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

FINAL REPORT

July 1993

NIPPON KOEI CO., LTD.

IN ASSOCIATION WITH

TOKYO ELECTRIC POWER SERVICES CO., LTD.

TOKYO,JAPAN

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PREFACE

In response to a request from the Supreme National Council (SNC), the Government of Japan decided to conduct a Master Plan Study on Rehabilitation and Reconstruction of Electricity Supply in Phnom Penh and Siem Reap in Cambodia and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Cambodia a study team headed by Mr. Ko Nakajima of Nippon Koei Co., Ltd. 3 times during the period from January 1993 to July 1993.

The team held discussions on the project with the officials concerned of Cambodia, and conducted field surveys at the study area. After the team returned to Japan, further studies were made and the present report was prepared.

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 Cambodia for their close cooperation extended to the team.

July 1993

Kensuke Yanagiya

Kensuke Yanagiya
President
Japan International Cooperation Agency

30 July 1993

Mr. Kensuke Yanagiya
President
Japan International Cooperation Agency
Tokyo, Japan

Dear Mr. Yanagiya,

Letter of Transmittal

We are pleased to submit to you the master plan study report on Rehabilitation and Reconstruction of Electricity Supply in Phnom Penh and Siem Reap, Cambodia. The study has been conducted by the team from January 1993 through July 1993. The report contains the advice and suggestions of the authorities concerned of the Government of Japan and your Agency as well as the formulation of the above mentioned project. Also included are comments made by the Ministry of Industry and Electricite du Cambodge of the Government of Cambodia during technical discussions on the progress report and draft final reports which were held in Phnom Penh.

This report presents the master plan for rehabilitation and reconstruction of power supply facilities in both cities and the basic design level study for the most effective facilities for restoration of the Phnom Penh power system recommended in the master plan for the Phnom Penh power system.

We believe that our recommendation for quick restoration of the power systems in both cities will be useful for programming the restoration of the country's infrastructures and that power facilities recommended for Assistance of the Government of Japan greatly contributes direct effect to restoration of the Phnom Penh power system and indirect effect to various fields of the area as well as improvement of people's life level.

We wish to take this opportunity to express our sincere gratitude to your Agency, the Ministry of Foreign Affairs and the Ministry of International Trade and Industry. We also wish to express our deep gratitude to the Ministry of Industry, the Ministry of Foreign Affairs, Electricite due Phnom Penh and other authorities concerned of the Cambodian Government for the close cooperation and assistance extended to us during our investigations and study.

Very truly yours,

K. Nakajima

Ko Nakajima
Team Leader
Master Plan Study on Rehabilitation and
Reconstruction of Electricity Supply in
Phnom Penh and Siem Reap, Cambodia

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Master Plan Study

Chapter 1

Introduction

CHAPTER 1 INTRODUCTION

1.1 Background of the Project

(1) Present situation of the project site

Cambodia is administratively divided into twenty-one (21) municipalities and provinces. The capital, Phnom Penh, which is one of the areas subject to this Study, is the political, economic, and cultural center of the country. Traditionally an agricultural country, Cambodia was known as an exporter of rice, rubber, and other agricultural commodities. However, with the outbreak of war in 1970 and the continuing civil conflict, the economic infrastructure of the country was almost completely destroyed. The annual Gross National Product (GNP) per capita in 1992 was estimated at 150 US dollars with an annual growth rate of 9.0% over the previous year.

Over the past few years Phnom Penh has experienced a tremendous increase in automobiles, motorcycles, and restaurants, as well as increased dispersion of televisions, jewelry, and garments. While many products can be seen in market stalls, there is little in the way of production and, thus, practically no real economic growth. Cambodia has yet to pull itself out of poverty.

Another area subject to this Study is Siem Reap, the central city of Siem Reap province. The city is a typical tourist town, and is only a few kilometers from the Angkor Complex which was built between the ninth and thirteenth centuries by the Khmer Empire. It is reported that the number of tourists who visited Siem Reap city reached 10,000 in 1992 and the number of hotel rooms available was 250, in 6 hotels, as of February 1993. The number of tourists is anticipated to rapidly increase due to stabilized security conditions in the region. Therefore, the People's Committee of Siem Reap province approved applications to construct new hotels and increase the number of hotel rooms in Siem Reap city to a total of 2,000 by 1995.

(2) Energy and power sector conditions

There has been no exploration of fossil resources yet. A major problem hampering reconstruction and development efforts in Cambodia is the acute shortage of fuel to meet the country's basic needs. Before 1990, all fuel was

imported from the former Soviet Union through long-term commodity agreements. From early 1991 onwards, no further fuel supply was forthcoming from the former Soviet Union and the fuel supply situation rapidly deteriorated. In 1990, fuel imports were estimated to be about 300,000 tons. The total fuel imports for 1991 were estimated to be less than 200,000 tons. The total demand, however, is estimated to be at least 450,000 tons. Some 40% of the available fuel supply goes to industry and transportation; 35% to the electric power sector; and 25% to the agricultural sector. Presently, most fuel imports are from Singapore, but due to the lack of foreign exchange the imported quantities are much constrained. The severe shortage of fuel is seriously affecting all sectors of the economy. In addition, all the hydroelectric power stations were destroyed by war and are yet to be restored. Cambodia relies on petroleum imports to generate electricity, and on charcoal and firewood for its entire energy resources at present. Per capita annual electricity consumption 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. Thus, charcoal and firewood remain the main source of energy for the general population.

Both the cities of Phnom Penh and Siem Reap are obliged to introduce the scheduled shutdown of power supply due to a shortage in 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 the power situation in the cities.

(3) Official request from the Government of Cambodia to the Government of Japan

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.

1.2 Scope of the Study

The scope of the Study was agreed between the Ministry of Industry (MOI) in the Supreme National Council (SNC) and the 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.

The actual scope of the Study to be undertaken for both cities is outlined below:

(1) Collection and preliminary analysis of all information and materials in Japan.

(2) Site investigation on the following facilities and items:

- (a) power market
- (b) existing generating facilities
- (c) existing distribution facilities
- (d) operation and management of the power system
- (e) policies and management of the power sector
- (f) environmental condition of the existing generating facilities
- (g) transportation route

(3) Formulation of master plan

The following will be studied for formulating the master plan:

- (a) power demand forecast (5-6 years)
- (b) optimum plan for rehabilitation and reconstruction of generating facilities
- (c) optimum plan for rehabilitation and reconstruction of distribution facilities
- (d) optimum plan for rehabilitation and reconstruction of power network, telecommunications, and load dispatching facilities
- (e) power tariff
- (f) management of power sector

(g) operation and management of the existing power facilities
(h) diagnostic examination of generating facilities in Siem Reap
(i) evaluation of the master plan
(j) selection of the most effective and adequate sub-projects for rehabilitation and reconstruction of the power supply facilities

(4) Basic design study of facilities recommended for Phnom Penh city

The following will be carried out for the basic design study:
(a) detailed site investigation for the selected sub-projects
(b) basic design for the selected sub-projects
(c) preparation of an implementation schedule
(d) recommendations for the operation and management of the selected sub-projects
(e) evaluation of the project

(5) Preparation and submission of reports

The following reports were submitted:

(a)	Inception report	:	Beginning of January 1993
(b)	Interim report	:	Beginning of February 1993
(c)	Progress report	:	End of March 1993
(d)	Draft final report	:	End of June 1993
(e)	Final report	:	End of July 1993

Chapter 2

Profile of Country and Project Area

CHAPTER 2 PROFILE OF COUNTRY AND PROJECT AREA

2.1 Project Area

The project area of the present Study covers Phnom Penh city and Siem Reap city. The profile of both cities is as follows:

2.1.1 Phnom Penh City

Phnom Penh is the capital of Cambodia. It is located on the west bank of the Chaktomuk river where four rivers (upper Mekong, lower Mekong, Tonle Sap, and Bassac) meet. It is the center of politics, culture, economics, and trading. Since its establishment, the city has been the connecting point for land, air, and water transportation, and also a distribution center for goods to all other parts of the country.

In 1910 Phnom Penh was a small city with a population of only 100,000, located on an area of 4 km x 1 km. At that time the city area was on forested and low wetland. The city then expanded; a series of dikes were constructed and the land was filled with materials dredged from the riverbed for protection from flooding during the rainy season. The river's high water level is EL. 10 - 10.5 m while the city land level is EL. 6.0 - 15.0 m.

Administratively the city is divided into 7 districts with a total area of 289 km^2. Four districts form the inner city (urban center) with an area of 29 km^2. The suburban area comprising three districts extends over 260 km^2. The Municipal Government has a plan for expanding the city in four directions: 1) to the southwest: production and industrial center; 2) to the west: residential and service area; 3) to the northwest: residential and production center, and 4) to the east: Chruoy Changwa Island.

The Municipal Government estimated that the registered population of the city was 674,000 and the number of households was 113,000 at the end of May 1992. Besides the registered population, there are a number of unregistered people who stay as temporary residents. Thus, the actual population of Phnom Penh is estimated at 1 million. The city's population increased from 428,000 in 1985 to 625,000 in 1990 with an annual growth rate as large as 7.9% while the growth rate of the whole country was 2.8%.

2.1.2 Siem Reap City

The city of Siem Reap, which lies 250 km northwest of Phnom Penh, is the central city in Siem Reap province. The population of the province was 555,000 in 1991 and its land area is 15,270 km^2. Rice farmers make up 90% of the total population.

The Siem Reap city territory covers 306 km^2 and had a population of 80,000 in 1991. The famous remains of Angkor are located in this area. The urban population increased from 71,000 in 1989 to 80,000 in 1991 with an annual average growth rate of 6.1%. The city planning objective area is just 25 km^2 of the 306 km^2, covering 50,000 people. The inner city covers only 2 km^2 (1 km x 2 km) and absorbs 30,000 people.

The city is a typical tourist town and is only a few kilometers from the temples of Angkor and, thus, it serves as a base for visitors to the monuments. It is reported that 10,000 foreign tourists visited in 1992. Foreign tourists are expected to increase greatly following the restoration of political stability in Cambodia. It is expected more than 100,000 tourists will visit Siem Reap in 1995 and about 2,000 hotel rooms will be operated.

