliary facilities
d) Construction of 22 kV underground cable lines to interconnect with the existing distribution network

As mentioned in Clause 2-2-4-2, (3), all items of works need to be executed in good coordination.

Fundamental subjects and items that need special attentions are mentioned below.

(1) Cambodian Executing Agency

(a) Arrangement of budget and staff necessary for executing responsibilities of the Cambodian side

Some portions of works of this project are to be executed by the Cambodian side. Such assigned works need to be executed timely with good coordination with other related works. The necessary budget and staff must be secured for this purpose.

(b) Transfer of technology

In this project, utmost effort must be made to the transfer of technology by participation of proposed operation and maintenance staff to the site erection and tests. Through a series of site works, basic principles of generating equipment, and technology of assembling and disassembling of diesel generators and other works will be transferred to Cambodian technicians. EdC Phnom Penh and Siem Reap must fully understand that such participation of engineers and technicians is required not only for execution of the Cambodian side duties related to the project but also for technology transfer aimed at future execution of machine maintenance by Cambodian workers.

(2) Implementation Contractors

Under the project, various kinds of works such as civil and building works, supply and erection of diesel generators, supply and erection on interconnecting underground cables, etc. will be executed, and various works are executed at the same time in the premises of power station. Each construction is closely related with others in work relation and schedule. Therefore, a Japanese contractor will assume overall responsibilities to whole works in security of quality, guarantee of characteristics, defects liability, schedule management, etc.

In accordance with specifications prepared by the consultant, the contractor will carry out civil and building works, and design, manufacture, factory inspection, packing for export, transport to site, erection, site tests and taking-over of generating equipment and materials. Through the site construction, equipment erection works and tests, the contractor will perform transfer of technology to Cambodian staff.

2-2-4-2 Implementation Conditions

(1) Safe Site Works

Various kinds of site work such as erection of heavy equipment, works at high location and other works will be executed in parallel in the same power station premises. Therefore, utmost cares must be taken to security of safe working.

Before commencing site works, detailed work plans shall be prepared through detailed discussions among working groups, and safe and efficient working environment shall be established by providing danger warnings, safety fences, etc.

(2) Land Mines and Unexploded

CMAC carried out mine searching operation in the power station premises. There were not land mines detected in the shallow depth, and general safety of the site has been confirmed. However, possibility of unexploded shells (lies deep if existing) could not be confirmed. Therefore, enough cares need to be taken in deep excavation for foundations, etc. In driving piles, existence of unexploded needs to be examined by hand auger or any other methods.

(3) Coordination of Various Works

In the power station site, various kinds of site work such as civil and building works, erection of diesel generating facilities and electrical facilities, installation of underground lines, etc. must be executed under good coordination. The civil and building works must be completed before the commencement of diesel generator erection, and the interconnecting transmission lines must be constructed before the site tests of diesel generators.

For timely completion of the project as a whole, various kinds of work must be executed in parallel in the premises of power station. Each work is closely related with others in work relation and schedule.

Therefore, the consultant and contractor must take utmost care for coordination of each component work, responsibility to each work, safety of workers and facilities, quality control, etc. The implementation plan must be prepared to ensure efficient and smooth execution of site works as a whole under good coordination among each other.

2-2-4-3 Scope of Works

In this project, all the works related to power station facilities will be carried out by Japanese contractors as follows:

Japanese Side	Cambodian Side
Civil & building works Diesel generating facilities works 22 kV interconnector works	Acquisition of necessary land Construction of access road Disposal when unexploded shells are found Assignment of counterparts Participation in diesel generator erection works

2-2-4-4 Construction Supervision

Before taking up the project under Grant Aid program from Japan, the Japanese Government will at first confirm appropriateness of the project referring to the basic conditions for grant aid. After that, an Exchange Note (EN) is concluded between the two concerned governments, the project implementation will be commenced. In executing the detailed design and project supervision, due attentions must be paid to the followings:

(a) Background of the project implementation is to be understood.
(b) Contents of the Basic Design Study are to be confirmed.
(c) The framework of grant aid assistance from Japan is to be understood.
(d) The contents of Exchange Notes agreed between the two governments are to be confirmed.
(e) Site working conditions are to be fully taken into account.

Taking into account the above understandings, the contents of consulting services, member of consultants and a necessary organization for execution are mentioned below.

(1) Basic Policies of Construction Supervision

The consultant shall manage and supervise the whole phases of work execution of the contractors so that the project works may be surely executed on schedule, with the 3 basic principles as given below:

(a) Schedule Management

(i) For each facility, progress of manufacture, transport and erection of equipment and materials must be reviewed all the time. The progress of the Cambodian side works shall also be confirmed.
(ii) Process of works by both of the Japanese contractors and Cambodian authorities shall be confirmed and coordinated.
(iii) Schedule meetings shall be held at appropriate times for overall schedule management and its adjustment. The schedule meetings will be held weekly during site erection period and daily during the site test period.

(b) Safety Management

(i) Safety arrangement of site works shall be confirmed before starting works.

(ii) In case that many works are executed at the same place, necessary safety measures shall be taken to avoid accidents by confirming working methods and schedules of concerned parties.

(iii) Transporting in and out of equipment and site works near the electrically live parts shall be executed under supervision of a safety manager.

