JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

ELECTRICITE DU CAMBODGE

SUPREME NATIONAL COUNCIL OF CAMBODIA

MASTER PLAN STUDY ON REHABILITATION AND RECONSTRUCTION OF ELECTRICITY SUPPLY IN PHNOM PENH AND SIEM REAP, CAMBODIA

SUMMARY

July 1993

NIPPON KOEI CO., LTD.

IN ASSOCIATION WITH

TOKYO ELECTRIC POWER SERVICES CO., LTD.

TOKYO,JAPAN

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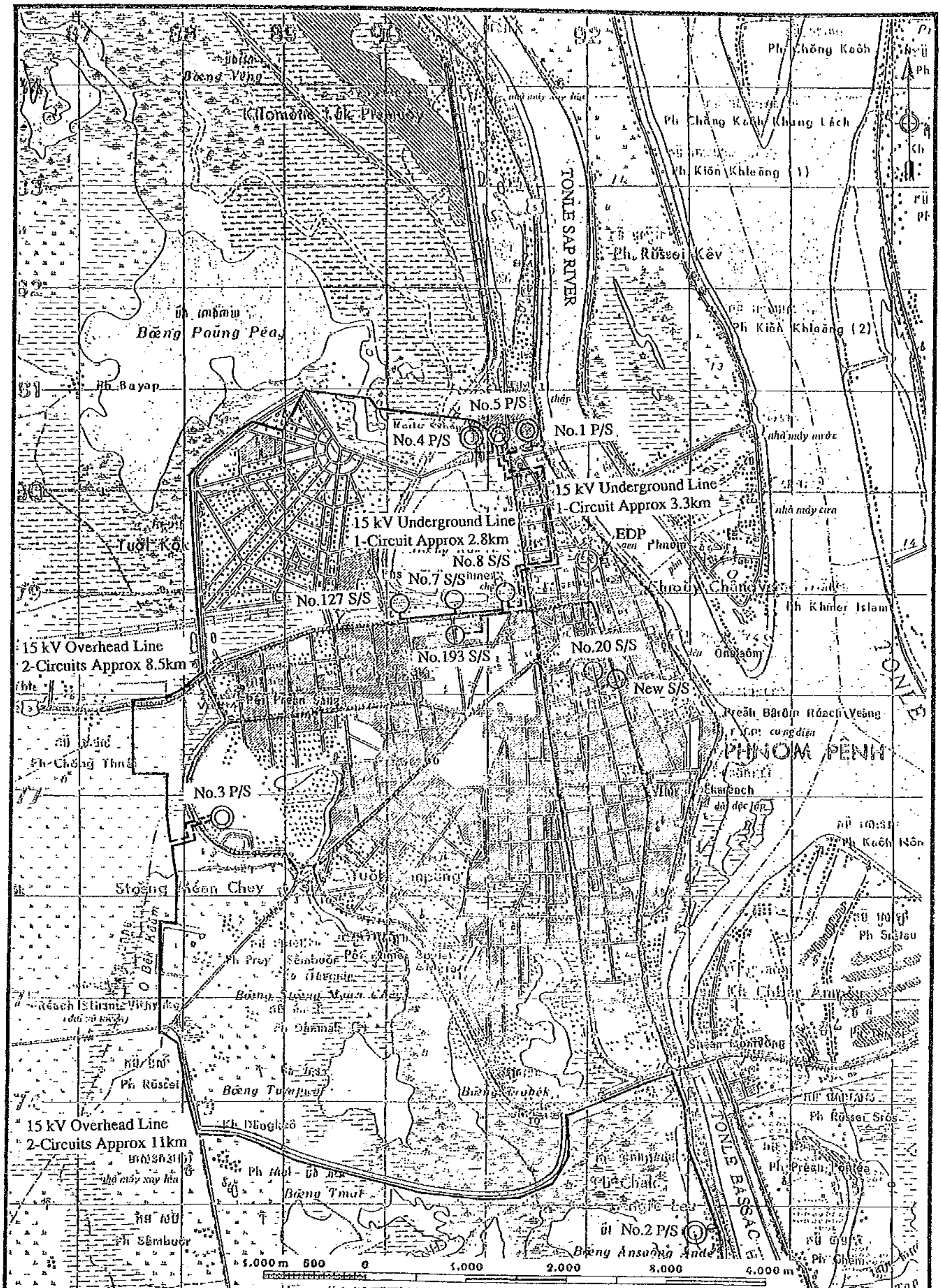

TONLE SAP RIVER
No.5 P/S
No.4 P/S
No.1 P/S
15 kV Underground Line
1-Circuit Approx 3.3km
15 kV Underground Line
1-Circuit Approx 2.8km
EDP
No.8 S/S
No.7 S/S
No.127 S/S
15 kV Overhead Line
2-Circuits Approx 8.5km
No.193 S/S
No.20 S/S
New S/S
PHNOM PENH
No.3 P/S
15 kV Overhead Line
2-Circuits Approx 11km
TONLE BASSAC
No.2 P/S
1.000 m 500 0 1.000 2.000 3.000 4.000 m

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1. INTRODUCTION

Per capita annual electricity consumption in Cambodia amounted to approximately 20 kWh in 1992, which is the lowest level among countries in Asia and Oceania. Because of the location of electric facilities in isolated areas and due to the progressing deterioration of the electric facilities and shortage of spare parts and tools, the existing facilities are not able to meet the energy requirement.

Both the cities of Phnom Penh and Siem Reap are obliged to introduce the scheduled shutdown of power supply due to a shortage of the generating capacity. This hinders stable daily life and promotion of welfare, and delays restoration and reconstruction of the industrial and agricultural sectors as well as regional restoration. As a tentative countermeasure most of the hotels, restaurants, embassies, and international institutions use their own generating sets. There are other issues, such as deterioration of the aged distribution facilities, inefficient system and management of the power sector, and inadequate operation and maintenance, which are aggravating of the power situation in the cities.

Cambodia is now facing a serious shortage of power which is hindering the restoration and reconstruction of the country. The country is also under such conditions that it is unable by its own efforts, to restore the existing facilities and add new facilities. On such basis the Government of Cambodia officially requested the Government of Japan to assist in formulation of the master plan for rehabilitation and reconstruction of the power supply system in Phnom Penh and Siem Reap.

The scope of the Study was agreed between the Ministry of Industry in the Supreme National Council (SNC) and Japan International Cooperation Agency (JICA). The Study is to be undertaken by the consultants selected by JICA.

The scope of work for this study covers (a) the master plan study of the power supply in both the cities of Phnom Penh and Siem Reap, and (b) the basic design level study on the facilities selected in the master plan study for effective restoration and reconstruction of the power supply in Phnom Penh city. One of the important areas of this study is to transfer technology to the Cambodian counterparts over the whole duration of the study.

2. PROFILE OF COUNTRY

2.1 Economic Situation

Cambodia's major industries are agriculture, forestry, and fishing. Cambodia has few mineral resources. Its economy has been under pressure since independence, and has suffered tremendous damage owing to the recurring civil wars since 1970. The People's Republic of Kampuchea, established in January 1979, inherited a destroyed state and economy, and country-wide famine erupted during the same years. There was mass population emigration to Thailand, where many still remain in refugee camps. The citizenry thus came to rely on humanitarian aid from international institutions and Western countries, and on foodstuffs and medicines from the former Soviet Union and other socialist countries.

Despite these hardships, Cambodia made significant progress in their efforts to rebuild the country during the 1980s. Progress was made in restoring basic health and education services. A structured civil administration was put in place.

Gross Domestic Product (GDP) in real terms (constant 1989 prices) has grown steadily in recent years: after falling by 0.1% in 1990, and growing by 13.5% in 1991, then advancing by 9.0% in 1992 according to an assessment by IBRD experts.

Cambodia is implementing economic reform moving from a collective economy to a planned and then market economy and to pure market economy. Farmers are encouraged to upgrade the quality of soils. At the same time implementation of a free market for agricultural products and the introduction of tax exemption/reduction policy for the agricultural sector have contributed significantly to accelerating agricultural development.

The reform of the management system for state enterprises was made in two stages. Firstly an autonomous economic management system was implemented. The second stage was privatization of state enterprises through long-term leasing (10-15 years) of fixed assets to private investors. As a result foreign investment increased greatly. Foreign investment, especially in hotel businesses and processing industries amounted to US$800 million during 1991 and 1992. Foreign investment was encouraged in the field of energy and mining (petroleum exploitation, etc.) from September 1991.

Foreign investment contributed significantly to the development of Phnom Penh tourism.

2.2 Rehabilitation Program and External Assistance

With the signing of the Paris Accord on 23 October 1991, a United Nations (UN)-sponsored comprehensive political settlement of the country is being carried out, and major international programs of assistance for the rehabilitation and reconstruction of Cambodia are being launched.

In April 1992, the UN Secretary General issued an appeal for international support for an emergency Rehabilitation Program for Cambodia (RPC), to be provided to the country for the period from October 1991 to December 1993. RPC and its policy framework are the result of an international cooperative effort under the leadership of the United Nations.

As of September 1992, a total of about $800 million had been pledged or committed by way of external assistance to finance specific activities of RPC for the period from October 1991 to December 1993. About $60 million (or 7%) originate from United Nations Development Program (UNDP), United Nations Educational, Scientific, and Cultural Organization (UNESCO), and United Nations International Children's Emergency Fund (UNICEF), and about $155 million (or 20%) from the World Bank and ADB. The rest is mostly being provided bilaterally and by the European Community. The major sources of bilateral assistance include the USA, Japan, France, Australia, Sweden, and the Netherlands.

3. PRESENT SITUATION OF COUNTRY'S POWER SECTOR

The Ministry of Industry is responsible for management of the power sector in the whole country. Rural power sectors are controlled by the industrial department or electricity department of the respective municipality or province.