2.2 Land

Cambodia is an agricultural country blessed with fertile lands and water resources of the Mekong river basin. It is a compact territory situated in the southwestern part of the Indochina peninsula (longitudes 102°-108° East, latitudes 10°-15° North). It is divided into 21 provinces and special cities (Phnom Penh, etc.).

Cambodia has 181,035 km^2 in land area, a little over a half the size of Viet Nam, about one third of Thailand, or slightly less than half of Japan. It is bounded by Viet Nam to the east and southeast, by Thailand to the west, by Laos and Thailand to the north, and by the Gulf of Thailand to the south and southwest.

The country consists mainly of low plains crossed by many rivers. About 70% of the country is forested, while 16% of the country is mountainous. There are low mountain ranges along the northern border with Thailand and in the southwest, while the northeast part is a forested plateau which has a higher elevation than the central plain.

During the monsoon flood season between June and October, the overflow from the Mekong is diverted up the Tonle Sap River into the Great Lake, reversing Tonle Sap's

flow, expanding the area of the Lake to many times its normal size (normal area 2,600 km^2, maximum expanded area 25,000 km^2) silting and fertilizing the rice plains, and providing a large supply of fresh water fish. As the Mekong begins to recede, the Tonle Sap resumes its normal flow from mid-October.

2.3 Climate

The climate in Cambodia is tropical monsoonal. In summer, the southwest monsoon is drawn landward from the Indian Ocean, and, during the winter, the northeast monsoon sends back dry air. The southwest monsoon brings the rainy season from mid-May to early October, and the northeast monsoon's flow of drier and cooler air lasts from early November to March. The average annual rainfall is between 1,000 and 1,500 mm, with the heaviest falls in the southwest and southeast coastal areas (over 3,000 mm annually). Rainfall from April to September in the Tonle Sap Basin-Mekong lowlands area averages 1,300 to 1,900 mm annually, with the lowest rainfall found in the rain shadow region of the Elephant and Cardamom Mountains.

Temperatures are fairly uniform throughout the Central Basin area, with small variations from the annual mean of about 25°C. The maximum mean is about 28°C; the minimum about 22°C. Maximum temperatures of higher than 32°C, however, are common and, just before the start of the rainy season, maximum temperatures may rise to more than 38°C. Minimum temperatures rarely fall below 10°C. January is the coldest month, and April is the warmest. Typhoons (tropical cyclones), which often devastate coastal Viet Nam, rarely cause damage in Cambodia.

In Phnom Penh, the average annual rainfall is 1,375 mm, and the average annual temperature is 27.5°C. January is the coldest month, and April is the warmest.

2.4 Demography

According to the 1993 State Plan the total population of Cambodia at the end of 1992 was estimated at 9.17 million. Historically, the population has increased at an average annual growth rate of 2.8% which was estimated from the 1962 population census and 1980 population survey. The Government forecasts that the population will increase to 9.63 million in 1993 (5% increase from 1992) including repatriation of refugees estimated at 0.2 - 0.3 million.

According to the World Bank and Asian Development Bank (ADB) reports, the overall life expectancy is estimated to be 48 years. The birthrate is roughly estimated to be 40 per thousand, the death rate at 12 per thousand, and the infant mortality rate at 120 per thousand live births. Nearly half of the population is under 15 years of age and about a third of them is under three years. The economically active population is estimated to be only around 3 million.

About two thirds of Cambodia's population lives in the central plains which accounts for about one third of the country's total land area. About 90% of the population lives in rural areas. The average population density is approximately 50 persons per km^2 for the whole country; about 2,330 persons per km^2 in Phnom Penh city; and about 260 persons per km^2 in Siem Reap city.

Cambodia is almost ethnically homogeneous with Khmers accounting for 5/6 of the population. The rest of the population is made up of over 30 minority ethnic groups. Buddhism is the religion of 95% of the population.

Chapter 3

Economic Status of Cambodia

CHAPTER 3 ECONOMIC STATUS OF CAMBODIA

3.1 General Economy

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 devastated state and economy, and countrywide famine erupted. 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.

Since that period, the Government placed the utmost emphasis on rebuilding the country's agricultural production, with the assistance of Viet Nam, the former Soviet Union, and other socialist countries, in order to ensure an adequate supply of foods. Considerable progress was made, despite the wealth of problems besetting the country including floods, lack of fertilizer, and labor shortages. However, with the withdrawal of the Vietnamese Army in September 1989, the country returned to a state of civil war, which has affected all of Cambodia, including agriculture. The Government began its first 5-year national reconstruction and development plan in 1986. This plan has focused on four main items: foodstuffs, rubber, lumber, and marine products.

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. Life expectancy rose from 37 years in 1979 to 48 in 1989. Rice production increased again after having declined by more than two thirds between 1969 and 1979 to 800,000 tons. Production of milled rice reached 1.49 million tons in 1990. The value of exports rose to $50.0 million in 1989 from $1.0 million a decade earlier, although this was still well behind the 1969 levels.

Since 1989 a shift from a centralized planning regime to a market economy is being made. In the agricultural sector the responsibility for production has been returned to individual farmers. In the industrial sector a substantial proportion of state-owned enterprises has been privatized through the leasing of their assets to the private sector.

Recently the United Nations (UN)-sponsored peace keeping operations and energies brought about by privatization and liberalization have produced a surge of economic activity in Phnom Penh and in other urban areas. Commerce is flourishing and the refurbishing of real estate is in full swing. Consumer goods are normally imported through Thailand and Singapore, and the country remains heavily dependent on the West for a wide range of commodities. In addition, the Government permits private enterprise and joint venture activities between public and private sectors which has resulted in a steady growth in the manufacture of consumer goods. From 1987 through 1988, prices remained roughly stable. From the latter half of 1989, however, owing to the conditions described above, hyperinflation set in affecting foodstuffs, including rice and other daily necessities.

In the midst of this upsurge in activity, Cambodia's economy is now facing a number of severe challenges. These include: (i) the need to arrest and reverse the deterioration that has occurred in economic infrastructure and in the provision of basic services; (ii) the need to reduce inflation by increasing fiscal revenue and financing the budget deficit by non-inflationary means; (iii) the need to complete the transition to a market economy and to strengthen the country's capacity for macro-economic and financial management; and (iv) the need to reintegrate into the economy large numbers of Cambodian returnees, internally displaced persons, and demobilized military personnel.

The basic indicators of Cambodia are shown in Table I.3.1.

3.2 Production and Industrial Activities

3.2.1 Economic Growth

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

GDP Statistics

	1990	1991	1992
GDP (current prices, billion Riel)	594.8	1,396.8	2,695.8
GDP (constant 1989, billion Riel)	247.0	280.3	305.5
Growth rate (%)	-0.1	13.5	9.0

The agricultural sector, which absorbs about 85% of the work force, accounted for 47% of real GDP in 1991. The industrial and service sectors represented 16% and 37%, respectively. Of the total industrial output in 1991, manufacturing accounted for 54%, construction 38%; electricity, gas and water 1%; and mining and quarrying 7%. Real output of the industrial sector increased by 8.6% in 1991 and by about 9-10% in 1992.

3.2.2 Agriculture

Agriculture is the main industry in Cambodia. The agricultural sector produces mostly foodstuffs, particularly rice. In addition to paddy rice, farmers cultivate corn, potatoes, coconuts, soybeans, sugar cane, and other vegetables.

Cash crops include rubber, jute, kapok, mulberry, and tobacco. Rubber is a particularly important crop, making up one third of Cambodia's exports prior to the breakout of war in 1970. At the end of 1992, the area of rubber plantations amounted to 50,000 ha.

From 1979, the Government embarked on large scale agricultural production, and established the first collective federation, the Krom Samaki (102,000 collectives with 1.3 million farmers as of 1984). The Government has, however, abandoned this agricultural policy as it is considered unsuited to Cambodia and detrimental to improving agricultural production. After the constitutional reform of February 1989, personal possession and use of land became permitted, and private ownership of land was allowed.

Although Cambodia has a climate well suited to rice production, destruction of fields and shortages of seeds, fertilizers, tools, draft animals, and labor have wreaked havoc on harvested yields. In 1992 the land under rice cultivation amounted to 1.84 million ha, and paddy output reached approximately 2.22 million tons in 1992 (while annual requirements were approximately 2.8 million tons). Irrigated land as of 1992 was approximately 410,000 ha. There was a substantial amount of cattle, water buffalo, pigs, poultry, and other livestock; fishing and salt production were also important.

The region is blessed with the Mekong River and the Tonle Sap Lake which have an abundant supply of fish. At the end of 1992, there were 3.23 million cattle, 1.63 million pigs, and 8.38 million fowl (chicken and duck), while the combined annual catch of fish was 96,500 tons (freshwater fish 68,900 tons, sea-water fish 21,000 tons, and cultured fish 6,400 tons). Lumber production amounted to 117 million tons in 1992.

3.2.3 Industry and Mining

Cambodia began to restore its industrial facilities with assistance from Viet Nam and other socialist countries in 1979. A total of 69 factories were reopened and had commenced production by 1988. Total industrial production (within the Ministry of Industry's jurisdiction only) reached 19,805 million Riels in 1992, which in real terms (1989 constant prices) is equivalent to 4,362 million Riels, about the same as in 1991. The electricity produced in 1992 was estimated to be 215 GWh of which Electricite de Phnom Penh (EDP) accounted for 90.7% (195 GWh). The volume of clean water supplied in Phnom Penh in 1992 amounted to 21 million m^3.

Although mining is at present undeveloped, there are thought to be oil resources off the coast in the Gulf of Thailand. Cambodia has a 450 million tons per year demand for petroleum products, and about 300 million tons were imported from the former Soviet Union in 1990, through barter transactions for agricultural products.

3.3 Trade

Cambodia's trade has traditionally focused around Viet Nam, Laos, the former Soviet Union, and other socialist countries. However, in recent years, trade has grown with private associations in capitalist countries such as Japan, India, Singapore, Thailand, and France. There is considerable unofficial cross border traffic with Thailand and Singapore, and Cambodia's commercial network prospers from distribution of these goods. The state export-import corporation KAMPEXIM is responsible for trade.