(iv) The areas shall be sectionalized with safety ropes around openings and electrically live parts, to avoid personnel faults.

(c) Quality Control

(i) The implementation contractor is to submit drawings, specifications, calculation data, etc. for approval to the consultant, who will review the submitted documents to confirm conformity to applied standards, contract specifications, etc.

(ii) The consultant will attend the factory tests before shipment of major equipment to confirm whether facilities have been manufactured according to the applied standards and contract specifications.

(iii) The completed works will be tested at site before taking over.

(2) Consulting Services

(a) Detailed Design and Preparation of Tender Documents

(i) Detailed Design

Based on the results of the Basic Design Study, the implementation costs are to be explained to and confirmed by the Cambodian authorities. At the same time responsibilities of the Cambodian side are to be confirmed for timely work execution. Prior to the preparation of tender documents, the detailed design shall be performed, the implementation cost be estimated and construction plan be prepared.

(ii) Preparation of Tender Documents

The tender documents shall be prepared based on the results of detailed design and the construction plan conforming to the requirements of the grand aid rules of Japan.

(b) Construction Supervision

(i) Tendering Process

The process includes the tender calling, questions and answers, attendance to tender closing and opening, evaluation of tender results, assistance to tender negotiation and conclusion of implementation contracts.

(ii) Site Supervision Process

This process comprises meetings among concerned parties before commencing site works, approval process of design drawings, factory inspection before shipment, supervision of site erection works, preparation of progress report during site construction, issue of interim certificates, and attendance to site tests before taking over.

(iii) Process After Completion of Construction and Erection

This process comprises issue of completion certificate, processing for taking over, preparation of completion report and defect liability test to be carried out one year after taking over.

(3) Members of Consultant

To smoothly execute necessary services itemized in Item (2) above, it is required that a senior engineer with ample experience to similar kinds of services and enough understandings to the contents of the project will be nominated as the Project Manager and an effective organization for execution consisting of staffs for detailed design, tendering procedures, review and approval of design, factory inspection, and site supervision need to be established.

(a) Project Manager

Based on full understanding of the background and purposes of the project, the Project Manager will manage overall execution of the project. He will review and understand progress of the project and current problems, and control progress of the works, and instruct and provide advice to constituting members.

(b) Engineers for Detailed Design

Based on the established basic criteria, the engineers will determine specifications of equipment and materials for the project, layout design, detailed design, and construction plan taking into account supply interruption planning, and estimation of project cost.

(c) Engineers for Tendering Process

The consultant shall at first prepare the tender documents and carry out tender calling, questions and answers, tender acceptance, evaluation of submitted tenders, and assistance to negotiation and conclusion of contract.

(d) Engineers for Design Review and Factory Inspection

In the home office, the consultant shall review drawings, specifications, instruction manuals, etc. to be submitted for approval by the implementation contractor, decide approval or not and inform contractors, and carry out factory inspection prior to shipment.

(e) Engineers for Site Supervision

The resident supervising engineer will supervise the entire site works from commencement of construction up to completion of the project. In addition, specialist engineers in charge of civil and building works, electrical facilities, mechanical facilities will be dispatched to the site to perform necessary supervising works.

2-2-4-5 Procurement Plan

(1) Purchasing Sources

The purchasing source of each facility is to be determined with due considerations to the following:

(a) Items used in Cambodia and easiness in operation and maintenance.

(b) Items available and repairable in Cambodia, on the conditions of no problems in quality and favorable in price.

(c) Coordination with facilities used in other plans.

A plan for purchasing sources of equipment and facilities under this project is presented in Table 2-11 below:

Table 2-11 Purchasing Sources of Major Equipment and Materials

Equipment & Materials	Particulars	Purchasing Source
Civil and building works:		
Equipment & materials for civil works		Third countries/local
Equipment & materials for buildings		Third countries/local
Storage oil tanks	2 x 300 kl, 1 x 150 kl	Third countries/local
Concrete piles	400 x 400mm, 12m length	Third countries/local
Diesel generating facilities:		
Diesel engine generators	6.6 kV, 3,500 kW	Japan
Engine auxiliary equipment		Japan
Main transformers	3-phase, 6.6/22 kV, 4,500 kVA	Japan
Cubicles & control boards		Japan
Other electrical facilities		Japan
22 kV interconnect :		
Underground cables	22 kV, 3-core x 240 mm^2	Japan
Underground cables	22 kV, 3-core x 150 mm^2	Japan
Cable treatment materials		Japan

(2) Scope of Spare Parts

To continuously operate diesel generators for long time with the original operating characteristics, considerable quantities of spare parts are indispensable. In this plan, spare parts necessary for 2-year operation will be supplied.

(3) Particulars of Defect Liabilities

Defect liabilities for the period of one year after the taking-over will be requested to all the facilities under the project. In case any defects are found on facilities not included in the project due to reasons attributable to the project works, such defects will be included in the defect liabilities of the project.

2-2-4-6 Quality Control Plan

(1) Quality Control of Equipment and Materials to be Supplied

Quality of equipment and materials to be supplied under the project will be controlled in the following steps.

(a) Review of Design Drawings and Specifications and Their Approval

The consultant will review drawings, specifications, calculations, etc. for approval to be submitted by the implementation contractor after conclusion of the contract to review their conformity to applied standards, contract specifications, etc. and will approve them if there are no problems or give necessary comments. The consultant will perform these services in Japan. Equipment and materials will be manufactured after such approval is obtained.