3.1 Condition of Power Facilities

Power facilities exist only in the municipalities and provincial capital cities. All the facilities installed in the cities are of extremely small scale (except those in Phnom Penh city) and are isolated and independently operated without interconnection among them. Before the war, the Kirirom hydropower station was running with an installed capacity of 10 MW, and energy generated at the plant was delivered to Phnom Penh through a 110 kV transmission line over a distance of 120 km. However, the facilities were completely destroyed during war and have not been restored.

Electricity is being wholly produced by oil-fired generating facilities and depends, accordingly on imported oil. The aforementioned 10 MW Kirirom power plant was completed in 1968 as the first hydropower station in Cambodia, but it was demolished during the war after only 13 months of operation. The Prek Thnot multipurpose project with an installed capacity of 18 MW was implemented near the Kirirom power station, but the construction has been interrupted due to war since 1970. Thus, there is no hydropower plant at present in Cambodia, and the generating facilities under operation now are of diesel engine-generator type, except 3 steam turbine-generator units installed in the No. 2 power station in Phnom Penh.

The Following table shows all the generating facilities in Cambodia as recorded by EDC in 1989. The facilities were installed only in provincial capital cities.

City	Installation (kW)	Possible output (kW)
Phnom Penh	71,200	39,350
Kompong Cham	2,160	1,270
Prey Veng	500	200
Kandal	-	-
Takeo	1,020	900
Battambang	4,350	2,500
Siem Reap	2,230	1,720
Kompong Thom	330	285
Kampot	525	250
Kompong Speu	25	20
Svey Rieng	930	250
Banteay Meanchey	200	80
Kompong Chhnang	650	400
Pursat	1,000	900
Kratie	270	-
Preah Vihear	30	30
Kompong Som	3,830	3,300
Batanakiri	200	200
Stung Treng	500	400
Koh Kong	1,940	900
Mondulkiri	100	80
Total	91,990	53,035
Total excluding Phnom Penh	20,790	13,685

The average output of the facilities in the country was only 58% of the total installed capacity. The average output of the Phnom Penh system, which was 55% in 1989, was further lowered to 34% as of February 1993. It is assumed that the output in the provinces also has decreased due to the shortage of necessary spare parts.

3.2 Issues and Recommendation

Following are the main issues inherent in the power sector in Cambodia:

(a) Difficulty of procurement of spare parts;

(b) Present national situation in which the sector is obliged to operate seriously deteriorated power facilities;

(c) Shortage of power facilities to meet the rapidly growing power demand;

(d) Existing oil-fired generating facilities which are relying on imported fuel;

(e) Absence of implemention programs for large scale power resources development;

(f) Absence of implemention programs for medium- and long-term power development.

The following causes are considered to be the roots of the issues:
- Deterioration of power facilities caused by war over a long period;
- Lack of funds;
- Shortage of experienced persons and absence of educational system in the power sector.

Following programs are recommendable for rehabilitation and reconstruction of the power sector in the country:

(1) Master Plan and Basic Design Studies for the provincial power sector
(2) Supply and installation of spare parts
(3) Hydropower development for medium-and long-term power sector reconstruction
(4) Installation of additional oil-fired generating facilities in the short term
(5) Upgrading of operation and maintenance technology
(6) Upgrading of knowledge on planning of system development and management
(7) Coordination among supporting countries and institutions

4. PRESENT PHNOM PENH POWER SECTOR

4.1 Generating Facilities

There are five (5) power plants (No. 1 to No. 5 power stations) existing in the Phnom Penh power system. Of those 5 plants, the No. 5 power station was started its construction 1988 under assistance of U.S.S.R, but it has been broken off at September

1991 due to collapse of U.S.S.R. Most of main equipment and ancillary materials were installed in the power house. Models of the equipment installed in the No. 5 power station are same as those operated in the No. 4 power station, and spare parts for the equipment in the No. 4 power station are quite short. Therefore, various equipment in the No. 5 Power station are disassembled for spare parts of generating equipment in the No. 4 power station.

Four (4) power stations are running in the Phnom Penh power system at the present, accordingly. Energy generated in those 4 power stations are delivered into the area of approximate 350 km^2 covering Phnom Penh municipality and its suburb. Present operation of those 4 power stations are outlined below:

(as of January 1993)

Station	Type	No. of Unit	Installation (kW)	Possible Output (kW)	Operative Unit
No. 1	Diesel	11	23,500	4,650	5 units only
No. 2	Steam	3	18,000	10,000	2 units only
	Diesel	4	8,400	3,000	2 units only
No. 3	Diesel	3	6,300	1,500	1 unit only
No. 4	Diesel	5	15,000	5,200	2 units only
Total		26	71,200	24,350	12 units only

As seen above, the present total possible output (24,350 kW) is only 34% of total installation (71,200 kW).

There exist a lot of issues such as total possible output to be only 30% of the installed capacity, unavoidable enforcement of the scheduled load shedding, etc. Those issues seem to be originated by the following causes:

(1) Deteriorated facilities
(2) Shortage of equipment and materials for maintenance and repair
(3) Insufficient tools and apparatus for repair
(4) Lack of technical reference books
(5) Insufficient safety measures

4.2 Distribution Facilities

There are such three (3) kinds of voltage as 15 kV (3 phase), 6.3 kV (3 phase) and 4.4 kV (2 phase) in the high voltage system, and two (2) kinds as 380/220V (3 phase) and 220V (single phase) in the low voltage system in the Phnom Penh network.

Distribution network in Phnom Penh is consisted of two (2) systems, one is the northern system distributing energy from the No. 1 and No. 4 power stations, and another is the southern system being supplied by the No. 2 and No. 3 power stations. Both systems are operated independently.

Following are issues of the existing distribution facilities.

(1) Operational hindrance due to two independent and isolated systems (northern and southern systems);

(2) No power trade among 15 kV, 6.3 kV and 4.4 kV systems due to lack of interconnection of those systems resulting in inconvenient operation and maintenance of the power network;

(3) More than 25 years old and not renewed 15 kV facilities, which will cause more faults;

(4) Improper metering of energy consumed by customers. Metered values include energy losses on the low voltage facilities, because customers' meters are installed not at the customers ends but at the aggregating meter houses;

(5) No loop system in low voltage lines causing more frequent power interruption;

(6) Large amount of energy losses, equivalent to 30% of generated energy, is mostly caused in the low voltage network;

(7) No protection devices on low voltage system; and

(8) Shortage of tools and safety devices for operation and maintenance.

4.3 Load Dispatching Facilities

The existing load dispatching center is operated in the EDP's headquarters. Citizen band transceiver sets are used for communications among the center, power stations and distribution line maintenance vehicles. Public telephones are also used among the center

and power stations, but the telephone is rarely used for communications due to poor communications network.

There is no communications facility for exclusive use of load dispatching system. In addition to poor condition of the public telephone system, the present transceiver sets are functioning for use of only 2 channels. Serious interference of communications due to 2 routes only disturbs proper transmission of instructions and orders of the center to respective stations.

In addition, diagram only is indicated on the existing board, but no indications of operational condition of power stations, substations, transformer houses and distribution network.

4.4 Operation of Electric Power Enterprise

(1) Organization of power enterprise

The power sector in Phnom Penh is managed by Electricite de Phnom Penh (EDP). Since the distribution area is limited to the area centering on Phnom Penh, this organizational scale is deemed appropriate for an electric power enterprise of this scale. As the scale of the organization is enlarged along with increase in the supply area and supply capacity, it is considered to become necessary to classify clear-cut roles into the respective departments and to create more stratified organization structures from medium and long term viewpoints.

(2) Operation

One of the major bases that have contributed to the improvement of the financial situation in the earlier half of 1992 is the increased ratio of sold energy against generated energy.

Another basis of the financial improvement depends on the increased electricity charge. The electricity sales price exceeded the electricity sales cost in the earlier half of 1992, which consequently indicates that the electricity sales costs had been basically recovered by the revenues from electricity charge in the earlier half of 1992. However, one caveat is that electricity sales cost does not include costs of depreciation for generation and distribution facilities. Therefore, further study and analysis have to be made in order to comprehensively examine whether the

sales price would exceed the sales cost when depreciation costs were included in the analysis.

The amount of unpaid electricity charge by the organizations related to the Government of Cambodia and Phnom Penh Municipality Government located in Phnom Penh has been raising a serious problem for EDP. The accumulated total amount of unpaid electricity charge at the end of 1991 is as much as 5,958 million Riel, which exceeds the annual revenue of total sold energy in the same year. Such a huge amount of unpaid electricity charge has been tightening the financial situations of EDP and causing an immensely adverse effect upon procurement of fuel and spare parts.

5. PRESENT SIEM REAP POWER SECTOR

5.1 Generating Facilities

The power station having a total capacity of 2,230 kW is at the present operated in the Siem Reap City. The station capacity ranks fourth in Cambodia following Phnom Penh, Bttambang and Kompong Som. The power station was built in 1985 under assistance of U.S.S.R.

Facilities of the power station are shown below:

Unit No.	1	2	3	4
Manufacturer	Russky Diesel (USSR)	Same as left	Same as left	Same as left
Model	Diesel G72 300	Same as left	Diesel DGA 315	Same as left
Year	1985	1987	1985	1987
Rated	800 kW	800 kW	315 kW	315 kW
Possible Output (as of Jan. 1993)	550 kW	720 kW	280 kW	-
Generated voltage	6,300 V	6,300 V	400 V	400 V
Speed	375 rpm	375 rpm	500 rpm	500 rpm

The No.4 generating unit has been left incomplete because of suspension of assistance from U.S.S.R, which has been disassembling in order to provide spare parts for the No.3 generating unit.

The electric power is supplied by three units, which is resulting in shortage of electric power supply. Under such circumstances as the insufficient installed capacity and also difficulties of procurement of spare parts, the committee is obliged to force the scheduled load shedding to maintain the plants in sound conditions for a long period.