In the past, Cambodia's main exports were fish and agricultural commodities, including rice, rubber, corn, pepper, peanuts, sesame, and jute. Cambodia has re-commenced exports of rubber, kapok, lumber, leaf tobacco, corn, soybeans, and shrimp. Cambodia's major imports are petroleum, machinery and equipment, automobiles, and motorcycles.

It was announced that total exports reached US$11.5 million in 1988, and imports reached US$16.6 million, while for 1989 the respective totals were US$17.4 million, and

US$24.1 million (Far Eastern Economic Review, Asia Year Book, 1991). In 1990, exports to socialist countries (Zone I) reached 20.11 million Rubles while imports reached 103.3 million Rubles.

The external trade with Zone II (non-socialist countries) has expanded noticeably since the introduction of an open trade policy in 1989. The exports to Zone II increased 1.6 times and the imports from Zone II expanded 2.7 times for the period from 1989 to 1992 as shown in the table below.

External Trade with Non-Communist Countries

(Unit: US$ million)

	1989	1990	1991	1992
Export	44	35	63	70
Import	135	115	243	360
Deficit	91	80	180	290

The trade statistics (1992) for Zone II countries are detailed in Table I.3.2.

Trade with Japan commenced in November 1990 through the Japan Cambodia Trade Association, and constructive exchanges continue. According to Japanese tax statistics, imports from Japan amounted to US$6.69 million, and exports amounted to US$5.47 million in 1991.

3.4 Financial and Monetary Situation

Before 1988 the Government fiscal revenue (including aid from socialist countries) formed 95% of the expenditure. In 1989 the budgetary deficit was 20% of the expenditure. The situation changed drastically in 1990 when the revenue dropped to less than 60% of the expenditure due to cessation of aid from the former Soviet Union. The deficit was covered by printing more bank notes. In 1992 the deficit was 42% of the expenditure. The reasons for this deficit were as follows:

- Hasty implementation of the market mechanism along with inefficient execution of the new tax system led to a decrease in state revenue.
- New sources of revenue have not actually increased budgetary revenue.
- Aid from the former Soviet Union ceased.

- A large amount of unplanned expenditures was required.

In 1992, revenue could cover just 58% of the expenditure. Most of the expenditure was for public administration, defense, and security. This led to high inflation and increased prices. Consequently the value of Riel against US$ dropped sharply : From Riel 800 per US dollar in March to Riel 2,300 per US dollar in December 1992.

Monetary financing of the budgetary deficit increased money supply volume, which increased by 28% in 1989, 150% in 1990, and 47% in 1991. However, this caused extremely high inflation in the country, running at average rates of 70% in 1989, 157% in 1990, 121% in 1991, and over 200% in 1992. This has badly affected the living standard of low income earners and government employees.

More detailed information on public finance is presented in Table I.3.3.

3.5 Economic Reform and Foreign Investment

Cambodia is implementing economic reform moving from a collective economy to a planned economy and then market economy to a pure market economy. Recognition of private land ownership has had positive effects, both politically and economically, on the agricultural sector. 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. Firstl an autonomous economic management system was implemented. However this system reached a deadlock because of the lack of raw materials, capital, guidance, and an imbalanced implementation of the policy by the concerned organizations. 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.

The reform of the banking system was also successful. At the end of 1992 there were 10 foreign bank branches (including joint ventures): Thai, Malaysian, French, British, etc.

Foreign investment contributed significantly to the development of Phnom Penh tourism. Many hotels and guest houses have been leased to private businesses (local and foreign). They have been quickly repaired, renovated, and equipped, with the expectation that there will be more foreign tourists coming before and after the general election in 1993.

By the end of December 1992 the Council of Ministers had approved 547 direct investment projects, of which 108 projects already have contracts and statutes.

3.6 Rehabilitation Program and External Assistance

With the signing of the Paris Accord on 23 October 1991, a 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.

Pursuant to the Paris Accord, the responsibility for the administration of Cambodia during the transitional period before the establishment of a new government through elections, planned for May 1993, is being shared by three entities: the Supreme National Council of Cambodia (SNC), the United Nations Transitional Authority in Cambodia (UNTAC), and the existing administrative structures. The Paris Accord also requires that existing administrative structures remain in place and operate, during the interim period, under the control and supervision of UNTAC.

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 UN.

RPC includes the following four main components:

(a) Humanitarian and Repatriation/Resettlement Assistance including: (i) repatriation of refugees from Thai border camps; (ii) food aid; (iii) programs for demobilized soldiers and internally displaced people; and (iv) resettlement activities.

(b) Agriculture and Rural Development and Maintenance of Essential Social Services including: (i) food security and agriculture rehabilitation; (ii) rehabilitation and maintenance of health and rural water and sanitation services and facilities; and

(iii) rehabilitation and maintenance of education and training services and facilities.

(c) Rehabilitation of Physical Infrastructure and Public Utilities including the rehabilitation of the following facilities: (i) transport system (roads, bridges, railways, ports and inland waterways, and civil aviation); (ii) electricity generation and distribution systems; (iii) urban water supply and sanitation systems; (iv) fuel storage and distribution facilities; and (v) special public works programs.

(d) Public Administration Support including: (i) public sector financing (including import support); (ii) strengthening of macroeconomic management and policy advice; and (iii) public administration capacity building and institutional strengthening and training.

As of September 1992, a total of about $800 million in external assistance had been pledged or committed to finance specific activities of RPC for the period from October 1991 to December 1993. About $60 million (or 7%) originates from the 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.

About $171 million has so far been allotted for humanitarian assistance and repatriation/resettlement activities. About $119 million has been pledged or committed by various countries for the rehabilitation of transport infrastructure. For the power sector, about $14 million is expected for rehabilitation of generation and distribution facilities in Phnom Penh (from France, Italy, Japan, Ireland, and UNDP). In November 1992 ADB decided to extend a $68 million loan for the Special Rehabilitation Assistance Project for rehabilitation of the transport, power, agriculture, and education sectors.

Under the Paris Accord, SNC and UNTAC are ultimately responsible for the monitoring and coordination of aid to Cambodia during the pre-election transitional period. UNDP is also playing a vital role in aid coordination. A UNTAC Director for Rehabilitation (appointed in March 1992) is responsible, in close consultation with SNC, for the coordination and clearance of all proposed external assistance to Cambodia during the transitional period. The Director is supported by the UNDP office in Phnom Penh. In

Cambodia, UNTAC/UNDP have also established a Donor Consultative Group to advise the Director on matters related to external assistance to be considered by SNC. The Donor Consultative Group also includes a series of technical subgroups for specific coordination in various sectors. From the beginning, RPC has been developed on the basis of an international coordinated effort involving the UN, International Monetary Fund (IMF), World Bank, ADB, and bilateral agencies and Non-governmental Organizations (NGOs).

3.7 Development Plan

Cambodia's economy is being rehabilitated and developed basically according to the second 5-year development plan (1991-1995). This plan was firstly prepared under a centralized planning system using the Net Material Product system rather than the UN System of National Accounts (SNA). Accompanying the introduction of a free market economic system the plan was reformulated in line with a market-oriented economy, with a prime focus on identifying broad sectoral priorities. The highest priority has been put on agricultural development. This requires the provision of more irrigation facilities and agricultural inputs such as seeds, fertilizers, pesticides, and an increase in draft animals. The intermediate objective is self-sufficiency in rice production, but the ultimate objective is to return to the pre-war status of a net exporter of rice. The second priority is power generation and distribution. The third priority is transport and communications, especially the repair and improvement of roads and bridges, the rehabilitation of the railway system, and the dredging of waterways. The fourth priority is urban development, especially in Phnom Penh. There is a strong need to improve the supply of electricity, hygiene, water supply, and sewerage. The fifth priority is social action, covering basically health, education, and culture.

The Ministry of Planning prepares annual development plans on the basis of the second 5-year plan. The state development plan for 1993 was approved by the Council of Ministers in mid January 1993. According to this plan policy objectives and main tasks for 1993 are set out as follows:

- To stabilize the livelihood of the people mainly focusing on the gradual alleviation of poverty in under-developed areas and poverty of newly repatriated people.
- To make efforts to effectively use emergency assistance from the international community.
- To launch a drive to increase GDP at an average annual growth rate of 10% according to the target of the second 5-year plan (1991-1995).

- To partially solve major issues in three priority sectors (water, electricity, and roads).
- To manage the economy based on macro-economic planning with appropriate administrative structure and efficient statistical system.
- To stabilize the value of the Riel in order to reduce the inflation rate.
- To make the best use of domestic resources to gain state income so as to be able to meet expenditure for development and to reduce unnecessary expenditure.
- To give attention to raising the educational level of government employees for the new economic management mechanism.

GDP at current prices will amount to Riel 5,203 billion in 1993. The required gross investment amount will be Riel 936.5 billion which is 18% of GDP. The gross investment amount will be financed by the following sources:

- The state revenue (30%)
- External aid (50%)
- Private investment (20%)

Table I.3.1 Cambodia - Basic Indicators

Land Area	181,035 sq.km
Population (1992)	
Whole country	9.17 million
Phnom Penh	0.6 - 1.0 million (average 0.8 million)
Population density	50 per sq. km
Urban population	12.0%
Population growth rate	
Whole country	2.8% per year
Urban	4.0% per year
Rural	2.5% per year
Gross Domestic Product	
GDP in 1992 (current price)	US$1,350 million
Growth rate (1992)	9.0%
GDP per capita (1992)	US$150
Structure of Production (1992)	
Agriculture	47%
Industry	16%
Services	37%
Major Products (1992)	
Rice	2,221,000 ton
Rubber product	28,000 ton
Timber	117,000 cu.meter
Foreign Trade (1992)	
Export	US$70 million
Import	US$360 million

State Budget (million Riel)	1992	1993
Revenue	153,000	283,000
Expenditure	263,000	467,000

External Debt (1989)	Non-socialist countries: US$279 million
Inflation Rate	1989: 70% 1990: 157% 1991: 121% 1992: over 200%
Exchange Rate (year end)	1989: US$1 = 345 Riel 1990: US$1 = 600 Riel 1991: US$1 = 1,000 Riel 1992: US$1 = 2,300 Riel
Social Indicators	
Life expectancy	48 years
Infant mortality rate	120 per 1,000 live births
Adult literacy rate	70%
Population per doctor	12,700
Hospital beds	1.9 per 1,000 population

Sources: Report on Social Economic Situation (1992) and 1993 State Plan, National Statistics (draft), and others.