(b) Factory Inspection

After equipment is manufactured it is subject to factory inspection before delivery to the site. The purpose of this inspection is to confirm the equipment is manufactured in accordance with applied standards and contract specifications. Generally, visual inspection and characteristics tests are carried out. The tests of major equipment are attended by the consultant engineers. EdC engineers also attend to tests of important equipment.

(c) Site Supervision and Tests on Completion

The consultant will carry out construction supervision with cooperation of EdC engineers so that the site construction and erection works are performed in accordance with the specifications. The completion tests are performed before taking over to confirm whether the works are completed in accordance the specifications or not.

(2) Quality Control of Civil and Building Works

(a) Review of Construction Drawings and Their Approval

The structural design will be prepared by the consultant. But the construction drawings are to be prepared and be subject to review and approval by the consultant. These review and approval services of the consultant will be performed in Tokyo and at site.

(b) Inspection of Materials to be Used

The consultant will inspect all the materials to be used for the works before their use.

These tests will be performed at the supply origins or at site as required.

(C) Construction Supervision at Site

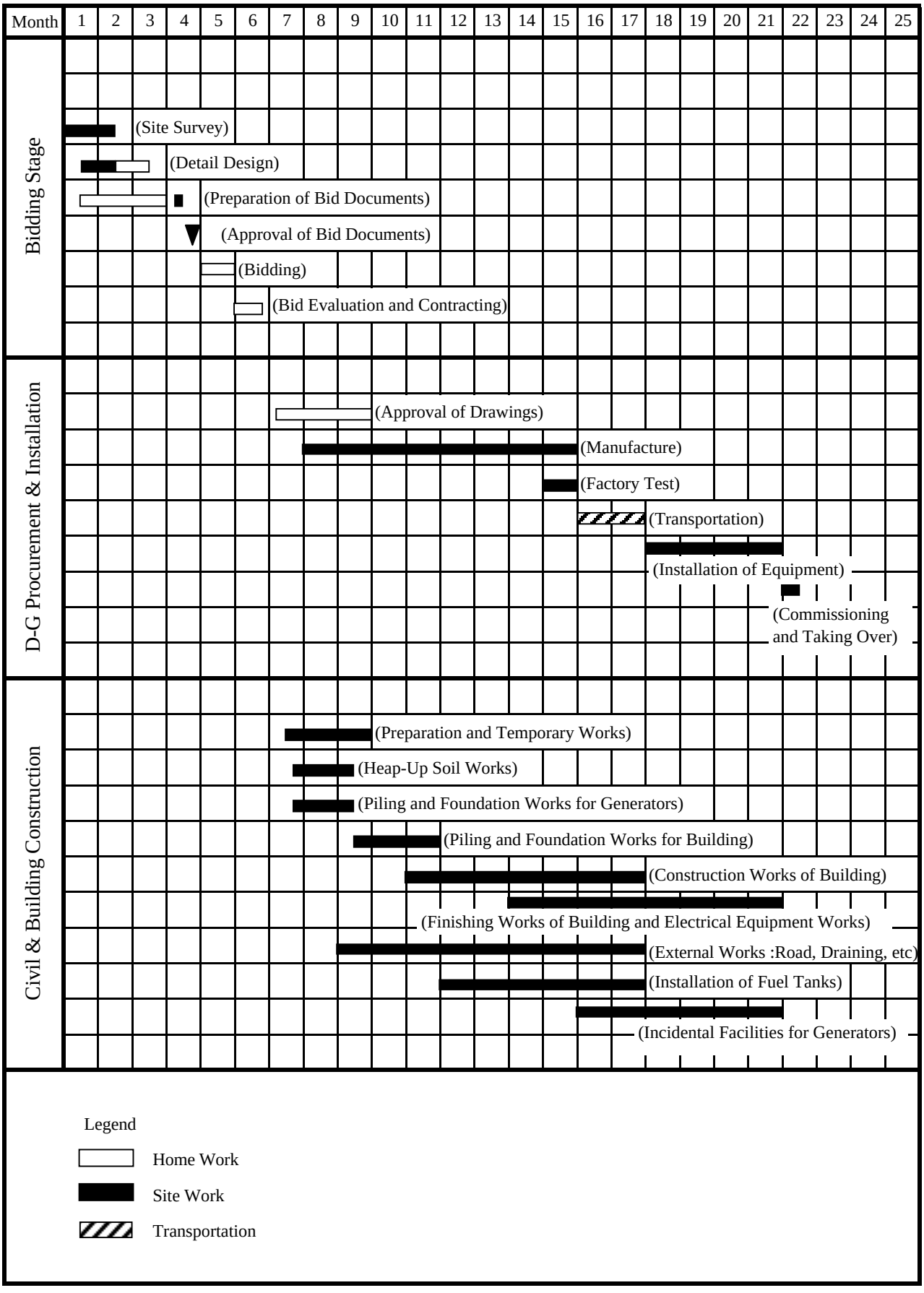
The consultant will carry out construction supervision with cooperation of EdC engineers on the soil filling, concreting (concrete quality and arrangement of steel bars), steel frames of power station building, building works, foundation works, etc. including attendance to some work items.