Although there exist a lot of issues on the generating facilities in Siem Reap at present as well as in future, major aspects are summarized as follows:

(1) Shortage of generating facilities

According to the People's Committee, the maximum power demand at the beginning of February 1993 is expected to reach 1,700 kW excluding latent demands, which is more than the existing possible output of 1,550 kW with three(3) generating units operating in parallel. Siem Reap is the major tourist spot in Cambodia and foreign currencies income from tourists is contributing to the city. From this point of view, the rehabilitation of the existing generating facilities and expansion of the facilities are required.

(2) Parallel operation

Parallel operation among the generating units is conducted under commercial operation, but remedial works to the synchronizers will urgently be required for No.2 and No.3 generating units, because they are not properly working, while the synchronizer for No.1 generating unit is well functioning.

(3) Shortage of equipment and materials for maintenance and repair

At present, damaged parts are repaired with the same parts or modified parts either from the old power station or No.4 generating unit without any supplement of parts. Shortage of equipment and materials for maintenance will cause faster deterioration of the existing generating facilities.

5.2 Distribution Facilities

The high voltage lines are radially extended with 3 phase 3 wire and composed of overhead and underground system, while the low voltage lines in whole area are of overhead system with 3 phase 4 wire. The switching equipment such as circuit breakers and disconnecting switches are installed in only limited transformer houses, and most of the houses are not equipped with the switching and protective equipment, which is causing a difficulty of the system control.

5.3 Load Dispatching Facilities

A load dispatching system is not organized in Siem Reap due to its small scale of power network. Generation scheme and restoration work are undertaken by the power station staffs. Operation of switching equipment or restoration work in the distribution system are carried out by means of transceiver's communications mounted in maintenance vehicles.

No supervisory panels have been installed. Indications of equipment status in the power station and the transformer houses are not available, accordingly.

5.4 Operation of Power Facilities

Electricite' de Siem Reap (EDSR) is a subordinate organization of the People's Committee of Siem Reap city.

EDSR had been in the red every year since 1989 until 1991. The balance moved into the black as a result of a substantial increase in the electricity charge in 1992. However, if the equipment depreciation cost is added to the operation cost described in the profit and loss statements, then the balance is deemed to be in the red even in 1992.

The organization of SEPE is small in scale and has only one power station. There are no loan from any bank or financial institution. However, since the funds for procurement of spare parts, lubricants, fuels, and so forth are not sufficient, it is deemed that this may cause a shortage of spare parts, lubricants, and others.

6. POWER DEMAND FORECAST

6.1 Phnom Penh System

	1992	1993	1994	1995	1996	1997	1998	1999	2000
Peak Demand (MW)	44	47	53	58	62	69	76	83	89
Generation (GWh)	230	253	291	322	354	401	449	499	548

The base load of the system in1995-96 is estimated at about 30MW.

6.2 Siem Reap System

	1992	1993	1994	1995	1996	1997	1998	1999	2000
Peak Demand (MW)	1.4	2.2	3.2	4.4	4.9	5.5	6.1	6.8	7.5
Generation (GWh)	(6.1)	9.8	14.8	20.6	23.6	27.4	31.0	34.9	39.4

7. MASTER PLAN FOR REHABILITATION AND RECONSTRUCTION OF PHNOM PENH POWER FACILITIES

7.1 General Facifiliteis

(1) Rehabilitation plans

Various countries and international institutions are programming to assist Cambodia to rehabilitate and reconstruct the Phnom Penh power supply system. Completion of all the programs will much increase the output of the existing generating facilities, as below:

Increase of Possible Power Output

Unit: kW

Power Station	Assisting Country & Institution	Feb. 1993	End 1993	End 1994	End 1995
No. 1	-	4,650	4,650	4,650	4,650
No. 2 Steam	Czech	10,000	12,000	18,000	18,000
No. 2 Diesel	Ireland	3,000	8,400	8,400	8,400
No. 3	"	1,500	1,500	6,300	6,300
No. 4	UNDP	5,200	5,200	5,200	15,000
No. 5	-	-	-	-	-
Total		24,350	31,750	42,550	52,350

(2) Expansion plans

The following table presents the additional output from expansion plans presently planned by other countries as well as international organizations.

Additional Power Output

Unit: kW

Power Station	Assisting Country & Institution	Feb. 1993	End 1993	End 1994	End 1995
No. 1	France	-	1,800	1,800	1,800
No. 3	Italy	-	-	4,200	4,200
No. 1 or No. 4	ADB	-	-	-	12,000
No. 2 or No. 3	World Bank	-	-	-	8,400
Total		-	1,800	6,000	26,400

(3) Supply and demand balance

The following table presents the balance between total generating capacity and demand as of year end 1993 through 1999 including rehabilitation and expansion of the generating facilities.

Power Demand/Supply Schedule

Unit: kW

Year	1993	1994	1995	1996	1997	1998	1999
Output from restoration	24,350	31,750	42,550	52,350	52,350	52,350	52,350
Output from expansion	1,800	1,800	6,000	26,400	26,400	26,400	26,400
Total output	26,150	33,550	48,550	78,750	78,750	78,750	78,750
Demand required	47,000	53,000	58,000	62,000	69,000	76,000	83,000
Allowance for inspection of the largest unit	6,000	6,000	6,000	6,000	6,000	6,000	6,000
Total output required	53,000	59,000	64,000	68,000	75,000	82,000	89,000
Demand/supply balance	-26,850	-25,450	-15,450	10,750	3,750	-3,250	-10,250

(4) Recommendation to assistance from Japan

Despite timely efforts by various countries and international organizations, demand will continue to outstrip supply through the end of 1995, making planned load shedding unavoidable.

Although demand can be expected to meet supply after 1995, this balance will only be temporary, and Cambodia will once again have a capacity shortage from mid-1998. Since hydroelectric power contributions can only be expected from 2000 at the earliest, as stated previously, Cambodia will depend completely on combustion generators at least until the end of 1999. Therefore, as the Team has determined that no plans for expanded combustion generation exist, other than

those discussed above, Japan should provide assistance for at least 10,000 kW in consideration of maintenance period of one of the largest unit (6,000 kW).

7.2 Distribution Facilities

(1) Major facilities to be implemented

(a) Unification of distribution voltage
(b) Connection of power stations
(c) High and low tension lines

(2) Assisting programs by donors

(a) Unification of distribution voltage

The works required to boost the 4.4 kV system to 15 kV shall be executed under the technical assistance of the Government of France in the model area . It is envisaged that EDP's staff will be trained during these works. The necessary equipment and materials required to boost the voltage shall be salvaged from the existing equipment supplied by the former Soviet Union. On the other hand, it is envisaged that the above-mentioned trained staff, will be able to unify the small scale 6.3 kV distribution line network by utilizing transformers from the former Soviet Union.

(b) High voltage lines

EDP and UNDP reported that a lot of 15 kV cables, conductors, equipment for distribution lines supplied by U.S.S.R are stocked in EDP's warehouses. Improvement of high voltage lines in the network will be achieved by EDP itself, if donor countries will supplement construction tools, safety equipment, testing apparatus, power fuses, load break switches, etc. with experts for construction and maintenance of distribution lines.

France is to supply about 60 units (40 kVA to 250 kVA unit capacity) of transformers. While, UNDP and ADB are programming to assist in restoration of the distribution lines including improvement of low voltage lines.

(c) Low voltage lines

Both UNDP and ADB have programs of restoration of low voltage lines as well as that for high voltage lines. France is supplying various tools and 10,000 units of customers' demand meters.

(3) Assistance from Japan

(a) Interconnection of power stations

Construction of exclusive connecting lines in order to connect all the power stations together including the No.5 power station, is recommended for flexible power exchange among the power stations.

The other donors countries and international agencies do not at present, have any plans for implementation of above-mentioned countermeasures, therefore, it is expected that they will be carried out under the assistance of the Government of Japan.

(b) Reinforcement of high tension lines

Improvement works of the distribution lines will be executed by EDP itself under assistance of France, UNDP and ADB as discussed above. However, provision of new 15 kV line from No.5 power station to the heavy loading area in the town is to much improve the existing power supply in the area and to advance the earliest effect of the power station. The team's recommendable program is to construct new 15 kV lines from No. 5 power plant to the existing substations No. 8, No. 127 and No. 193 for the main purpose to improve the situation of the heaviest loading areas Nos. 2, 4, 5 and their adjacent areas.

7.3 Load Dispatching Facilities

At present, other donors have no rehabilitation and reconstruction programs for the load dispatching facilities in the Phnom Penh power system. The Team recommends following facilities to be provided to the system under assistance from Japan.

(a) New exclusive communications for the load dispatching
(b) New system control panel for the power system

7.4. Electric Power Enterprise

7.4.1 Institutional Operation

(1) Organization of EDP

The recent changes in the job descriptions of the Planning and Technical Office reinforced the functions of the office. Consequently, the office started formulating power facility expansion program, overseas procurement planning of fuel and other materials such as spare parts, and administration of official development assistance. However, the functions and human resources of the office will have to be reinforced more around the time when electric power systems will expand throughout the country in future so that the office will be capable to plan and evaluate generation and system planning, and investment planning.

(2) Consolidation of office equipment

It will be necessary to introduce more typewriters, photocopy machines and other office equipment within an appropriate range in order to improve the office work efficiency.

(3) Education and training

In order to improve work efficiency, it will be necessary for EDP to prepare its own work manuals and training materials and to institutionalize training and education for its employees.

7.4.2 Operation and Management of Facilities

(1) Maintenance and repair

The low usage rate together with the problem of a huge amount of unpaid electricity accounts is oppressing the financial condition of EDP. Such a very low availability of power stations and distribution facilities has been caused by insufficient maintenance and repair of equipment. Insufficient maintenance and repair of equipment is caused by excessively aged power plant equipment and distribution facilities, lack of spare parts, and inadequate maintenance and workshop tools. One of the reasons for the shortage of spare parts is deemed to be the lack of adequate funds for EDP resulting from difficulties in collecting the huge amount of unpaid electricity accounts. Thus, it is essential to work out and

implement countermeasures for recovering the unpaid electricity accounts and not increasing the amount of unpaid bills during the course of future business activities.