Table I.3.2 Foreign Trade Statistics (1992)

1. Exports for 1992 (estimated)

Item	Unit	Quantity	Amount (US$1,000)
1. Timber	m^3	347,050	35,328
2. Rubber (processed)	ton	14,000	9,266
3. Rubber (by-product)	ton	9,300	2,372
4. Fish/Fish product	ton	2,907	3,363
5. Soybeans	ton	5,000	1,150
6. Maize	ton	7,400	662
7. Others	-	-	17,859
Total			70,000

2. Imports for 1992 (estimated)

Item	Amount (US$1,000)
1. Luxury goods(1)	193,000
2. Petroleum	76,000
3. Construction materials	26,000
4. Capital goods	15,000
5. Medicine & medical equipment	7,000
6. Agricultural equipment & tools	4,000
7. Industrial raw materials	1,000
8. Others	38,000
Total	360,000

(1) Major items are cigarettes (43%), motorcycles (19%), automobiles (13%), TV sets (9%), and beer (8%). (%: percentage share)

3. Breakdown of Construction Materials Imports for Jan.-Oct. 1992 (Actual)

Item	Unit	Quantity	Amount (US$1,000)
1. Cement	ton	135,013	9,562
2. Steel	ton	37,726	8,898
3. Rooting sheet	-	-	1,674
4. Tile	-	-	639
5. Plywood	-	-	-
6. Others	-	-	1,133
Total			21,906

Source: Department of Trade, Ministry of Commerce

Table I.3.3 Data on Public Finance

Unit: Million Riels

1.	Actual Account for 1992	
	1) Revenue	
	· Taxes	97,000
	· Transfer from state enterprises	37,000
	· Others	19,000
	Total	153,000
	2) Expenditure	
	· Economic development	59,000
	· Administration expenses	90,000
	· Defense & security	111,000
	· Others	3,000
	Total	263,000
	3) Deficit	110,000
2.	Budget for 1993	
	1) Revenue	
	· Tax revenue	209,000
	- Import duties	140,000
	- Sales tax	55,000
	- Turnover/profit taxes from state enterprises	14,000
	· Transfer from state enterprises	67,000
	· Others	7,000
	Total	283,000
	2) Expenditure	
	· Economic development	69,000
	- Public construction	50,000
	- Capital construction to state enterprises	14,000
	- Subsidy to state enterprises for 1992 deficits	3,900
	- Others	1,100
	· Administration expenses	213,000
	· Defense & security	180,000
	· Reserved fund	5,000
	Total	467,000
	3) Deficit	184,000

Source: 1993 State Budget, Ministry of Finance

Chapter 4

Present Situation of and Recommendation on Country's Power Sector

CHAPTER 4 PRESENT SITUATION OF AND RECOMMENDATION ON COUNTRY'S POWER SECTOR

4.1 Administrative Organization of Power Sector

Electricity was introduced in Cambodia for the first time in 1906. In Phnom Penh and in its neighbouring areas, the operation, management, and maintenance of the power stations were entrusted to the Compagnie des Eaux et Electricité (CEE) while in the provinces, the Union d'Electricité de *l* 'Indochine (UNEDI), another private company, obtained the concession rights to supply electricity. In 1958, the Cambodian Government purchased the CEE's and UNEDI's concession rights and created the "Electricité du Cambodge (EDC)", a state-owned company, to produce, transmit, and distribute electricity to Phnom Penh and provinces. During long war, most of the power facilities were destroyed.

EDC was re-integrated into an administrative structure under the jurisdiction of MOI. In 1991, EDC was transferred to the Phnom Penh Municipality and changed its name to Electricité de Phnom Penh (EDP). Electricity production in the provinces is managed by the electricity department or industry department of the provincial authorities.

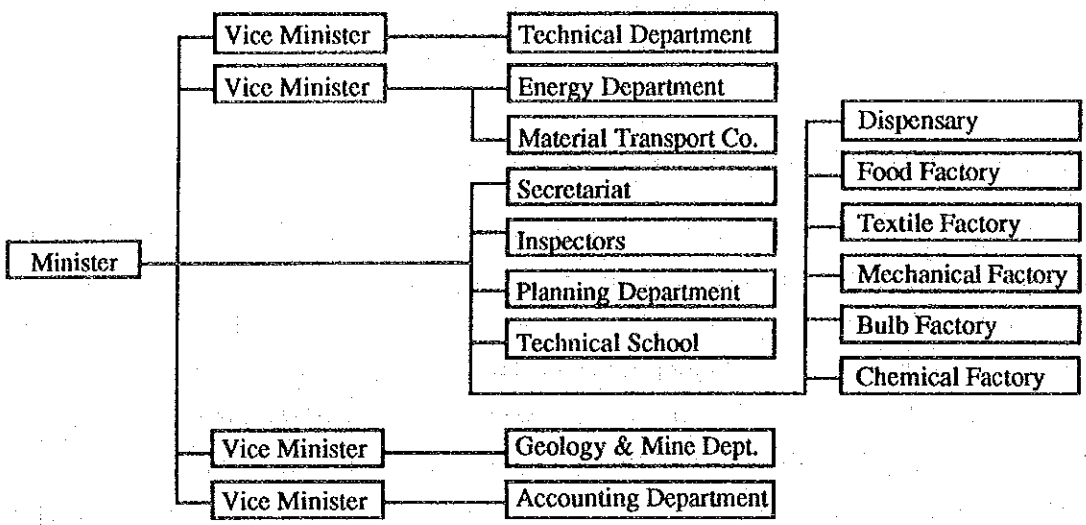
MOI is responsible for management of the power sector in the whole country including the Phnom Penh Municipality.

Note:

After the general election in Map 1993, a new government organization was inaugurated on July 1, 1993. Prior to the new organization, EDP was renamed EDC for managing the power sector in the whole country. New EDC is structured under the new Ministry of Energy and Mines.

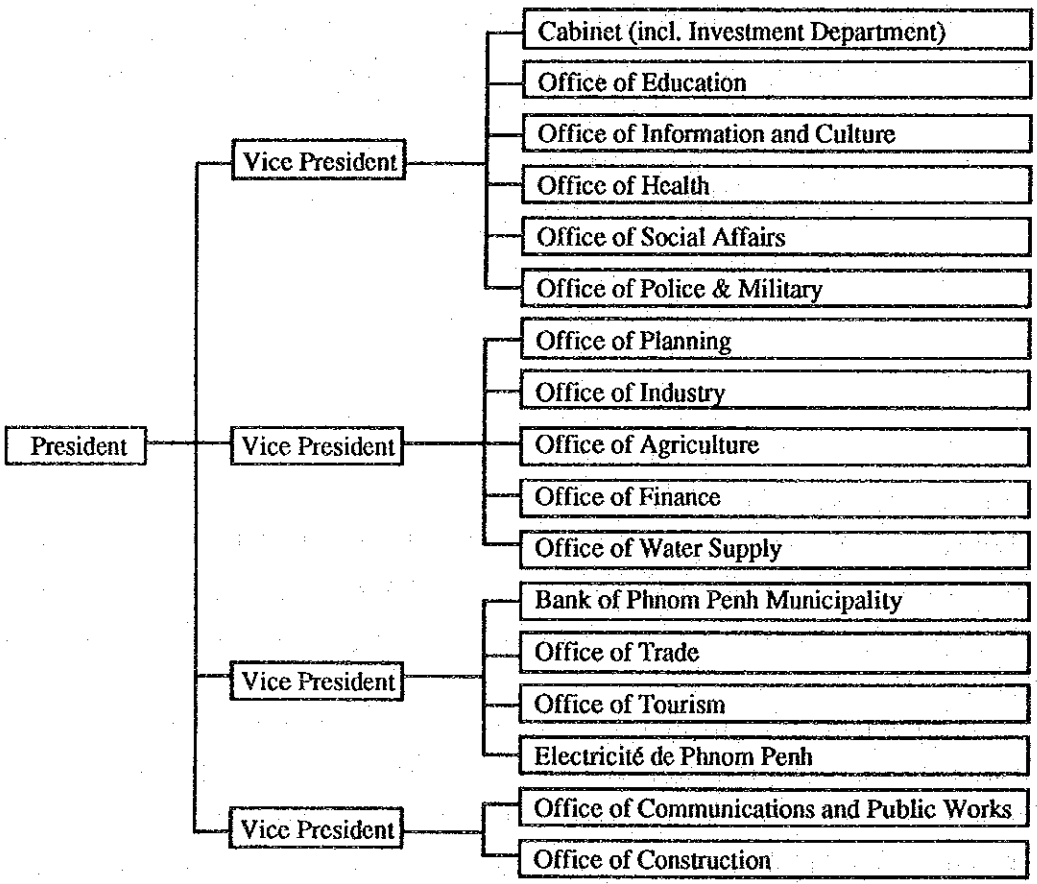
At the beginning of July, however, the new organization and function of substructures of each ministry and public institutions were not defined. Under such fluid situation, descriptions concerned in the organization for the power sector in the country would not be altered in any way in this report, with full consent of EDC. Accordingly, the term EDP in this report is the new EDC.