2-2-4-7 Implementation Schedule

The work execution of this project will require 22 months from the conclusion of the Exchange of Notes up to completion of the project. The Exchange of Note will cover both of detailed design and project implementation.

The estimated implementation schedule is shown in Table 2-12.

Table 2-12 Implementation Schedule



2-3 Obligation of Recipient Country

Items to be executed by the Cambodian authorities in case that a grant aid project from Japan is executed are as follows:

(a) Banking arrangement
(b) Authorization to pay
(c) Obtaining license for import to Cambodia of generating facilities and payment of necessary fees for it
(d) Tax exemption to services of Japanese people engaged in the project works, hand tools to be used for work execution, etc.
(e) Right to enter the project area
(f) Obtaining permissions of related authorities in relation to project works
(g) Acquisition of land necessary for the power station
(h) Construction of the access road
(i) Settlement of troubles with inhabitants in the surrounding area
(j) Other items that can not be provided under the grant aid

In relation to the implementation of the project, the following services and works are to be executed by the Cambodian side.

(a) Acquisition of Power Station Land

As the power station land, EdC is to acquire a land of 155m x 127m (19,685 m^2) at the location selected by EdC.

(b) Construction of Access Road

From the existing regional road to the power station land, an access road suitable for transport of heavy cargoes of about 220m in length and 7m in width is to be constructed by EdC.

(c) Participation to Diesel Generator Erection

The erection works of diesel engine generators are to be executed with participation of the Cambodian executing agency, EdC, to the works by Japanese contractors. In carrying out this responsibility, all members of the proposed operation and maintenance group of the new power station need to participate in the erection works as working staff. These staff members are not only to engaged in the erection works but also to acquire technology of assembling and disassembling diesel engine generators through cooperation with Japanese technicians of the contractors.

The estimated total expenditure of the Cambodian side in case that the planned power station is implemented as scheduled with grant aid from Japan is as given below:

1) Power station land acquisition cost	127m x 155m		
	19,658 m^2 x 8US$/$m^2$	US$157,200	
2) Access road construction cost		US$40,810	
Land acquisition	220m x 7m		
	1540m^2 x 8US$		US$ 12,320
Road bed construction	1540m^2 x 8.5US$		US$ 13,090
Asphalt pavement works	1540m^2 x 10US$		US$ 15,400
3) Total		US$ 198,010	

In addition to the above-mentioned expenditures, the expenditures for Bank Agreement (B/A) and Authorization to Pay (A/P), for obtaining import permit from the government and others will be required. For smooth execution of such duties, EdC needs to secure necessary budget beforehand.

2-4 Project Operation Plan

(1) New Power Station Operation Plan

To carry out the actual operation and maintenance of new equipment without difficulties by the staff, the following measures will be needed.

a) Establishment of proper organization for operation and maintenance

To carry out operation and maintenance of modern large equipment, EdC needs to establish a capable organization for operation and maintenance. Not only recruitment of necessary staff, operation manuals and various forms for systematic reporting of operation, inspection, maintenance, faults, etc. need to be arranged.

b) Employment of staffs with education at high school or higher

For operation and maintenance of large machines to be supplied, considerable technical knowledge is required. It is required to employ staffs with high education of technical high school and higher as future core staff of the operation and maintenance team.

c) General education of technology

In Phnom Penh, there is a training center of EdC constructed with ADB assistance. Although the full-fledged operation of facilities has not yet been commenced, up-to-date training is possible on electric technology general, distribution technology, small diesel engine, etc. For assigning new high school graduates as operation and maintenance staffs, it will be useful to train such staffs on fundamental technologies in this center.

d) Training with actual equipment in Phnom Penh

In Phnom Penh, large diesel generators are under operation at the Phnom Penh Nos. 5 and 6 power stations. The machines of the No. 5 power station were supplied under a grant aid from Japan, and diesel engines of the No. 6 power station are of C-heavy oil fired. It is effective to dispatch staff of Electricity Siem Reap Unit at the time of overhaul, major maintenance works, etc. to learn handling methods of large machines.

e) Training during erection period

In Siem Reap there are no large diesel generators as those to be supplied under the project, and the present operation and maintenance staff has no experience and no knowledge of such large equipment. It is effective to participate in the erection works and become familiar with such equipment through guidance of instructors of the contractor and consultant personnel. The practice to employ local capable workers as operation and maintenance staff is also widely adopted.

f) Support of EdC head quarter

When a local power station without capable staff starts operation, in many cases experienced staff of EdC Phnom Penh are dispatched to assist the operation and maintenance on a short time basis. This method was adopted for the Sihanoukville power station completed in 1999. The similar practice will be required also for this project. The shifting of the present operation and maintenance staff of the Phnom Penh No. 5 and No. 6 power stations to Siem Reap will be required for trouble-less operation.

g) Employment of Cambodian experts in overseas

There are some Cambodian engineers who left the country during the civil war and acquired technology in overseas, and in now considering to contribute to the reconstruction of the country. EdC wishes to employ such persons on the conditions of availability.

h) Employment of foreign expert

In other developing countries, there are many cases that power utilities employ experienced foreign technicians in short time basis (say 2 to 3 years) from the construction staffs or other sources as key personnel for equipment maintenance and for education of local staffs.

i) Guidance contract with equipment supply manufacturer

For the Phnom Penh No. 5 power station, EdC made a guidance contract with the equipment manufacturer relating to guidance to the overhaul works in the initial stage. Similar contract will be required also for the project.