(2) Shift of work system

At present, the power stations and distribution lines are operated by four shift teams based on a four shift system. Since the four shift teams are engaged in the work at all times, it is impossible for any shift team member to take a complete dayoff.

Because there may be a considerable allowance for the number of members constituting the respective shift teams, one team can be added without changing the total number of shift work members. As a result, the number of shift teams will be increased from four to five. In this way, it will be possible for members of any team out of five to take a complete dayoff. Furthermore, it will also be possible to carry out education and training of the operation staff during such a dayoff.

(3) Night time repair work

Although the distribution lines are operated based on a system for coping with troubles on a twenty-four hour basis, the repair staff from the Public Light and Network Office do not work on a twenty-four hour basis. If power failure occurs after the end of normal working hours, the repair work will be carried out the next morning.

Taking these conditions into consideration, it is proposed to execute repair work during the night.

(4) Safety control

Taking into consideration the insufficient safety control under present conditions, the following points are proposed for improvement:

(a) Clearing around and appropriate arrangement of power plant equipment and facilities;
(b) Appropriate indication and division of work areas and open sections using partitions, rope, etc.;

(c) Appropriate arrangement and reinforcement of lighting equipment;
(d) Improvement of safety on steps by providing handrails, etc.,
(e) Indication of dangerous overhead structures, high voltage, and high temperature parts by color identifications;
(f) Use of insulated helmets and shoulder protectors to prevent workers on a lift basket truck from electric shock; and
(g) Use of safety belts during work on poles.

7.4.3 Power Sales System

(1) Structure of electricity charges

As long as the present demand structure prevails in Phnom Penh and surrounding areas, it is not deemed necessary to set electricity charges according to the categories of consumers. However, when the electric power demand structure is diversified along with the development of medium and small scale industries, it will become essential for EDP to set electricity charges according to the categories of consumers.

From a medium-term point of view, it will be necessary for EDP to start revising the electricity charges in order to prepare a tariff that reflects differential supply costs among consumers.

(2) Fair electricity charge system

The electricity charges applied at present by EDP vary depending on the payment methods. The charge is 170 Riel/kWh in the case of payment in local currency and U.S.$0.21/kWh in the case of payment in hard currency. However, if the charge is paid through a regional electricity wholesaler or a Collective Group, the charge is 180 Riel/kWh in local currency and U.S.$0.224/kWh in hard currency.

As Cambodia is experiencing hyperinflation, the value of the U.S. dollar is increasing rapidly compared with the local currency. Therefore, this means that the substantive electricity charge paid in U.S. dollars is increasingly higher than that paid in local currency. Even if the same category of electric power is supplied in the same area, the fact that there are different electricity charges raises the issue of unfairness in the long run. The solution to this issue has to be formulated within the framework of the electric power rate category. This means

that this issue concerns not only EDP but also other electric power supply organizations.

7.5 Assessment of Project assisted by Japan

(1) Generating facilities

Phnom Penh needs to increase power capacity immediately, and if Japan were to supply a 10 MW facilities, it would be in operation by the beginning 1995, and increase total capacity in 1993 by 40%. This would be a major contribution to the timely execution of infrastructure rehabilitation as well as economic reconstruction plans.

The generator would supplement total output for the Phnom Penh power grid until year end 1999 when generation of hydroelectric power can be expected to begin. This will enable Phnom Penh's recovery projects which have already begun to progress without being hindered by power shortages, and contribute to social stability and public welfare.

(2) Distribution facilities

(a) To enable free power flow among the power stations.
(b) To reduce frequency of power failures due to the free power flow.
(c) To enable to program the optimum system operation.
(d) To ensure stable power supply to the heavy loaded areas and to much improve energy losses and voltage regulation.
(e) To promote efficient activities of the administrative and economic fields leading to quick restoration of the municipality.

(3) Load dispatching facilities

(a) Quick and accurate communication without interference is possible because the new radios will have 10 channels and an exclusive line will be used for each power station.

(b) The new radios will be able to relay accurate information on the condition of the distribution lines for the power stations between each system.

(c) As information will be able to be relayed accurately and quickly, the present situation can be analysed on the system control panel immediately.

8. MASTER PLAN FOR REHABILITATION AND RECONSTRUCTION OF SIEM REAP FACILITIES

8.1 Generating Facilities

(1) Repair of synchronizers

The best measure is to replace the present devices with its genuine device. The team proposes in the report an idea to tentatively improve the existing device.

(2) Repair of turbo-charger

If U.S.S.R's genuine charger can not be procured, the same charger should be manufactured and installed after detailed investigation at site.

(3) Expansion of generating facilities

To promote the tourism which ranks in a high priority under the reconstruction and development work of the city, further expansion of at least 4,000 kW generating facilities will be required in the present system by 1995, for which 50 % of the facilities should be constructed to cover base load mainly for supplying hotels and restaurants.

8.2 Distribution Facilities

(1) Extension of the existing high voltage distribution line

One of the existing two main trunk lines of the distribution network shall be extended through the airport and the Angkor monument and connected to another distribution line for making a loop system which will ensure the electricity supply.

(2) Installation of a new high voltage distribution line

The additional distribution lines for major demand for commercial use, such as hotels, and for a pumping station for agriculture are required for reinforcing the existing single circuit line.

(3) Increase of the capacity of the existing high voltage distribution lines

The size of the existing overhead power lines and underground lines is not sufficient if demand increases.

Upgrade of sizes of the existing conductors and cables effects increase of line capacity, improvement of line voltage regulation, and reduction of line energy losses.

(4) Boost of the voltage for high voltage distribution lines

The voltage shall be boosted from 6.3 kV to Cambodia's standard voltage 15-20 kV, and the capacity of distribution lines shall also be increased. The materials for operation and maintenance shall also be commonly used in the country's distribution network.

(5) Extensions of low voltage distribution lines

The electrification rate shall be increased remarkably (the present rate is about 10%) by the increase of the generating facilities. Low voltage lines should be expanded, accordingly.

8.3 Load Dispatching Facilities

Since the present Siem Reap power system is operated with one power station in distribution network, the load dispatching facility is not urgently needed. Distribution line patrol and switching operation are now achieved by use of transceiver radio sets at present, and no hindrance is observed.

New radio sets will be required when a lot of similar transceiver sets will be used in the town and public communications by those sets will interfere with load dispatching works of the power system.

When hydropower station(s) would be developed and connected with the Siem Reap power system in the future, the load dispatching system should be established in power line carrier system.

8.4 Project Assessment

(1) Generating facilities

Improvement of the existing generating facilities and the supply of spare parts will much contribute to utilize the existing facilities in more efficient manners and to prevent further deterioration. The construction of new generating facilities will

meet the rapidly increasing power demand and contribute to the acquisition of foreign currencies with the promotion of the tourism.

(2) Distribution facilities

- Stable power supply will be secured.
- The tourism sector, one of the major sources of foreign exchange earnings, will be promoted.
- Quick action in regard to accidents will be possible.
- A decrease of power losses and an improvement of voltage will be expected.

(3) Load dispatching facilities

- Exclusive communications channels of the power system will contribute to improvement to enable the accurate and quick communications among respective power facility.
- The facilities will enable to transmit precise information and instructions for stable and economical system operation by controlling power generation of each generator and efficient managing distribution system.
- The collective supervisory board indicates operation condition of the system on time to enable prompt and optimum load management of the system and quick restoration of distribution line faults.

9. BASIC DESIGN FOR REHABILITATION AND RECONSTRUCTION OF PHNOM PENH ELECTRICITY SUPPLY

On the Project site, there are some facilities and machinery which were constructed and installed from November 1988 to September 1991. Since the construction was interrupted in 1991, the existing facilities and/or machinery were left on the site.

The existing buildings can be used again if works such as changing doors, windows and sash, fittings, and metallic materials, painting of interiors and exteriors, and repair of roof are carried out. All of the installed existing machinery have been partly erected and

remain in an incomplete condition. The most have deteriorated or rusted, except for the 16-ton ceiling crane and all other machinery cannot be used for the new power station.

(1) Generating facilities

Diesel engine

(a)	Type	:	Vee-type, 4 stroke cycle, water cooled, trunk piston type supercharged medium speed diesel engine with air cooler
(b)	Rated output & unit	:	More than 7,050 PS (Generator rated output 5,000 kW), 2 units
(c)	Engine output & speed	:	7,050 PS or more and less than 750 rpm
(d)	Overload	:	110% 1 hour
(e)	Fuel system	:	Automatic feeding system with 1,000 kl storage tank. The storage tank shall be newly constructed
(f)	Lubricating oil system	:	Manual feed system with 5 kl sump tank
(g)	Cooling system	:	By means of cooling tower with treatment facilities including pump station at the Tonle Sap river side
(h)	Starting system	:	By means of compressed air
(i)	Intake exhaust air system	:	Filter and silencer type

Generator

(a)	Type & electric system	:	Cylindrical, rotating field, 3 phase, synchronous, air cooled AC generator, 3 phase, 3 wire system
(b)	Rated capacity & units	:	6,250 kVA (rated output 5,000 kW) x 2
(c)	Rated voltage	:	6.3 kV
(d)	Frequency & no. of poles	:	50 Hz and more than 8 poles
(e)	Power factor	:	0.8
(f)	Exciter	:	Brushless, rotating type with automatic voltage regulator, self-ventilated, air cooled type

Main transformer

(a)	Type	:	3 phase, oil immersed, outdoor type with on load tap changer
(b)	Voltage ratio	:	6.3 kV / 15 kV
(c)	Rated capacity & unit	:	6,300 kVA x 2
(d)	Cooling system	:	ONAN

(2) Distribution facilities

(a) 15 kV overhead distribution line materials

(i) Overhead line support

Supports for overhead lines are to be of a jointable steel tubular pole type. Stay wire is set with drive type steel anchors to increase the strength of angle type and dead-end type supports.