The present structure of MOI is as follows:

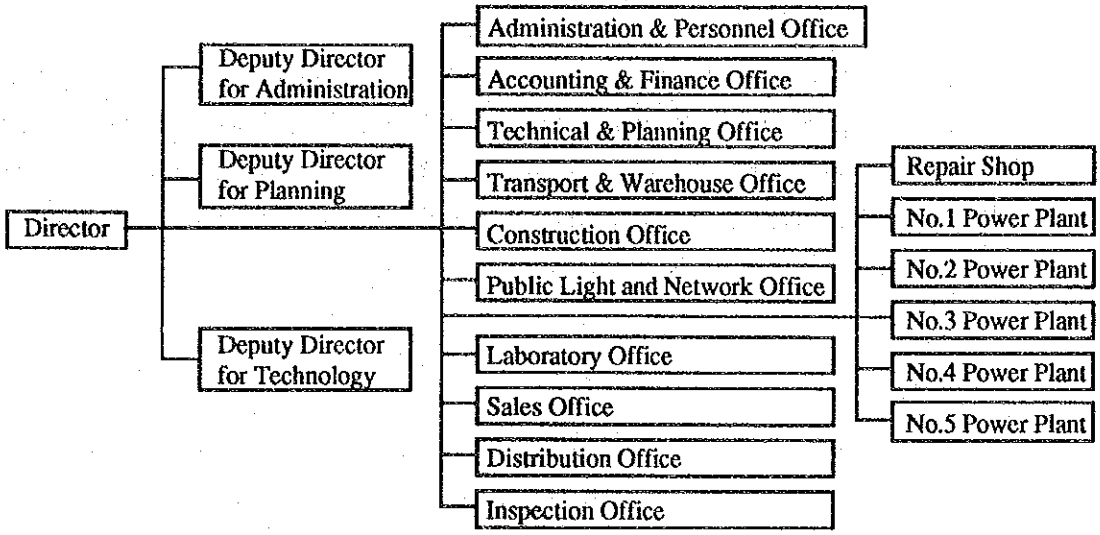


The Energy Department is in charge of management of the power sector of the country.

The structure of the Phnom Penh Municipality as of February 1993 is shown below:



The structure of EDP as of March 1993 was shown below:



Electric power production and distribution in Siem Reap city are managed by the Electricity Section of the Industry Department under the Economy Division of the city's People's Committee.

4.2 Power System

Because of long war and isolation of the country, historical power records prior to 1979 were lost, therefore no reliable power information is available for the period before 1979.

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.

In the Phnom Penh Municipality, there are five (5) power stations: No. 1 to No. 5; however, only No. 1 - No. 4 were running as of February 1993. The construction of the No. 5 power station with five (5) diesel generating units of 3 MW each began in November 1988 under assistance of the former Soviet Union, but was interrupted after the collapse of the Soviet Union in September 1991. Energy produced by the existing four (4) power stations is delivered mostly to the town area and partially to the suburbs.

The present power system in Phnom Penh is divided into two: the independently operated northern and southern systems.

In Siem Reap city, there are two (2) power stations, one old and one new . There were four (4) diesel generating units installed in the old power station in 1960 , but they were disposed of in 1989 because of the deterioration of machines. At present, a new power station, constructed in 1985 under assistance of the former Soviet Union, is supplying power to the town, but it is in a critical mechanical condition.

4.3 Condition of Power Facilities

Electricity is being wholly produced by oil-fired generating facilities and depends accordingly on imported oil. The above-mentioned 10 MW Kirirom power plant was completed in 1968 as the first hydropower station in Cambodia, but it was demolished during 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 for three (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

Further details are shown in the attached Table I.4.1 . The following was revealed from the table:

(1) Seventy-seven percent (77%) of the existing generating facilities in the country are installed in Phnom Penh, while the remainder are scattered in other provinces .

(2) 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% by February 1993. It is assumed that the output in the provinces also has decreased due to the shortage of necessary spare parts.

The decrease in output has been caused by the shortage of spare parts and poor operation and maintenance, in addition to the obsolescence and deterioration of the facilities. Due to the output decrease, the supply capacity in both Phnom Penh and Siem Reap cities

does not meet the power requirement. Accordingly, both cities are obliged to cut power supply to their customers according to a daily shutdown schedule.

Because the generating facilities are scattered in isolated areas and are small in size and the 110 kV transmission line constructed before war was destroyed, there is virtually no transmission line system in Cambodia at present.

Some distribution systems in the country are operated in limited areas at the terminal voltage of the generators. Since old distribution systems are still used, there are three (3) distribution line voltages being operated in the Phnom Penh power system.

4.4 Issues and Recommendation

Issues observed in the power sector in Phnom Penh and Siem Reap cities are discussed in Chapter 5. In this section, issues related to the power administration and power facilities in the whole country are discussed and solutions to those issues are recommended.

4.4.1 Administration and Organization

MOI administers the power sector in the whole country, while the municipalities and provinces are responsible for power supply in their own regions. The loss of a number of experienced staff during war and lack of education of the people over a long period during and after war has resulted in inordinate functioning of the power administration.

MOI envisages to reorganize the country's power and energy sector for efficient and smooth operation and management through:

(a) Establishment of EDC and its branch offices in all municipalities and provinces for operation and management of the power sector in each region. MOI will totally control EDC.

(b) Establishment of the new Ministry of Energy in addition to existing MOI for controlling all fields related to power, fuel, mineral, and other energy resources.

(c) Establishment of the New Power Secretariat under the cabinet of the Government and under MOI's control.

Besides the rehabilitation and reconstruction of power facilities, the reorganization of the power sector is also urgently required for efficient, smooth, and comprehensive

management. Simultaneously, education of the people engaged in the power sector for upgrading their managerial and technical knowledge is more urgently required.

The JICA Team recommends that specialists be dispatched to MOI and EDP in medium- and long-term assignments for training Cambodians on fundamental knowledge of review and formulation of modern power management, operation, tariff, and others. UNDP also plans to dispatch specialists to Cambodia for the same purpose. Those training courses should be introduced through discussions with other international institutions to coordinate the curricula.

4.4.2 Recommendation on Rehabilitation and Reconstruction of Power Sector

The 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 rely 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 education system in the power sector.

The 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

Master plan and basic design studies, similar to this JICA Study, should be formulated to rehabilitate and reconstruct the power facilities in each province. The studies should start urgently, first in the safe provinces and then in other provinces immediately after security is restored. It is recommended that

investigations on indigenous energy sources such as biomass generation, solar energy, and mini-hydro generation, be conducted in local regions at the same time.

(2) Supply and installation of spare parts

The materials and equipment which are recommended in the master plan and basic design studies should be urgently supplied and installed for rehabilitating the existing facilities in order to upgrade the people's daily life and welfare. This assistance should be implemented in cooperation with donor countries and international institutions.

(3) Hydropower development for medium- and long-term power sector reconstruction

Abundant hydropower resources in Cambodia have been confirmed. Development of hydropower will much contribute to the improvement of the country in energy and economy, which is seriously confronted with the financial difficulty of importing fuel for energy source. Development of hydro resources will further contribute to the promotion of agricultural production. Since the period for development of hydropower from planning to completion is long, it is recommended to begin the master plan study of indigenous hydropower resources as soon as possible.

Austria has pledged assistance to Cambodia for the reconstruction of the Kirirom hydropower station. Resumption of construction of the Prek Thnot hydropower plant is also planned. Besides, development of the Kamchay hydropower scheme located between Phnom Penh and Kompong Som is expected. There are more than 30 sites for hydropower development in Cambodia as seen in Table I.4.2, which was prepared by the Mekong Committee. The necessity of the master plan study is emphasized. The study will be conducted in cooperation with the Mekong Committee.

(4) Installation of additional oil-fired generating facilities in the short term

Development of hydropower schemes usually takes 6 to 7 years from commencement of planning to completion. For meeting the growing power demand in the country, installation of more oil-fired generating facilities is unavoidable because of their short construction period, though they consume

imported fuel. From this aspect too, development of hydropower schemes is urgently required.

(5) Upgrading of operation and maintenance technology

A number of experienced operators and staff as well as technical materials, records, and manuals were lost during war. For properly operating and maintaining the rehabilitated or newly added facilities under assistance of donors, upgrading of operation and maintenance technology of Cambodians is one of the urgent problems to be solved. The following measures are recommended for upgrading the technology:

(a) To dispatch specialists to Cambodia in medium- and long-term assignments for training Cambodians on operation and maintenance of the installed facilities.

(b) To train medium- and high-grade Cambodian technicians on advanced technology in developed countries.

(6) Upgrading of knowledge on planning of system development and management

For improving the present situation where all plans and programs for power systems are formulated and prepared by foreigners, Cambodians should be, in the near future, capable of formulating, planning, and designing the facilities, and developing/managing the power systems. It is recommended that developed countries dispatch experts to Cambodia to train Cambodian personnel in those fields .

(7) Coordination among supporting countries and institutions

It seems at present that each country and institution assists Cambodia on the basis of a Cambodian request or individual plan. To prevent complicating the system, a comprehensive plan for rehabilitation and reconstruction of the country should be formulated, and coordination of facilities assisted by various institutions should be conducted.

It is recommended to station experts in MOI until Cambodian officials are able to undertake the work by themselves. The experts will advise MOI to coordinate international assistance and to unify design standards of the facilities so as to structure the renewed power system in a standardized manner for easy operation and maintenance.