For this project, EdC will be obliged to organize the operation and maintenance team with members having neither sufficient experience nor technical knowledge. During the detailed design stage, it is required to review carefully a combination of the above measures and determine an appropriate action plan. Further review based on actual outcomes, and possible extension of periods and other measures may be required.

(2) Operation and Maintenance Cost

The records of operation and maintenance costs of the existing Siem Reap power station of the past 4 years from 1997 to 2000 are shown in Table 2-13 below:

Table 2-13 Operation and Maintenance Cost of Existing Siem Reap Power Station

(Unit: x 1,000 Riel)

	1997	1998	1999	2000	Average
Fuel Cost	2,735	9,808	57,952	431,758	125,563
Machine Maintenance Cost	23	379	1,213	8,234	4,462
Personnel Expense	604	2,587	5,071	16,854	6,279
Management Cost	54	143	101	713	253
Others	17	75	3,326	11,221	3,660
Total	3,433	12,992	67,663	468,780	

At present necessary power for Siem Reap is being supplied mostly by leased generators. Therefore, EdC's generators are operated for 1 or 2 hours during peak time only to supplement deficiency of supply capacity of the lease generators. For this purpose Electricity Siem Reap Unit secures 16 staffs for operation and maintenance.

(i) Assignment Plan of Operation and Maintenance Staff

The present numbers of staffs for operation and maintenance of the existing power stations, Siem Reap, and Phnom Penh Nos. 5 and 6, and the proposed numbers for the new power station under the project are shown in Table 2-14 below:

Table 2-14 Numbers of Operation and Maintenance Staff

	Phnom Penh No. 5 & 6 PS	Siem Reap Existing PS	Siem Reap New PS
Unit Capacity and Number of Units	5,000 kW x 2 sets 6,300 kW x 3 sets	800 kW x 2 sets 280 kW x 2 sets	3,500 kW x 3 sets
Operation Staff			*1
Engineers	3	-	3
Operators	26	7	12
Maintenance Staff			*2
Engineers	1	1	1
Skilled Workers	11	4	8
Laborers	14	4	11
Total of O&M Staff	55	16	34

*1: Operation staff assignment plan

The new power station is assumed to be operated daily with 3-shift by 3-team system, by one engineer and 3 operators on duty. The number of operators is assumed as 4 teams of 3-shift, 12 men in total.

*2 Maintenance Staff Assignment Plan

5 large diesel generators of the Phnom Penh Nos. 5 and 6 power stations are maintained by 26 persons, assigned to 2 power stations in common, without problems. The total number of maintenance staffs of the Siem Reap new power station is assumed to be 20 for 3 diesel generators.

(ii) Operation and Maintenance Cost

Fuel Cost

According to the result of power demand forecast, the average generated energy for 5 years after starting operation is 22,000 MWh, and annual fuel cost is calculated as US$ 1,086,800 (fuel rate 190g/kWh x generated energy 22,000 MWh x fuel price 260 US$/ton).

Equipment Maintenance Cost

In 1996, the Phnom Penh No. 5 power station (2 x 5,000 kW) was completed with grant aid from Japan. The past examples of actual expenditures for purchasing maintenance parts after expiry of 2 years (spare parts for 2 year operation was supplied with diesel generators) are given below:

(Unit: US$)

	1999	2000	2001	Total	Average
Parts Purchasing Costs	228,952	616,500	53,095	898,547	299,516

For the equipment maintenance cost of the new Siem Reap power station, 120% of the above cost is assumed. The total installed capacity is a little larger and is provided with 3 sets of diesel generators, compared with those of the Phnom Penh No. 5 power station.

Personnel Expenditure

The assumed number of operation and maintenance staff of the new power station is 34. If the average salary is assumed same as the average of whole EdC staffs (65 US$/month), the total annual personnel cost is obtained as US$ 26,520.

Management Cost and Other Expenditures

In case of the existing Siem Reap power station, the management cost and other expenditures correspond to 0.2% and 2.9% respectively of the fuel cost. The same rates are assumed also for the new power station.

From the above assumptions, the annual operation and maintenance cost of the new power station is calculated as shown in the following Table 2-15:

Table 2-15 Operation Cost of New Power Station

	US$	Riel
Fuel cost	1,086,800	4,254,822,000
Equipment maintenance cost	360,000	1,409,400,000
Personnel cost	26,520	103,825,800
Management cost	2,173	8,507,295
Other expenditure	31,517	123,389,055
Total	1,507010	5,899,944,150

Exchange rate: 1US$ = 3,915 Riel

From the above, the followings are noted:

1) As for the fuel cost per kWh generation, the oil unit cost will be lowered to 60% and the fuel consumption rate will be much improved, and the fuel cost is expected to become about a half.

2) The equipment maintenance cost in 2000 was mostly expended as generator lease cost at the rate of about 200 Riel/kWh, and this will be lowered to 64 Riel/kWh.