(ii) Insulators

Pin and disk insulators are to be used for supporting the 15 kV line conductors. The conductors will be fixed to the insulators by bare annealed aluminium bind wires.

(iii) Conductors

To reduce the weight of conductors, hard drawn aluminium (HAL) conductors will be used instead of the existing bare ACSR conductors.

(iv) Overhead ground wire

For protection against lightning, an overhead ground wire will be fixed on the top of the pole. The wire will be 45 sq.mm galvanized steel stranded wire.

(b) 15 kV underground cable line materials

20 kV cables, consisting of 150 sq.mm x 3-cores copper conductor, vinyl sheathed, cross linked polyethylene insulated steel armored type, will be used.

The cable head ends will be of premould stress cone type and the straight through joint of the cables will be installed in concrete pits for their protection.

(c) Distribution transformers

Distribution transformers will be of outdoor use, three-phase oil immersed type with a voltage ratio of 15 kV/380-220 V. All the distribution transformers will be 250 kVA capacity.

(d) Distribution switchgear

Distribution switchgear which is to be mounted in a cubicle, will be of indoor use, self-standing, metal-clad type.

(3) Load dispatching facilities

(a) Fixed radio station facilities (LDC, each power station)

(i)	Frequency band	:	335-470 MHz
(ii)	Channel capacity	:	8 channels or more
(iii)	Modulation method	:	PM
(iv)	RF output	:	25 W (tentative)

(b) Mobile radio facilities (car mounted type)

(i)	Frequency band	:	335 - 470 MHz
(ii)	Channel capacity	:	8 channel or more
(iii)	Modulation method	:	PM
(iv)	RF output	:	5 W

(c) Antenna

(i)	Frequency band	:	400 MHz band
(ii)	Type/gain	:	Collinear type/14 dBi (LDC, each power station)

(d) Collective supervisory board

(i)	Construction	:	Self-standing, metal enclosed cubicle type
(ii)	Indication mode	:	Manual lamp indication and figures indication (MW, down to one decimal place)

(e) Power supply equipment

(i)	Type	:	Compact battery/charger set (LDC, each power station)
(ii)	Voltage	:	DC 24V or 12V

10. Construction Plan for Facilities from Japan

(1) Conditions on site construction works

The matters to be attended to for the site construction works are described below:

(a) Special consideration for construction work is to be taken so as to avoid overlapping the construction works for heavy equipment.

(b) Special consideration for installation and testing of electrical equipment is to be taken in the interests of safety.

(c) Though acquisition of private and arable lands for the Project is easy, the lands are swampy. Therefore, new lines will be constructed along the road or on the existing lines routes.

(d) Power shall be shutdown during the execution of construction and reinforcement works for distribution lines and reconnection of cables to power stations. Power supply shall resumed toward evening. Special attention shall be paid to the work schedule and pre-information to the customers for the shutdowns.

(e) For construction of underground cables, prior applications will be required to be made in order to get the necessary permission from the Road Department. The finishing works, including paving and asphalting of roads, will be done by the Contractor according to the regulation of the Road Department.

(f) For tree felling and trimming for distribution line works including exploration of the line route, prior applications for permission from the concerned authorities are required.

(2) Construction supervision plan

EDP's project office will administrate and coordinate the Project works. The design and construction supervision of the Project will be undertaken by the Consultant. The works to be done by EDP, such as supervision of construction work and storage of the dismantled materials and equipment, will also be managed by the project office.

(3) Procurement plan of materials and equipment

Supply and erection of materials and equipment for the Project will be executed by a Japanese Contractor(s). However, considering local material prices, materials such as gravel, plywood and blicks will be procured in Cambodia.

(4) Transportation plan

All materials and equipment procured in Japan will be transported from Japan to Phnom Penh by the following route:

Japan - transport by sea - Cambodia (Kompong Som) - transport by land (Route 4) or railway - Phnom Penh

From the economical aspect, equipment and materials are to be packed and transported by container, except heavy machines.

(5) Implementation schedule

Stage-1 Project

Generating facilities

(a) Diesel engine generator set, 5,000 kW x 1 set
(b) Auxiliary equipment
(c) Transformer, 6,300 kVA x 1 set
(d) 6.3 kV switchboard
(e) 15 kV switchboard, in total 4 sets
    for city service : 2 sets
    for No. 1 P/S : 1 set
    for No. 4 P/S : 1 set
(f) Station service transformer, 630 kVA x 1 set
(g) AC panel, Motor Control Center
(h) Battery and charger 1 set
(i) Control and protection equipment

Distribution line facilities

(a) City service distribution line, 2 circuits 7.6 km
(b) Interconnection line for No. 1 P/S and No. 4 P/S
(c) Substation transformer, 250 kVA x 3 sets

(d) Distribution switchgear, single bus bar with CB for No. 1 P/S and No. 4 P/S
(e) Distribution switchgear, single bus bar with LBS, 5 sets (SS No. 8, No. 127, No. 20)

Civil and building works

(a) Civil construction work (land formation, access road, drain ditch, outdoor civil work)
(b) Building work (generator and auxiliary equipment foundations, painting, lighting, air-conditioning)

Stage-2 Project

Generating facilities

(a) Diesel engine generator set, 5,000 kW x 1 set
(b) Transformer, 6,300 kVA x 1 set
(c) 6.3 kV switchboard
(d) 15 kV switchboard, in total 2 sets
Interconnection lines: 2 sets
(e) Station service transformer, 630 kVA x 1 set
(f) Motor Control Center
(g) Control and protection equipment

Telecommunications and load dispatching system

(a) Fixed station equipment, 6 sets (LDC 1 set, power stations 5 sets)
(b) Mobile equipment, 4 sets
(c) Collective supervisory board
(d) Power supply equipment

Distribution line facilities

(a) North-South interconnection line, 22.0 km
(b) Distribution switchgear, single bus bar with CB for No. 3 P/S, 4 sets
(c) Distribution switchgear, double bus bar with CB for No. 2 P/S, 2 sets
(d) Distribution switchgear, single bus bar with LBS, 2 sets (SS No. 7, No. 193)

11. CONCLUSION AND RECOMMENDATION

It is forecasted that power demands in Phnom Penh and Siem Reap cities will grow at the respective rate of about 9% and 23% annually. The team recommends the following comprehensive rehabilitation and reconstruction plans for both cities.

Phnom Penh Power System

(1) Generating facilities

(a) Rehabilitation of all generating facilities except those installed in No. 1 and No. 5 Power Station. Total output of about 28 MW is excepted to be restored due to the rehabilitation.

(b) Medium and long terms development of hydropower generating plants as the main energy source in the country. The hydropower plants destroyed and interrupted during the war are scheduled to begin their generation around the end of 1999.

(c) Short term development of diesel-engine generating facilities till operation of hydropower plants. By the end of 1999, about 37 MW diesel generating facilities are anticipated to newly be added to the power system.

(2) Distribution and load dispatching facilities

(a) Construction of an interconnection line among power plants for exchange of power in both power systems.

(b) Unification of three (3) distribution line voltages for effective system operation and improvement of the voltage regulation and system energy loses.

(c) Repair and reinforcement of high and low voltage lines for upgrade of power quality.

(d) Supply of adequate tools and instrument for proper operation and maintenance.

(e) Renew of the existing load dispatching facilities for efficient system operation and quick response to system faults.

(3) Management of power system

(a) Re-organization of power utility for more efficient functioning.

(b) Introduction of adequate office equipment for efficient business.

(c) Education and training of employees to improve their abilities by expatriate experts.

(d) Review on operation system of power facilities for efficient and safe operation and maintenance.

(e) Establishment of store and safety control.

(f) Revision of power tariff system and establishment of meter calibration system.

Siem Reap Power System

(1) Generating facilities

(a) Improvement of synchronizing devices for the No. 2 and No. 3 generators for safe operation of machines.

(b) Increase of output of the No. 1 generating unit due to improvement of its turbo-charger.

(c) Stage wise addition of new generating units (4 MW at least by the year 1995) before hydropower is expected to be connected.

(2) Distribution and load dispatching facilities

(a) Construction of a high tension network due to extension of the existing lines.

(b) Upgrade of line voltage and conductors/cables in high tension system for improvement of voltage regulation and energy losses.

(c) Promotion of electrification due to expansion of low tension network.

(d) Supply of tools and instrument required for proper operation and maintenance.

(e) Provision of load dispatching system in expanding power system for efficient system operation and quick response to system faults.

(3) Management of power system

(a) Re-organization of power utility for more efficient functioning.

(b) Introduction of adequate office equipment for efficient business.

(c) Education and training of employees to improve their abilities by expatriate experts.

(d) Review on operation system of power facilities for efficient and safe operation and maintenance.

(e) Establishment of warehouse management and safety control.

(f) Revision of power tariff system and establishment of meter calibration system

Examining in detail the programs for rehabilitation and reconstruction by other donor countries and institutions, the Study Team recommends following facilities to be implemented urgently in the Phnom Penh power system under assistance of Japan.

(A) Addition of 10 MW diesel engine generating facilities to the No. 5 power plant

For covering deficit power supply until hydropower plants will be operated, 10 MW generating facilities are required in addition to program implemented by other donors. The facilities from Japan will be operated for base-load requirement in the system due to machines in high efficiency and low fuel consumption.

(B) Construction of interconnection line among power plants for effective system operation

(C) Construction of new high voltage lines from the No. 5 power plant to heavily loading areas for release of over-load condition of the existing lines.

(D) Improvement of the existing load dispatching facilities.

Japan's assistance to those facilities should give the following effects to the power system.

(a) The new 10 MW Power Station will produce power equivalent to 40% of total output of the system in February 1993, and contribute much to the improvement of the power shortage condition.

(b) The interconnecting lines makes smooth power exchange between the present two (2) power systems and results in technical efficiency and economical operation of the system.

(c) Direct 15 kV lines from the No. 5 power plant promise stable power supply to the important areas in the city and improve voltage regulation and energy losses in the areas.