Table I.4.1 GENERATION BY MUNICIPALITY AND PROVINCE IN CAMBODIA (1989)

Municipality or Province	Installation (kW)	Effective Output (kW)	Supply Hours (hrs/day)	Annual Generation (MWh/year)	Fuel Consumption		Generation Efficiency (%)	Population	Per Capita. Consumption	
					Annual (cu.m)	Per kWh (l/kWh)			kW	kWh/year
Kompong Cham	2,160	1,268	24(4)	2,613	843.0	0.323	30.6	1,411,000	0.0009	1.85
Prey Veng	500	200	4	200	353.3	n.a	n.a	868,000	0.0002	0.2
Kandal								(827,000)		
Takev	1,020	900	3	278	116.7	0.420	23.5	640,000	0.0014	0.43
Phnom Penh (*)	64,230	39,350	24	200,145	75,551.0	0.377	24.0	625,000	0.0292	137.84
Battambang	4,350	2,500	12	3,854	1,270.1	0.330	30.0	571,000	0.0044	6.75
Siem Reap	2,230	1,720	9	937	330.0	0.352	28.1	542,000	0.0032	1.73
Kompong Thom	326	285	3	229	110.0	0.480	20.6	475,000	0.0006	0.48
Kampot	525	250	16	980	1413.36	n.a	n.a	455,000	0.0005	2.15
Kompong Speu	25	20	4	20	7.9	n.a	n.a	440,000	0.00005	0.00005
Svey Rieng	930	250	24	1,540	2,190.0	n.a	n.a	395,000	0.0006	3.9
Banteay Meanchey	200	80	4	82	141.3	n.a	n.a	369,000	0.0002	0.00002
Kompong Chhnang	650	400	4	72	28.3	0.400	24.7	283,000	0.0014	0.25
Pursat	1,000	900	4	383	164.3	0.429	23.0	238,000	0.0038	1.61
Kratie	270	n.a	4	210	371.0	n.a	n.a	200,000	0.0014	1.05
Preah Vihear	30	30	4	30	53.0	n.a	n.a	92,000	0.0003	0.0003
Kompong Som (*)	3,830	3,300	24	6,066	1,820.0	0.300	33.0	74,000	0.4459	81.97
Batanakiri	200	200	4	200	318.0	n.a	n.a	60,000	0.0033	0.0033
Stung Treng	500	400	4	410	567.7	n.a	n.a	53,000	0.0075	0.0077
Koh Kong	1,940	900	24	5,500	6,570.0	n.a	n.a	43,000	0.0209	127.91
Mondulkiri	100	80	4	77	116.8	n.a	n.a	21,000	0.0038	3.67
Total	85,018	53,033	-	223,826	92,336.2	-	-	8,682,000	0.0065	25.78
Total excl. Phnom Penh	20,788	13,683	-	23,681	-	-	-	7,230,000	0.0019	3.28

Note : (*) Municipality
Source : EDC

Table I.4.2 PROPOSED HYDROPOWER PROJECTS
(Mekong Committee 1984 - 1985)

Proposed Location	River	Capacity (MW)	Energy (GWh/year)	Irrigation Area (ha)
PROJECTS AT PRE-FEASIBILITY OR FEASIBILITY STUDY LEVEL				
1. Study Chinit	Stung Chinit	4	9	25,400
2. St. Battambang-1	St. Battambang	24.	120	68,000
PROJECTS STUDIES AT DESK STUDY LEVEL				
1. Sambor	Mekong	3,600	18,820	34,000
2. Stung Treng	Mekong	7,200	35,150	-
3. Stung Atay	St. R. Chrum	110	559	25,000
4. Upper Se San-4	Se San	350	1,720	-
5. St. Battambang-2	St. Battambang	36	178	-
6. St. Pursat-1	St. Pursat	75	379	12,000
7. Prek Liang-1	Se San	55	282	-
8. Lower Se San-3	Se San	400	1,991	57,000
9. Prek Liang-2	Se San	40	202	-
10. Lower Sre Pok-3	Sre Pok	345	1,736	65,000
11. St. Pursat-2	St. Pursat	17	86	13,000
12. Stung Sen	Stung Sen	40	200	130,000
13. Upper Prek Te	Prek Te	15	73	-
14. O Phlai	Sre Pok	5	26	-
15. Prek Por	Sre Pok	17	86	-
16. Prek Rwei	Sre Pok	7	34	-
17. Ya Hlco	Sre Pok	-	-	28,500
18. Ya Lop	Sre Pok	-	-	18,500
19. Prek Chbar	Sre Pok	-	-	26,000
20. Prek Drang	Sre Pok	-	-	14,000
21. Prek Santai	Sre Pok	-	-	6,000
22. Prek Kriang	Prek Kriang	-	-	10,000
23. Prek Kampi	Prek Kampi	-	-	7,000
24. Lower Prek Te	Prek Te	-	-	30,000
25. Prek Chhlong	Prek Chhlong	-	-	24,000
26. Stung Staung	Stung Staung	-	-	20,000
27. St. Chickreng	St. Chickreng	-	-	10,000
28. Stung Sreng	Stung Sreng	-	-	25,000
29. St. M. Borey-1	St. M. Borey	-	-	10,000
30. St. Pursat-3	St. Pursat	-	-	2,800
31. St. Pursat-4	St. Pursat	-	-	5,900
32. St. Pursat-5	St. Pursat	-	-	3,400
33. ursat Weir	St. Pursat	-	-	3,400
34. Tonle Sap	Mekong	-	-	-

Chapter 5

Present Phnom Penh Power Sector and Issues

CHAPTER 5 PRESENT PHNOM PENH POWER SECTOR AND ISSUES

5.1 Generating Facilities

5.1.1 Existing Facilities

There are five (5) power plants (No. 1 to No. 5 power stations) existing in the Phnom Penh power system. Construction of the No. 5 power station began in 1988 under assistance of the former Soviet Union, but was abandoned in September 1991 due to the collapse of the former Soviet Union. Most of the main equipment and ancillary materials were installed and are the same as those that operated in the No. 4 power station. Thus, as spare parts for the equipment in the No. 4 power station are in short supply, various equipment from the No. 5 station has been disassembled for spare parts.

Four (4) power stations are running in the Phnom Penh power system at present and the energy generated is delivered to an area of approximate 350 km^2 covering Phnom Penh municipality and suburbs. Present operation of the 4 power stations are outlined below:

(January 1993)

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

As seen above, the present total possible output (24,350 kW) is only 34% of total installed capacity (71,200 kW). Further details of each power station are summarized in Tables I.5.1 to I.5.4. A location map and plans of those power stations are shown in Figures I.5.1 to I.5.5.

Present condition of each power station as of January 1993 is outlined below:

(1) No. 1 Power Station

The oldest machine in the station was manufactured in 1926, the newest one in 1966, as seen in Table I.5.1. All the machines are operating beyond their service lives. Due to a shortage of necessary spare parts and loss of experienced operators during war and succeeding period, the machines have deteriorated. As of January 1993, only 5 generating units out of 11 units in the station are in operable condition, and the total possible output of the station has reduced to 20% of its installed capacity. It is very difficult to procure the necessary spare parts due to the age of the units.

Cooling water and fuel for the power station are supplied through a pipeline from the nearby Tonle Sap river. Water is kept in a storage tank on the premises. Fuel from a small oil tanker in the river delivered through its exclusive pipeline is also kept in oil storage tanks at the station.

(2) No. 2 Power Station

This is the largest power station in the country with 3 steam turbine-generator sets and 4 diesel engine-generator sets. This is the only power station that operates steam turbine-generator sets in the country. The station is well managed and maintained. The steam turbine-generator sets manufactured in 1967 are still in efficient condition and are operated as a facility for the base load required in the town.

The machines are being rehabilitated and overhauled by Czech engineers as of February 1993, and their outputs are expected to be restored to their rated capacities after completion of the rehabilitation and overhaul works. Only 2 of the 4 diesel-generator sets of 2,100 kW unit capacity were operating in January 1993.

Water is supplied by the Bassac river through a pipeline to the water storage ponds on the premises. While, fuel for the station operation is delivered by tank lorries and stored in fuel tanks at the station.

(3) No. 3 Power Station

There are 3 package type GM-made diesel-generator sets installed in the power station. The sets are almost the same model as those installed in the No. 2 power

station. However, 2 out of the 3 sets were not operating in February 1993 due to machine troubles. The remaining set is operated only for the peak load of the power system. The present possible output of the station is 1,500 kW equivalent to less than 25% of the total installed capacity of 6,300 kW.

Cooling water is supplied through city water pipes. Fuel is supplied by oil tank lorries and stored in tanks at the station.

(4) No. 4 Power Station

The power station was constructed with 5 diesel-generator sets in the northern part of the town near the No. 1 power station under assistance of the former Soviet Union. Three (3) 3,000 MW diesel-generators sets were installed in 1984, and an additional 2 sets of the same model and unit capacity were installed in 1986. As of February 1993, only 2 of the 5 sets were operating in the station, 3 sets were in an inoperative condition after only several years of operation.

Cooling water and fuel to the station are supplied through the respective pipelines from the Tonle Sap.

5.1.2 Issues of Generating Facilities

The issues of the generating facilities, as mentioned above, such as total possible output of only 30% of the installed capacity, and unavoidable enforcement of the scheduled load shedding seem to have originated from the following causes:

(1) Deteriorated facilities

Service life of both steam and diesel generator facilities is normally 15 years. All generating facilities in the power system except those in the No. 4 power station are being used beyond their service lives. Total capacity of those facilities beyond their service life is approximate 80% of the total installation. Comparatively new facilities in No. 4 power station also have various machine troubles.

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

Much of the equipment and materials required for maintenance and repair are unavailabile due to the age of the models. In addition, the funds required for procurement are in short supply. At present, damaged parts are replaced with the same parts from other inoperative machines or parts modified from similar parts.

(3) Insufficient tools and apparatuses for repair

Main parts or main equipment are repaired in EDP's central workshop located near the No. 2 power station, while simple repairs are undertaken at individual power stations. Since the number and variety of tools and apparatus are insufficient in EDP, those that are commonly used circulate among the power stations which causes delays in the repair of facilities.

(4) Lack of technical reference books

War over a long period has resulted in great losses of not only experienced engineers, operators, and maintenance staff but also such documents as operation manuals, drawings, reference books, and various records. As a result, unexperienced people with inadequate training and education are required to operate and maintain the power generating facilities.

(5) Insufficient safety measures

Safety provisions such as fire extinguishers, lighting equipment, safety tools for operators, guard-rails for stairs, safety fences, and first-aid kits in all power stations were observed to be insufficient.

5.2 Distribution Facilities

5.2.1 Existing Facilities

(1) Existing facilities

There are three (3) different voltages 15 kV (3-phase), 6.3 kV (3-phase) and 4.4 kV (2-phase), in the high tension system and two (2), 380/220V (3-phase) and 220V (single phase), in the low tension system in the Phnom Penh network. The high tension lines are composed of underground cable lines in the central part of the city and overhead lines in other parts and suburbs. All low tension lines are overhead.