To determine the actual power rate, the distribution cost (as the existing system has a considerable allowance in transfer capacity, therefore per kWh distribution cost will go down in case the distribution energy increases) and general expenses must be added, however considerable decrease in power tariff is expected. Against the present Siem Reap power tariff of 23 cent/kWh, the Phnom Penh tariff of 15 cent/kWh will be the target level.

2-5 Other Relevant Issues

This project comprises the soft component plan as mentioned below in the consultant services.

(1) Necessity of Soft Component

Appropriate operation and maintenance are essential to realize the expected effects of the project for power generating facilities. The operation and maintenance system of the existing Siem Reap power station is not operated properly. Its constituent members are not well educated and have not sufficient capability in general technology and repairing technique. Although they have experience in repairing Russian engine generators, they have no knowledge of power generating facilities to be supplied under the project. Equipment are large Japanese machines and are completely different from the existing Russian machines in their mechanical principles and construction, characteristics, power generation control system, design concept, etc. Therefore, it is important that the proposed operation and maintenance staff learn new technologies based on the Japanese practices.

As a method of technology transfer and educational training, it is considered adequate to adopt one of the following methods of training or their combination as seen in usual projects. Thus, the conceivable training methods are mentioned below.

(2) Necessity of Upgrading Repairing Technology

To upgrade repairing technology, the maintenance staff must cease the past practice to merely replace faulty parts with available spares, and a proper system shall be established so as not to repeat the same failures. For this purpose, the maintenance staff must at first execute trouble-shooting properly. The maintenance staff must carefully review daily operation data of the machines and their variations, records of generators to utilize them for the long term operation planning. Planned execution of effective operation and maintenance to fully utilize mechanical

features will result in stable operation (reliability) in power generation. However, it is very difficult to clarify the causes of generator troubles unless the methods of trouble shooting, mechanical features of such machines and their control system are fully understood by the operation and maintenance staff.

Therefore, the educational training of operators, maintenance staff and their managers is the most important item in performing this plan.

(3) **Subjects to be Solved by the Soft Component**

Shown below are the subjects to be solved in the educational training of this project.

Training of managers for power technology and education of operation and maintenance staff

The existing Siem Reap power station is operated and maintained by the members who have not enough technical capability and proper education on technology. For proper operation and maintenance of power station, well-educated personnel are required for plant operation, repairing works, parts stock control, etc. Thus, a proper system completely different from the existing organization needs to be established.

Thus, in carrying out the technology education, the Basic Maintenance Training (I, II, III) will be aimed to train personnel who easily understand soft component training and can prepare technical reports for control, repair, inspection, troubles, etc. After the completion of training, its outcome will be reviewed together with the EdC headquarter using the monitoring method (Basic Maintenance Training-IV), and countermeasures will be proposed if the consultant and EdC judge the results of training are not sufficient.

These are essential parts of the soft component education.

Understanding of enhanced technologies of power generation and purposes of training

Some extent of technical education is essential to understand the technologies of operation and repair of diesel generators. The operation and maintenance staff must understand technologies and concepts of safety control of rotating machines, and they must have capability to foresee occurrence of unexpected faults in rotary machines, high-voltage power sources, etc. Up-to-date machines can be operated conveniently, but their electrical control system is complicated. Their handling, repairing and monitoring is difficult for operators with only basic knowledge based on general education. This fact greatly influences the reliability of generator operation.

The soft component of this project aims to support EdC to establish its own generation business management and long term maintenance system with their judgment.

(4) Contents and Activities of Soft Component Training

The soft component training will be carried out in the following 4 steps, i) to iv):

i) Basic-I Maintenance Training

In the Basic-I Maintenance Training, the consultant will at first test trainees to know their knowledge level to refer to in the succeeding training and then perform the basic training of internal combustion engines. Items and contents of the training are as presented in Table 2-16 below:

Table 2-16 Contents of Basic-I Maintenance Training

	Training Items	Contents and Activities of Training
1	Engine generator basic knowledge test	Test to confirm basic technical knowledge of trainees
2	Basic engineering of internal combustion engines	Education on technical standards, units, Systems, etc.
3	Technical particulars of generators and engines	Understanding on particulars of generators and Engines
4	Particulars of electric control of generators and engines	Understanding on particulars of control of Generator and engine
5	Particulars of piping and equipment in each system	Confirmation of particulars of respective Systems

As the results of the above-mentioned training, the following effects are expected:

- Understanding on general concept of internal combustion engines and generators.
- Understanding on applied units, equations, consumption rates and quantity of fuel and lubricant, etc.
- Control and planning for effective, economical operation of power generating units, numbers of units operated and operating output of power generators.

ii) Basic-II Maintenance Training

All operators and maintenance staff will be trained through the On-the-Job-Training by participating in the erection works of diesel generating equipment. The training items and the expected effects of training are mentioned in the following Table 2-17:

Table 2-17 Contents of Basic-II Maintenance Training

	Training Items	Expected Effects of Education
1	Methods of shaft alignment for coupling engine and generator	Double alignment both in the driving side and in the rotation side of all rotary machines Training on foreseeing any troubles due to vibration and noise caused by improper-alignment
2	Methods of installation of diesel engine and its auxiliaries	Piping from engine to auxiliaries, erection of exhaust pipes taking into account temperature variation, points of notice in installation and arrangement of mist piping & drain piping and in installation of engines
3	Understanding of flow chart for flows between diesel engine unit and auxiliaries	Checking of electric system, operation system, protection and safety devices and control system, and reviewing methods of repairing, protection from secondary faults and long-term maintenance.
4	Points of notice in measurement and inspection of respective parts of engine	Appropriate measurement of equipment, standards, adjusting methods and handling of measuring apparatus
5	Handling of auxiliaries	Points of notice are handling methods, inspection, maintenance and adjustment of auxiliaries.

iii) Basic-III Maintenance Training

The Basic-III Maintenance Training will be carried out by the consultant and supplier's engineers for the purpose of upgrading technologies on operation, maintenance and repair of equipment as given in Table 2-18 below before and after the completion tests of diesel generating equipment.