(d) Improvement of the existing load dispatching facilities ensures efficient and economical operation of each generating units in the system and results in quick restoration of the system faults.

Besides those direct effects, the recommended plans should indirectly contribute restoration of infrastructures in the various fields of the area and improve people's welfare and life level. It is concluded that the recommendation mentioned above should be realized under Japan's assistance as urgently as possible, in combination with other donors.

TABLES

Major Materials and Equipment to be Provided (First Stage) (1/2)

Description	Quantity	Unit
A) Generating Facilities		
1) Diesel Engine 7,090 PS	1	No.
2) Compressed Air Starting System	1	Set
3) Fuel Oil Supply System		
Fuel Oil Tank 1,000 kl	1	Set
Fuel Oil Buffer Tank	1	No.
Fuel Purifier Unit	1	Set
Fuel Filter	1	Set
4) Lubricating Oil System		
Sump Tank	1	No.
Lubricating Oil Cooling Unit	1	Set
Lubricating Oil Filter	1	Set
Lubricating Oil Purifier Unit	1	Set
Sludge Collecting Tank	1	No.
5) Cooling Water System		
Cooling Water Tank	1	No.
River Water Treatment Unit	1	Set
City Water Purifier Unit	1	Set
Cooling Tower	1	No.
6) Intake Exhaust Air System		
Exhaust Air Duct	1	Set
Intake Air Duct	1	Set
Air Filter	1	No.
Intake Silencer	1	No.
Exhaust Silencer	1	Set
7) Sludge Treatment System	1	Set
8) Synchronous Generator 5,000kW	1	No.
9) Exciter Cubicle	2	Nos.
10) Syncronizing Panel	1	No.
11) Generator Control Panel	2	Sets
12) Switchboards for Generator (6.3kV)	2	Nos
13) Feeder Control Panel	1	Set

Major Materials and Equipment to be Provided (First Stage) (2/2)

Description	Quantity	Unit
14) Step-up Transformer 15/6.3kV 6,300kVA	1	No.
15) Station Service Transformer 6.3kV/400-230V 630kVA	1	No.
16) Switchbords for Station Service Transformer (6.3kV)	2	Nos.
17) Switchboards for Step-up Transformer (6.3kV)	2	Nos.
18) Low Tension Cubicles (400/230V)	2	Nos.
19) Motor Control Center	1	Set
20) DC Power Supply Unit (Battery and Charger) DC110V	1	Set
21) Maintenance Tools, Measuring Instruments & Spare Part	1	Set
B) Distribution Line Facilities		
1) 20kV Power Cable 3C-150 sq.mm	7.60	km
2) Pole Transformer 15kV/380-220V 250 kVA	1	Nos.
3) Feeder Cubicle (15kV)	11	Nos.
4) Measuring Instruments	1	Set

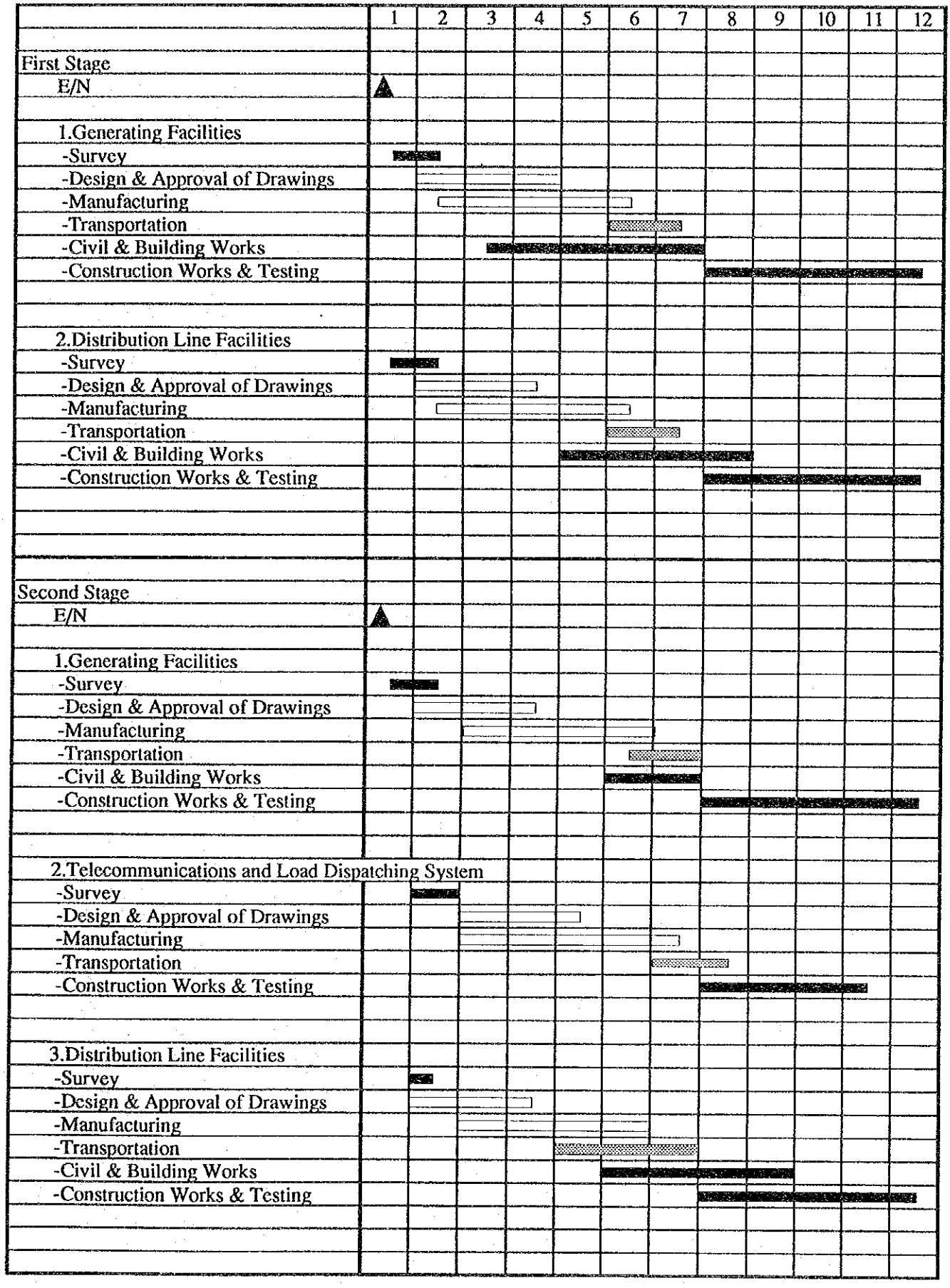
Major Materials and Equipment to be Provided (Second Stage) (1/2)

Description	Quantity	Unit
A) Generating Facilities		
1) Diesel Engine 7,090 PS	1	No.
2) Compressed Air Starting System	1	Set
3) Fuel Oil Supply System		
Fuel Oil Tank 1,000 kl	1	Set
Fuel Purifier Unit	1	Set
Fuel Filter	1	Set
4) Lubricating Oil System		
Sump Tank	1	No.
Lubricating Oil Cooling Unit	1	Set
Lubricating Oil Filter	1	Set
Lubricating Oil Purifier Unit	1	Set
5) Cooling Water System		
Cooling Tower	1	No.
6) Intake Exhaust Air System		
Exhaust Air Duct	1	No.
Intake Air Duct	1	Set
Air Filter	1	No.
Intake Silencer	1	No.
Exhaust Silencer	1	Set
7) Synchronous Generator 5,000kW	1	No.
8) Step-up Transformer 15/6.3kV 6,300kVA	1	Set
9) Station Service Transformer 6.3kV/400-230V 630kVA	1	No.
10) Maintenance Tool, Measuring Instrument & Spare Parts	1	Set
B) Telecommunications and Load Dispatching System		
1) Fixed Radio Station Facility for LDC	1	Set
2) Collective Supervisory Board	1	Set
3) Fixed Radio Station Facilities for Power Stations	5	Sets
4) Mobile Radio Facilities (car mounted type)	4	Sets
5) Maintenance Tools	1	Set