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

The Phnom Penh distribution network is arranged in a loop system of overhead lines (53%) and underground lines (47%). Most of the substations and transformer houses in the system are supplied by 15 kV distribution lines without disconnecting switches and circuit breakers. The present distribution facilities in the network are as follows:

System	Underground	Overhead
15 kV (3 phase)	112.9 cct-km	74.5 cct-km
6.3 kV (3 phase)	2.5 cct-km	0.5 cct-km
4.4 kV (2 phase)	49.8 cct-km	1.5 cct-km
Low tension line	1.3 cct-km	113.2 cct-km
Total	166.5 cct-km	189.7 cct-km

The distribution lines and distribution transformers in the Phnom Penh system are shown in Figures I.5.6 to I.5.10. The number of high voltage feeders from the existing 4 power stations to the network are shown below:

Power Station	Voltage (kV)	No. of Feeders
No. 1	15 kV	5
	4.4 kV	7
No. 2	15 kV	7
	6.3 kV	1
No. 3	15 kV	4
No. 4	15 kV	3
Total		27

The existing distribution transformers for 15 kV and 6.3 kV systems are 3 phase, while those for 4.4 kV are 2 phase. Those transformers are protected on their primary sides with power fuses, but no protective devices are provided on their secondary sides. Following is a list of the distribution transformers.

Transformer	No. of Units	Installation (kVA)
15kV/380-220V (3-phase, S/S or Trans. House)	270	110,614
15kV/380-220V (3-phase, Pole Transformer)	146	10,162
6.3kV/380-220V (3-phase, Transformer House)	3	850
4.4kV/220V (2-phase, Pole and Transformer House)	161	19,601
Total	580	131,227

The low tension lines are radically extended from the meter aggregating houses located adjacent to transformer houses or pole transformers, directly to the customers.

(2) Fault records on distribution lines

Following is an outline of faults on the distribution lines which occurred in 1992 in the Phnom Penh network.

Faults on the underground cables amounted to 60 caused by deterioration of cables (50 faults), artificial acts such as construction works (8 faults), and improper repair works to the cables (2 faults).

Faults on the overhead lines were caused by tree touching to the conductors (24) and artificial acts (15). The faults by artificial acts are caused by conductor breakage, breakage of insulators, falling of poles, etc.

Faults on substations and transformer houses were caused by deterioration of the facilities (16), overloading to the facilities (8), and inappropriate setting of transformers (4).

5.2.2 Issues of Distribution Facilities

Following are issues of the existing distribution facilities.

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

(2) Insufficient capacity and deterioration of conductors and cables on high tension lines will not be able to cater for the growing power demand;

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

(4) 15 kV facilities more than 25 years old and others not renewed, which will cause more faults;

(5) No section switches are installed, which causes expansion of power failure area;

(6) No power supply to 3-phase loads in the 4.4 kV system;

(7) Improper metering of energy consumed by customers; metered amount include energy losses on the low tension facilities, because customers' meters are installed not at the customers ends but at the aggregating meter houses;

(8) No low tension feeders results in larger energy losses on the low tension network;

(9) No loop system for the low tension lines causes frequent power interruption;

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

(11) Shortage of particular materials has resulted in the unavoidable connection of aluminum conductors to copper conductors and use of inferior insulators;

(12) Overloading of low tension lines due to small size conductors;

(13) No protection devices on the low tension system; and

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

5.3 Load Dispatching Facilities

5.3.1 Existing Facilities

The existing load dispatching center operats in 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, however the telephone is rarely used due to the poor communications network. Orders from the center to power stations and maintenance vehicles are made verbally for generation control, switching operation of substations and transformer houses, and restoration of distribution systems.

An outline of the existing dispatching facilities is given below:

(1)	Power network board	:	1 panel
(2)	Transceiver (144 MHz, 2 channel)		
	(a) Center	:	1 set
	(b) Power station	:	4 sets
	(c) Distribution network	:	10 sets

5.3.2 Issues of Load Dispatching Facilities

(1) There is no communications facility for the exclusive use of the load dispatching system. In addition to the poor condition of the public telephone system, the

present transceiver sets function on only 2 channels. As a result, serious interference disturbs proper transmission of instructions and orders from the center to respective stations.

(2) A network diagram only is indicated on the existing power network board, while there is no indication of operational condition of power stations, substations, transformer houses, and distribution network.

5.4 Operation of Electric Power Enterprise

5.4.1 Organization of Electricite de Phnom Penh (EDP)

(1) Overall structure

The organization of EDP and respective departments are presented in Figures I.5.11 to I.5.19. In addition, Annex I shows the job descriptions of the respective offices of EDP, which was originally described in Cambodian language and tentatively translated into English.

Generally, the organization of the electric power enterprise can be classified into the administration department; operation department undertaking power generation, transmission, and distribution; planning and construction department; and electricity charge collection department. According to the job descriptions of EDP, the Administration and Personnel Office, Accounting and Finance Office, and Inspection, Management, and Control Office are deemed to constitute the management department, while the Warehouse and Transportation Office, Public Light and Network Office, Central Workshop, and the respective power stations are deemed to constitute the operation department. The Planning and Technical Office, Technical Research and Construction Office, and Public Light and Network Office are deemed to constitute the planning and construction department, and the Sales Office is deemed to be the electricity charge collection department.

According to this classification, the Public Light and Network Office concurrently manages both the operation department and the planning and construction department. 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 expanded along with the increase in the supply area and supply capacity, it is considered necessary to

classify clear-cut roles into the respective departments and to create more stratified organization structures from medium- and long-term viewpoints.

In the present head office of EDP, the number of typewriters, copying machines and other office equipment is very limited except for a personal computer used for preparing bills for electric charges. Judging from the nature of electric power enterprise as an equipment industry, it will become necessary to manage a huge volume of such data as the operating conditions, availability and efficiency of power facilities, contracts with a large number of consumers, invoices, collection of electricity charge and so forth in addition to management of equipment and other assets. For this purpose, it is desirable to formulate appropriate administrative jobs in order to automate/mechanize within a suitable range.

(2) Organizational functions of planning and construction works

Cambodia is undergoing a transitional period at present and the organization of EDP is also undergoing changes. One of the EDP offices that has undertaken significant changes in their job descriptions is the Planning and Technical Office. Although the previous chief jobs included only generation planning and procurement of fuel, the recent organizational changes have increased the work load of the Office. In addition to previous jobs, the Office is now in charge of expenditure planning; procurement of fuel, spare parts, and other materials needed for maintenance from overseas; fuel supply; and monitoring the efficiency of fuel consumption. At the same time, the Office is in charge of preparing facility expansion programs, which was previously carried out by other Offices, and administrates planning of overseas official development assistance. While procurement of domestic materials for maintenance works is carried out by the Warehouse and Transport Office, the Planning and Technical Office is responsible for procurement of overseas materials. Thus, the jobs undertaken by the Planning and Technical Office have expanded.

In the organization of EDP, the Technical Research and Construction Office is responsible for construction works; however, the construction works this Office undertakes is limited to the maintenance of the existing facilities. The organizational capability of EDP does not include procurement and construction management of such major construction works as construction of new power stations and transmission lines. Instead, the General Directorate of Construction under the Phnom Penh Municipality is responsible for such undertakings.

5.4.2 Situations of Business Operation of EDP

(1) Problematical points in view of analysis

At present, Cambodia is undergoing a transition period in both the political and social systems. Since the concept of finance applied in the capitalism economy cannot necessarily be applied to the prevailing system of present Cambodia for analyzing the operational situations, it must be noted that it is considerably difficult to analyze and evaluate the financial situations of EDP.

The economic operation system in the socialist economy employs input and output models based on the physical flows of commodities for planning the economy, which is entirely different from the capitalist economic operation system adopting input and output models based on the market price. In considering that depreciation of capital cost is a particularly important element of business operation and management for electric power enterprises as an equipment industry, the contents of financial statistic data under the socialist economy system without any concept of capital are substantially different from those under the capitalist economy system. Moreover, the electricity charges, which have major impacts upon the financial situations, have not been collected in some cases in view of electric power being a social infrastructure necessary for the People's Committee. Particularly before the end of 1990 until the self-supporting system according to economic renovation/reformation policy was initiated, the capital for initial investment was basically covered by the contribution from the government budget and there had not been any concept at all to reflect the amount of investment into the electricity charge.

In addition to the problematical points along with the transition period from a socialist economy, another problematical point making analysis difficult is the hyperinflation of 200% or more per year and the resulting large scale devaluation of local currency. In consideration of the problematical points mentioned above, the business operation conditions of EDP were analyzed.

(2) Operating situations of EDP

The statement of profit and loss prepared by EDP is indicated in Table I.5.5.

The total electrical energy production has decreased continuously from 1989 to 1991. It is observed that the energy production is still decreasing gradually due to

the shortage of spare parts and fuel caused by suspension of the assistance from the former Soviet Union 1991. The total energy production in the six months from January through June 1992 was 65.9 GWh, giving an annual total energy production of 131.8 GWh. This means that the annual production increased from that in 1991. According to the results derived from the investigation of the operating situations in existing power stations at the time of the site survey (refer to Table I.5.1 through I.5.4), it is possible to infer that the energy production in the earlier half of 1992 is comparatively large although six diesel power units were shut down in 1992. This increase in the first half of 1992 is presumed to have been caused by full scale operation of the three 6 MW steam power units of the No.2 Power Station which share the base load. Since one of the steam power units has been shut down for maintenance since the latter half of 1992, the energy production in the latter half of 1992 is estimated to have decreased from that in the first half of 1992.

According to the electricity production/generation records obtained from EDP, the total electricity production and sold electricity in February 1993 were 5,031,142 kWh and 3,470,523 kWh, respectively. From the statement of profit and loss of EDP in Table I.5.5, the average total electricity production per month in the earlier half of 1992 was calculated to be 10,983,333 kWh, and it was noted that the total electricity production in February 1993 was roughly half the average value of the total electricity production per month in the earlier half of 1992.