Table 2-18 Contents of Basic- III Maintenance Training

	Training Items	Contents and Activities of Training
1	Inspection before and after starting operation	Points of confirmation and inspection before and after starting operation
2	Regular inspection and maintenance	Items to be noted in regular inspection and maintenance
3	Operation of diesel generators and auxiliaries	Points of auxiliaries maintenance for whole power generating plant
4	Trouble-shooting	Confirmation of quick reference tables for repair, accidents and preventive measures
5	Handling of measuring apparatus and special tools	Points of use of measuring tools for electrical and mechanical adjustment, etc.
6	Preparation of reports	Preparation of reports on operation and maintenance
7	Attendance to taking-over tests of generating equipment	Attendance to tests based on taking-over test manual, and confirmation of safety and protection tests

The effects expected from the above-mentioned training will be:

- Understanding on the inspection, confirmation and warming-up before starting equipment, synchronous operation and confirmation of operating status during operation.

- Points of maintenance and inspection of control panels, display panels, protection devices, etc. and detailed handling of various kinds of equipment and machines.
- Handling manuals of measuring apparatus, adjusting devices, special tools, calibration devices, etc. to be used for maintenance.
- Points of notice in economical load operation, regular inspection and maintenance manuals.
- Easy confirmation of basic causes of faults, foreseeing secondary troubles, and system buildup for maintenance and control.
- Preparation of reports for operational records, troubles and repair, inspection works, etc.
- Stock control of spare parts and tools.
- Storage of dangerous things and safety control around rotating machines.
- Environmental control related to noise, vibration and pollution.

iv) Basic-IV Maintenance Training

The Basic-IV Maintenance Training aims at confirmation of the education results of Basic-I, II and III training, in which the consultant will in cooperation of EdC confirm the conditions of understanding of trainees on operation and maintenance of generation equipment by the monitoring method. The consultant will give appropriate suggestions in case any problems happen.

Table 2-19 Contents of Basic- IV Maintenance Training

	Training Items	Contents and Activities of Training
1	Confirmation on preparation of operation reports and advice	Re-confirmation of reports preparation
2	Confirmation on countermeasures against initial trouble, status confirmation and advice	Re-confirmation of previous courses of training and evaluation of training results
3	Operation work, inspection and problems	Re-confirmation of equipment operation and others
4	Final examination of power generators and internal combustion engines	Confirmation of effects of education in the soft component

(5) Problems of Soft Component:

Instruction manuals of equipment are very important and indispensable to inspection and repair of diesel generation facilities. However, the existing Siem Reap power station there are no operators and maintenance staff who understand manuals written in English. When English knowledge is required, the problem is solved with assistance of EdC headquarter in Phnom Penh. Without improvement in knowledge of the English language, it is not possible to understand contents of training and instruction manuals, etc. usually written in the English language.

Under such a situation, it is required to select personnel who understand English technical terms and if required translate them into local language.

Chapter 3

Project Evaluation and Recommendations

Chapter 3 Project Evaluation and Recommendations

3-1 Project Effects

The effects of construction of a diesel power station of about 10,000 kW are reviewed in two phases of "direct effects" and "indirect effects" as given below.

Direct Effects

- By the commissioning of a power station of about 10,000 kW, the problem of supply shortage will be solved for some time toward the future and living standards of inhabitant will be improved.

  This power station will meet the general demand of up to around 2009 and the demand including some of hotel loads up to around 2006. The Siem Reap power system is planned to be interconnected with the EGAT system of Thailand in 2008. This interconnecting line will feed a demand more required than the capacity of the new power station after 2009

- By execution of the distribution system reinforcement project under the ADB finance from 2002, the reliability of the system has been much improved and the electrified area of Siem Reap will become wider. By the commissioning of a new power station, more inhabitants will be able to receive the stable and reliable power. The population including the surrounding area of 230,000 will be the object to be benefited.

- The unit generation cost can be reduced by the operation of large diesel generators of C-heavy oil fired, which will result in lowering of the power tariffs. Even if, the present tariff of 23 cent per kWh will be lowered to the similar level of the present Phnom Penh system, being around 15 cent, the financial situation of Electricity Siem Reap Unit will be supported in a sound finance.

Indirect Effects

- Stable power supply will contribute to improve the public utilities and result in advancing the medical facilities and the education.

- The abundant supply of electric power to the Siem Reap area will contribute to promotion of the tourism industry and its associated economic activities. Thus, the project will support the foreign currency earning of the country.

- By lowering of the power tariffs, it will promote the electricity use of the poor population in the area.

The problems of the present system, and the planned countermeasures and their expected effects are summarized in the following Table 3-1.