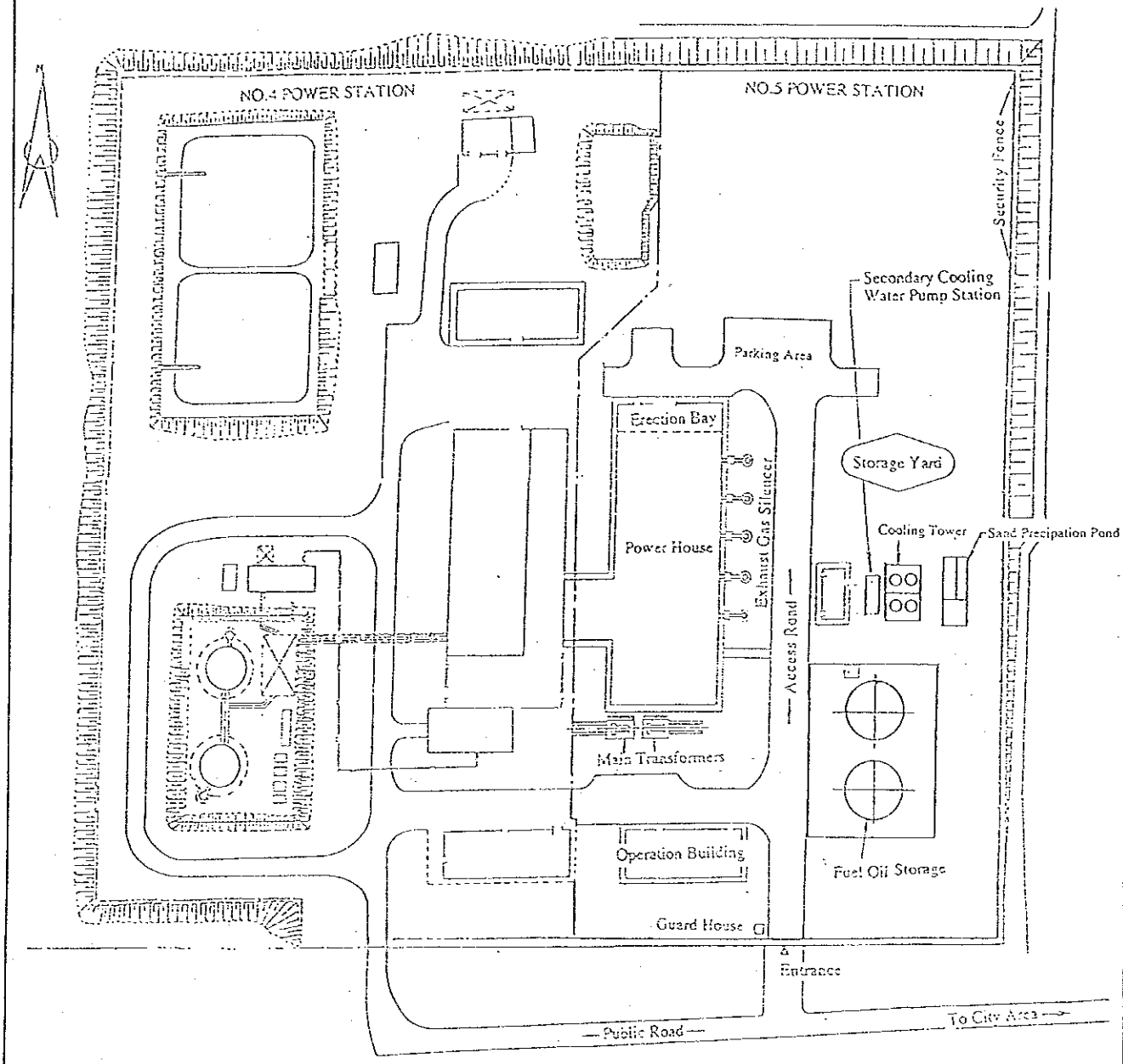
Major Materials and Equipment to be Provided (Second Stage) (2/2)

Description	Quantity	Unit
C) Distribution Line Facilities		
1) 20kV Overhed Line Supports		
2CCT Poles at Straight Point of the Lines	307	Sets
2CCT Light Angle Point of the Lines	27	Sets
2CCT Heavy Angle Point of the Lines	38	Sets
2CCT Poles at Dead-end Point of the Lines	6	Sets
2) Conductor HAL 120 sq.mm	113.1	km
3) 20kV Overhed Line Supports		
1CCT Poles at Straight Point of the Lines	19	Sets
1CCT at Light Angle Point of the Lines	1	Set
1CCT Poles at Dead-end Point of the Lines	4	Sets
4) Conductor HAL 120 sq.mm	3.78	km
5) 20kV Power Cable 3C-150 sq.mm	1.45	km
6) Pole Transformer 15kV/380-220V 250 kVA	2	Nos.
7) Feeder Cubicle (15kV)	10	Nos.
8) Maintenance Tools	1	Set

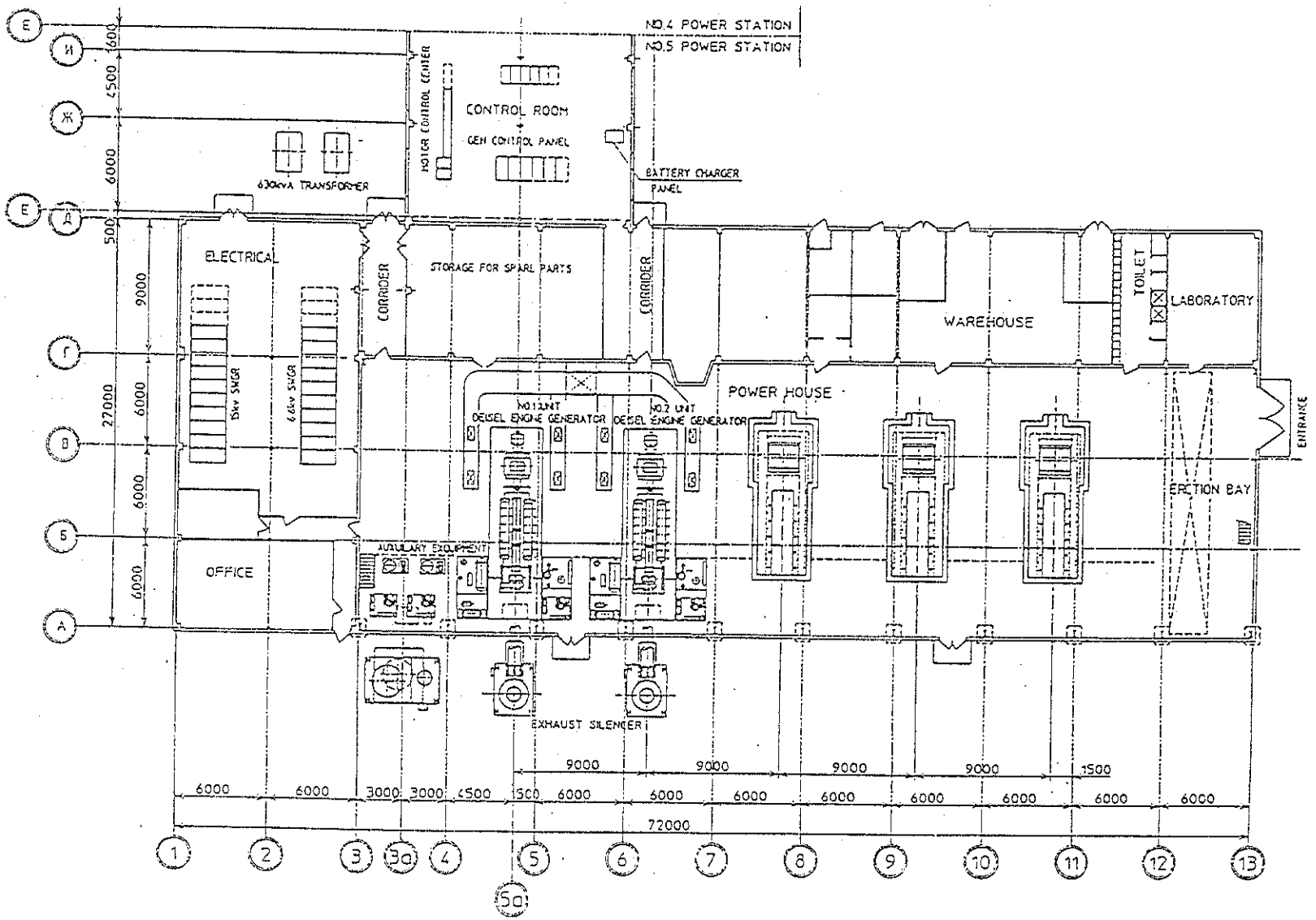
Implementation Schedule



FIGURES

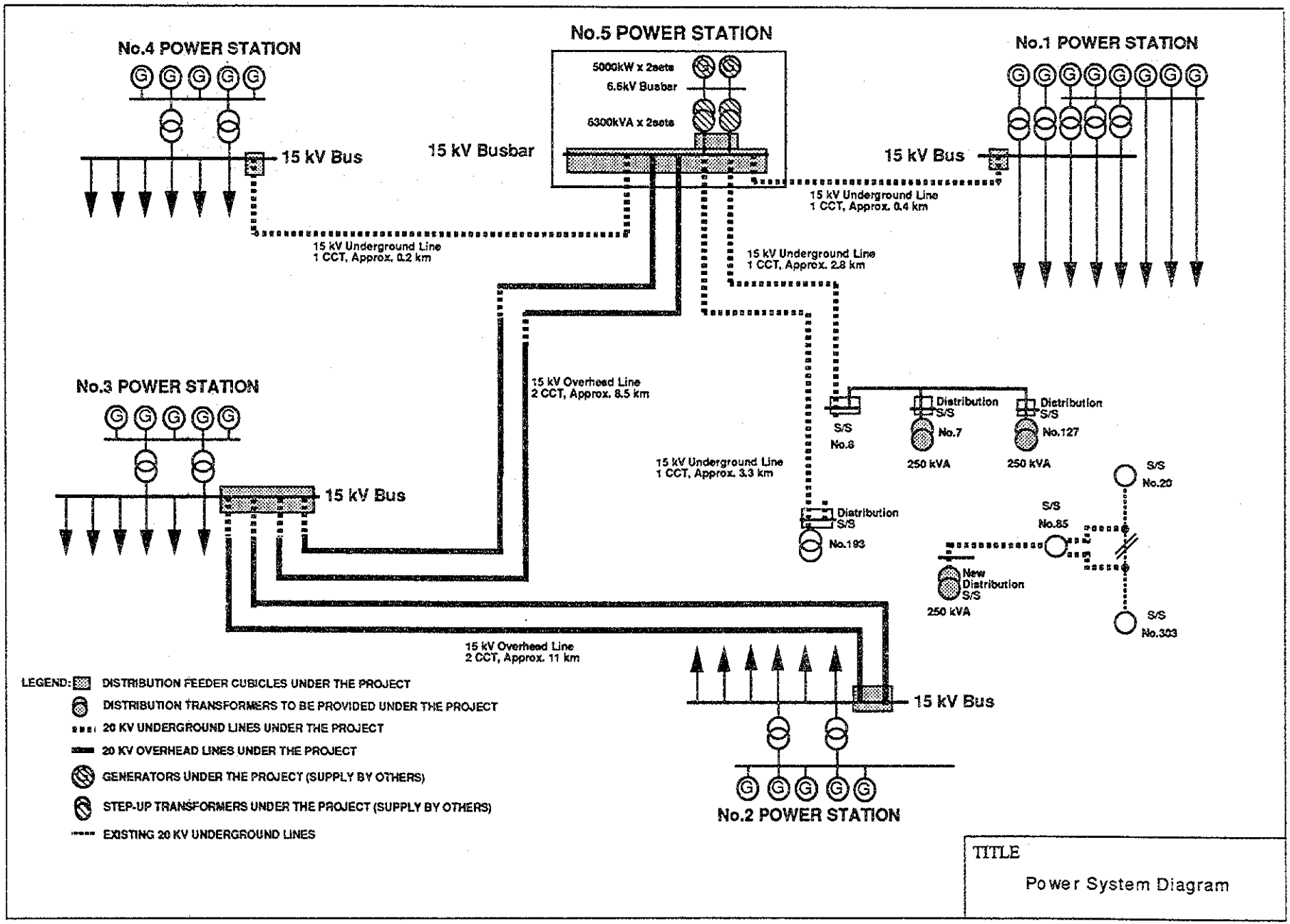


TITLE **Arrangement of No.5 Power Station**



TITLE

Arrangement of Equipment


No.4 POWER STATION
15 kV Bus
No.5 POWER STATION
5000kW x 2sets
6.6kV Busbar
6300kVA x 2sets
15 kV Busbar
No.1 POWER STATION
15 kV Bus
15 kV Underground Line
1 CCT, Approx. 0.4 km
15 kV Underground Line
1 CCT, Approx. 0.2 km
15 kV Underground Line
1 CCT, Approx. 2.8 km
No.3 POWER STATION
15 kV Bus
15 kV Overhead Line
2 CCT, Approx. 8.5 km
15 kV Underground Line
1 CCT, Approx. 3.3 km
S/S
No.8
Distribution
S/S
No.7
250 kVA
Distribution
S/S
No.127
250 kVA
S/S
No.20
S/S
No.85
Distribution
S/S
No.193
New
Distribution
S/S
250 kVA
S/S
No.303
15 kV Overhead Line
2 CCT, Approx. 11 km
15 kV Bus
No.2 POWER STATION
LEGEND:
DISTRIBUTION FEEDER CUBICLES UNDER THE PROJECT
DISTRIBUTION TRANSFORMERS TO BE PROVIDED UNDER THE PROJECT
20 KV UNDERGROUND LINES UNDER THE PROJECT
20 KV OVERHEAD LINES UNDER THE PROJECT
GENERATORS UNDER THE PROJECT (SUPPLY BY OTHERS)
STEP-UP TRANSFORMERS UNDER THE PROJECT (SUPPLY BY OTHERS)
EXISTING 20 KV UNDERGROUND LINES
TITLE
Power System Diagram

MINUTES

MINUTES OF DISCUSSIONS

MASTER PLAN STUDY ON REHABILITATION AND RECONSTRUCTION OF ELECTRICITY SUPPLY IN PHNOM PENH, CAMBODIA

In response to the request of Supreme National Council (SNC), Japan International Cooperation Agency (JICA) on behalf of the Government of Japan (GOJ) dispatched a study team for the captioned study to Cambodia from January through February for field survey, collection of information/data and discussion with the Cambodian counterparts. The team, in Japan, is studying the master plan for the captioned project and has completed the basic design level study on the Project for Rehabilitation of Electric Power Supply in Phnom Penh (hereinafter referred to as "the Project") recommended in the master plan study. JICA sent the study team to Cambodia again, and explained the progress report of the study and discussed with the Cambodian counterparts on the contents of the report from March 23 through March 26, 1993 in Phnom Penh.

In the course of discussions, the Phnom Penh municipality and Electricite de Phnom Penh (EDP) have agreed and accepted, in principle, with the components being studied for the master plan and the components concluded through the basic design level study for Phnom Penh power system. The team will further continue the master plan study on the basis of the confirmed items to prepare the draft Final Report of the study.

The Phnom Penh municipality and EDP have agreed to be responsible for taking necessary measures listed in the Attachment.

Phnom Penh, March 27, 1993

For H.E Hor Namhong
Member of S.N.C
Coordinator for Economic Cooperation

Ko Nakajima
Leader of JICA Study Team

Keo SAVIN
Director of Electricite de Phnom Penh

H O K L U N D Y
Mayor of Phnom Penh Municipality

4

ATTACHMENT

1. Responsible institutions of Cambodia for the Project

(1)	Responsible Ministry	: Ministry of Industry (MOI)
(2)	Responsible Authority	: Municipality of Phnom Penh (MPP)
(3)	Implementing Agency	: Electricite de Phnom Penh (EDP)

2. Japan's Grant Aid System

The MOI, MPP and EDP have understood the system of Japanese Grant Aid Program explained by the Team.

3. Necessary measures to be taken by MPP and EDP in case Japan's Grant Aid is extended.

MPP and EDP confirmed to undertake the following measures for implementing the Project, when the grant aid of the government of Japan (GOJ) will be extended.

(1) To provide with all data and information necessary for the design to Japanese nationals whose services may be required for the Project.

(2) To secure permission for entry into private properties or restricted areas for conduct of the Project.

(3) To assign the necessary counterpart experts working in Phnom Penh at the expense of Cambodia for the duration of assignment of the consultants related with the Project.

(4) To provide necessary vehicles with drivers, fuel and spare parts for the Cambodian counterparts working in Phnom Penh at the expenses of Cambodian side during their assignment.

(5) To bear the following commission to Japanese foreign exchange bank for the banking service on the basis of the banking arrangements:
   (i) advising commission of Authorization to Pay
   (ii) payment commission

(6) To ensure tax exemption and customs clearance of the products at the port of disembarkation in Cambodia.

(7) To accord Japanese nationals whose services may be required in connection with the supply of the products and the services under the verified contract, such facilities as may be necessary for their entry into Cambodia and stay therein for the performance of their work.

(8) To exempt Japanese nationals from customs duties, internal taxes and other fiscal levies

which may be imposed in Cambodia with respect to the supply of the products and services under the verified contracts.

(9) To bear all the expenses, other than those covered by the Grant, necessary for the execution of the Project.

(10) To secure land required to accomplish the project and to obtain the right of construction of all facilities under the Project in advance of the commencement of the Project.

(11) To maintain and use properly and effectively the facilities constructed and equipment provided under the Grant.

(12) To provide facilities for the distribution of electricity, water supply, drainage and other incidental facilities.

(a) the distribution line to the site.

(b) the city water distribution main to the site.

(c) the city drainage main (for storm, sewer and others) to the site.

(13) Other relevant undertakings:

(a) To obtain permission from authorities concerned for construction of underground cables and overhead lines along the routes selected.

(b) To inform purpose of the Project to people in the Project area and to request their cooperation to the Project.in advance of the commencement.

(c) To coordinate with the inhabitants living in the Project area on matters which may arise during the implementation of the Project.

(d) To take power shutdown required for implementation of the Project.

(e) To secure safety of Japanese nationals for the Project.

(f) To obtain right of water pumping from the Tonle Sap for cooling the engines.

(g) To extension the substation building in the existing No.2 power station for interconnecting line, at EDP's expenses as designed by JICA and before commencement of the construction of the interconnection line.

MINUTES OF DISCUSSIONS

MASTER PLAN STUDY
ON REHABILITATION AND RECONSTRUCTION OF ELECTRICITY SUPPLY
IN PHNOM PENH AND SIEM REAP, CAMBODIA

In response to the request of Supreme National Council (SNC), Japan International Cooperation Agency (JICA) on behalf of the Government of Japan (GOJ) dispatched a study team for the captioned study to Cambodia from January through February for field survey, collection of information/data and discussion with the Cambodian counterparts. The team, in Japan, is studying the master plan for the captioned project and has completed the basic design level study for the sub-projects recommended in the master plan study. JICA sent the study team to Cambodia again, and submitted the progress report of the study in 20 copies to the Ministry of Industry on the day of March 22, 1993.

The team held discussions with officials concerned of Cambodia on the contents of the report from March 23 through March 26, 1993 in Phnom Penh.

In the course of discussions, Cambodian side has, in principle, agreed and accepted in the components being studied for the master plan and the components concluded through the basic design level study. The team will further continue the master plan study on the basis of the agreement to prepare the draft Final Report of the study.

Phnom Penh, March 28, 1993

For H.E. Hor Namhong
Member of S.N.C
Coordinator for Economic Cooperation

Ko Nakajima
Leader of JICA Study Team

Mr. Khlaut Randy
Vice Minister of Ministry of Industry
Cambodia

MINUTES OF DISCUSSIONS

MASTER PLAN STUDY ON REHABILITATION AND RECONSTRUCTION OF ELECTRICITY SUPPLY IN PHNOM PENH AND SIEM REAP, CAMBODIA

In response to the request of Supreme National Council (SNC), Japan International Cooperation Agency on behalf of the Government of Japan (GOJ) dispatched a study team for the captioned study to Cambodia from January through July 1993. The Team has conducted field survey with collection of information/data, analyzed the information/data and prepared the progress report and interim report under cooperation of the Cambodian counterparts. The Team submitted its Draft Final Report for the study on June 28, 1993 to Electricite du Cambodge (EDC). The report includes Basic Design Level Study for the recommended facilities most effectively to contribute to rehabilitation and reconstruction of the Phnom Penh power system and to be implemented under the assistance of GOJ. The Team explained the master plan and basic design to EDC from June 30 through July 6 1993 in Phnom Penh. EDC agreed to the report.

On April 27, 1993 the former Electricite de Phnom Penh (EDP) changed its name to EDC. However, its new organization was not disclosed during the Team's stay in Cambodia. EDC agreed with the Team that descriptions in the report relating to the organizations and functions of the country's power sector as well as new EDC will remain unchanged due to current indefiniteness on them.

Through the discussion with the Team, EDC verbally asked the Team to convey the following EDC's proposals to GOJ. The Team undertakes to do this conveyance.

(1) request for further assistance in rehabilitation and reconstruction of electricity supply of the provincial power systems.
(2) request to conduct the master plan study of Cambodia's water resources for hydropower development in medium and long term program of energy sector.

Phnom Penh, July 8, 1993

ELECTRICITE DU CAMBODGE

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