Table 3-1 Effects of Plan Execution and Degrees of Improvement from the Present Status

Present Status and Problems	Countermeasures Under This Project (Objects of Grant Aid)	Effects of the Project and Degree of Improvement
1. Power demand of Siem Reap has increased much in recent years along with increase of tourists. EdC's generating facilities of Siem Reap are old and their capacity is not enough and EdC borrowed lease generators to meet requirements. However, the present system is not adequate to satisfy future growth.	• Supply of C-heavy oil-fired diesel generating facilities of about 10,000 kW. • Connection to existing 22kV distribution network.	• The power station can supply enough quantity of power for a certain period (up to around 2009 for general demand and up to 2005 if some hotel demand is taken into account), at tariffs much lower than present ones. • Improvement of reliability of power supply. • Promotion of tourism industry and support to earning foreign currency.
2. Due to insufficient technical capability of O&M staff, major maintenance works like overhaul is not possible and this is causing early deterioration of equipment.	• Training of O&M staff by the consultant as soft component of the project.	• Technical skill of O&M staff can be improved, and generating facilities to be supplied under a grant aid program can be operated in good conditions.

3-2 Recommendations

The contents of the work items to be undertaken by the Cambodian authorities mentioned in Clause 2-3 and necessity of their timely execution are summarized in the following Table 3-2.

Table 3-2 Work Items of the Cambodian Side and Their Necessity

Work Items of Cambodian Side	Necessity of Timely Execution
Search of land mines and unexploded	Security of safety of personnel during project construction and O&M after completion.
Establishment of project management office and arrangement of necessary staff	Smooth execution of detailed design works and site works of project execution
Arrangement of necessary fund for project execution	Security of fund necessary for carrying out work items allotted to the Cambodia side.

Acquisition of power station land and payment of compensation money to land right, which shall be finished before commencing detailed design works.	Smooth execution of detailed design works and site works of project implementation.
Construction of access road before commencing the site works.	Use of road for site works and O&M of power station.
Arrangement of O&M staff and execution proper staff training.	Smooth operation of power station and exhibition of effects of the project after completion.
Timely arrangement of Cambodian side responsibilities such as tax exemption, custom processing, obtaining necessary visa, etc.	Smooth execution of detailed design works and site works of project execution.

The diesel generators to be supplied under the project are large machines with unit capacity of 3,500 kW and are much larger than those existing in Siem Reap. More over the diesel engines are of C-heavy oil fired type, which requires pre-treatment of fuel oil. Thus the generating equipment is complicate in construction and requires high-class technology in operation and maintenance. Without proper operation and maintenance, the diesel engine generators will not be able to exhibit their inherent technical properties.

At present, the generating facilities of the existing Siem Reap power station are not properly maintained due to the insufficiency in technical skill of maintenance staff. The most important maintenance works like overhaul are not properly executed. The following measures are conceived to establish a capable operation and maintenance organization for the new power station in Siem Reap in view of technical capability and in number of staff.

- Core staff will be experienced staff in the existing Siem Reap power stations. Therefore, utmost effort shall be exerted to education and training of the present members.
- Recruitment of graduates of technical courses of the university, college and high school in Phnom Penh.
- Transfer of experienced staff of the EdC's power stations, No. 5 and/or No. 6, in Phnom Penh.
- On-the-job training of Siem Reap power station staff during the machine erection period under the project.
- Staff training by the consultant and equipment manufacturer.
- Recruitment of capable Cambodian engineers working overseas.
- Short-term employment of aged foreign expert.
- Recruitment of capable members from construction workers.
- Contract with equipment manufacturer on dispatch of guidance staff to initial stage overhaul.

A proper combination of the above measures must be selected and realized. Measures shall be studied before setting to the detailed design works. During execution of the training program, the results of training must be monitored not to cause troubles after commencing commercial operation.

Both to carry out construction works successfully and to establish capable operation and maintenance organization, active involvement and assistance of the EdC head office is indispensable.

At present, there are two kinds of power demand in Siem Reap; the public power supplied by EdC and the large demand of hotels, etc. currently supplied by their own generators. Though detailed survey of self-generation has not been made, the total capacity is estimated at around 10,000 kW and peak demand at 4,000 kW and the both are considerably larger than those of the EdC system. Large hotels usually have diesel generators of comparable capacity with those of EdC. The net generation cost is considered almost same, then their generation cost is surely lower than the EdC's power tariff that includes the distribution cost and overhead expenses. Moreover, the reliability of EdC's power supply has been no good. Under such circumstance, large consumers like hotels are getting power by their self-generation. After starting operation of the new power station with C-heavy oil fired large diesel generators, such situation will change completely. The power tariff of EdC will become comparable or lower than their generation cost. Hotel consumers basically do not want troublesome operation of own diesel generators, and they will rush to power receiving from EdC. In such case the following countermeasures are conceived:

- To reject connection of large hotels.
- To request large consumers who have their own generators separation of the load or parallel operation of their generators with the EdC system when such cooperation is requested by EdC. Such conditions are to be included in the power supply contracts with such consumers.

Distribution system reinforcement projects aiming at distribution of power to be generated at the power station are scheduled by the World Bank and ADB. The population that receive power from the project will increase by the execution of these distribution projects, however the implementation of this project has no direct relation with these projects.