(3) Changes in the ratios of sold energy to total energy production

The ratios of sold energy to total energy production have been increasing successively except from 1989 to 1991, through the earlier half of 1992. The ratios of sold energy to energy production increased in 1992 presumably as a result of an increase in the electricity charge recovery rate due to the formation of the Collective Group, which was started in 1991 when the electricity charge was revised. In 1991, the ratio was lowered substantially to 41% presumably because the collective group system, initiated in August, could not prevent theft of electric power in the early part of the year. Another reason is presumably the increase of the electricity charge rate to ten times that of the previous year, which in turn may have decelerated the growth rate of electric power demand.

(4) Changes in average sold energy price

The average sold energy price per kWh obtained by dividing the total electricity charge revenue with the total electrical energy production, which was 4 Riel/kWh in 1989, was nearly tripled to 11.3 Riel/kWh in 1990. In 1991, the price was raised by 10 times that of the previous year and reached the present level of 171.8 Riel/kWh in 1992. Since the electricity charge was raised to 170 Riel/kWh in August 1991, the average electricity charge was 126 Riel/kWh in 1992, during the transition period. Reflecting the hyperinflation of the Cambodian economy, it is apparent that the electricity charge rate has been raised rapidly. The inflation rate in every year since 1989 is indicated in Table I.5.6, and the electricity charge increase since 1989 is deflated by the inflation rate and converted to the price level in 1989 as shown in Table I.5.7. From this table, it is judged that the actual electricity charge level in 1989 is the same as that in 1990. However, the electricity charge in 1991 was raised by five times that of the previous year even based on the deflated electricity charge. Although the average electricity charge increased in the earlier half of 1992 from that in the previous year, the deflated electricity charge for that period is less than half that in the previous year, reflecting the hyperinflation rate of more than 200%.

(5) Changes in electrical energy production cost

The average electrical energy production cost is indicated in Table I.5.8. This production cost was obtained by dividing the operation cost of EDP including fuel and other costs, with the total electrical energy production based on the statement of profit and loss of EDP. Since it is difficult under the situation of hyperinflation to simply compare the average values of the production costs, these values were compared after deflating the average values. As a result, it is judged that the deflated energy production cost in 1989 is nearly at the same level as that in 1990. However, the deflated energy production cost in 1991 was raised to more than three times that in the previous year. Moreover, the deflated energy production cost in the earlier half of 1992 also indicates a comparatively high value of 4.27 Riel/kWh. From this fact, it can be presumed that the situation has worsened gradually as power stations have been operated continuously without sufficient maintenance due to a shortage of spare parts resulting from suspension of assistance from the former Soviet Union since 1991.

(6) Changes in energy selling cost

The transition of electrical energy selling cost is presented in Table I.5.9. This cost was obtained by dividing the total operation cost including fuel cost, with the sold electrical energy. Similarly as in the case of the electrical energy production cost, the selling costs since 1989 were compared based on the price level in 1989 after deflating the average costs. As a result, the costs range roughly from 6 Riel/kWh to 7 Riel/kWh in each year except in 1991 when the deflated energy selling cost was as high as 24.25 Riel/kWh in 1991. Therefore, the present substantive energy selling cost of EDP, excluding the depreciation cost, is estimated to range from 6 Riel/kWh to 7 Riel/kWh.

(7) Recovering electricity energy sales cost

Table I.5.5 shows EDP income statement, in which net income turned positive in the earlier half of 1992. 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. The ratio was 41% in 1991 and increased to 64% in the earlier half of 1992. Consequently, a bigger portion of the electricity sales cost was recovered by sold energy in the earlier half of 1992.

Another reason for the financial improvement was due to the increased electricity charge. Table I.5.7 shows that the substantive electricity sales price in the earlier half of 1992, which has been deflated to the price level in 1989, was 10.08 Riel/kWh. On the other hand, Table I.5.9 shows that the substantive electricity sales cost in the same period was 6.64 Riel/kWh. These figures show that the electricity sales price exceeded the electricity sales cost in the earlier half of 1992, which consequently indicate that the electricity sales costs had been basically recovered by the revenue from electricity charge in the earlier half of 1992. However, one caveat is that the electricity sales cost shown in Table I.5.9 does not include costs of depreciation for the 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.

In addition to the problem of depreciation costs, the other important caveat is that generation costs are increasing rapidly under the hyper-inflation condition in Cambodia. As a result, it will be very difficult to keep the electricity sales price

higher than the electricity sales cost unless electricity charge is continuously revised in order to catch up with the increasing generation costs.

(8) Effects of suspension of assistance from the former Soviet Union

The deflated energy production cost and deflated energy selling cost in 1991 were much higher than those in the previous years. Moreover, the ratio of the sold electrical energy to the total electrical energy production in same the year is much lower than that in the other years. The suspension of assistance from the former Soviet Union since 1991 has certainly caused serious impacts upon the electric power supply by EDP. As a result, the year of 1991 has been a significant turning point for the organizational operation of EDP.

(9) Problem of unpaid electricity charge by government agencies

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 raised a serious problem for EDP. The total amount of unpaid electricity charge at the end of 1991 was as much as 5,958 million Riel, which exceeds the annual revenue of total sold energy in the same year. Moreover, the total amount of unpaid electricity charge was 9,662 million Riel at the end of June 1992. The fact that such as extraordinarily large amount of unpaid electricity charge has been accumulated indicates the disturbed situations of EDP during the present transition period. Since the end of 1990 when EDP started transition to the self-supporting system, it is considered to have become mandatory for the government agencies to pay the electricity charge. However, the payment is deemed to have been delayed due to incomplete institutionalization of the payment and lack of budget on the part of the government agencies. As a considerably a large portion of electric power demand in Phnom Penh is occupied by the government agencies, this problem is all the more serious for EDP. Such a huge amount of unpaid electricity charge has tightened EDP's financial situation and caused an immensely adverse effect upon procurement of fuel and spare parts.

(10) EDP's financial situation

The financial management (control) system adopted by EDP is not similar to that adopted generally in Japan and other capitalist countries,. The balance sheet which was prepared by using the financial data of EDP obtained during site surveys is presented in Table I.5.10. This table indicates that the net worth to

total liabilities, which is a ratio of the total amount of owned capital represented by the amount of the capital and surplus to the sum of loans end year, and the capital and surplus, decreased to 40% in June 1992 from 61% in 1989.

5.4.3 Operation of Electric Power Facilities

(1) Power plant operation system

The number of operation and maintenance staff for the respective power stations is considered to be sufficient. The power stations are operated by four teams in a system of four shifts a day. Since the four teams are always scheduled in the shift work system, it is impossible for any team to take a complete day-off. The number of team members constituting one shift team varies depending upon the respective power stations. In the case of the No.1 Power Station, the number of members constituting one team ranges from six to fourteen. In the case of the No.2, No.3, and No.4 Power Stations, one shift team comprises fourteen to twenty-four members for No.2 station, three members for No.3 station, and about ten members for No.4 station. In addition to the shift work system, operation of distribution lines is also carried out according to the same system as that of the power stations and, therefore, there are the same problematical points. The number of team members on one shift for distribution lines ranges from ten through eleven, while for one load dispatching shift team the number of members ranges from two to three.

Although operation and other manuals were provided at the time of power plant construction, these manuals are written in French, Russian, or other various suppliers' languages, and manuals in local language have not been prepared by EDP. The situations are the same as for operation of distribution lines.

In order to execute appropriate maintenance and inspection, and prevent occurrence of power failures, it is important to exactly record the operating conditions of power plant equipment. The voltage, frequency, electricity production, and so forth are monitored in the central control room, while the temperatures and pressures of diesel engine lubricating oil, cooling water, cylinders, and fuels are recorded every one hour. However, some of the meters in the central control room did not function.

(2) Maintenance and inspection system of electric power facilities

(a) Maintenance of power stations

At the respective power stations, specialized maintenance staff are assigned. The number of maintenance staff varies depending upon the respective power stations. There are six members at the No.1 Power Station, ninety-eight at the No.2 Power Station, nineteen at the No.3 Power Station, and fifty-four at the No.4 Power Station. Unlike the operation system, shift work for maintenance is not carried out. In addition to the maintenance staff members assigned to the power stations, the construction and maintenance group is assigned together with the workshop group to the Technical Research and Construction Office. This construction and maintenance group is deemed to undertake comparatively large scale maintenance and repair works, and management of overall maintenance condition of power stations.

(b) Maintenance of distribution lines

Maintenance and inspection of distribution lines is carried out by the Public Light and Network Office with thirty-three maintenance members. Although there are two crane basket trucks for maintenance work, one is out of order and not available. No shift work for maintenance is performed. The repair of distribution lines is not carried out during the night but carried over to the next day. Should night time distribution be interrupted due to a distribution line failure when the electric power demand is the greatest because of the lighting demand, the usage rate of distribution lines will be lowered and the selling energy cost therefore will be raised.

Although periodical inspections of distribution lines are scheduled to be carried out at an interval of three months, such inspections are actually carried out only once every five months or so due to a shortage of manpower and other problems.

(3) Storage of equipment and spare parts

EDP has five warehouses to store spare parts. Two of these warehouses are annexed to the No.1 and No.2 Power Stations and store spare parts for the power stations. In the other three warehouses which are dispersed in Phnom Penh City, the spare parts for distribution lines are stored.

The warehouses are not so large in scale, and ledgers and arrangement drawings indicating the location of stored parts are not particularly provided. Therefore, whenever any parts are requested, the person in charge of the warehouse has to find out the location of the parts based on memory. For managing the quantity of parts, cards with names and remaining quantity of parts are arranged at the positions where the parts are stored, and the quantity of the parts taken out of the inventory is newly entered in the cards. The quantity of parts recorded based on these cards is finally integrated into a ledger after a certain time period.

The arrangement of spare parts is not unsatisfactory, however, some parts which cannot be stockpiled outdoors are stored directly on the ground together with some parts which can be stockpiled outdoors. Since small parts are stockpiled without proper arrangement, it would be difficult to confirm the quantity at the time of inventory taking. As pole-mounted transformers and other heavy-weight equipment are not placed outdoors so as to allow easy confirmation of their types, it would also be inconvenient to perform inventory taking of such equipment.

At present the kinds and quantity of existing parts are small, however, both the kinds and quantity of parts will certainly be increased along with the increase in the installed capacity of EDP. For this purpose, it is essential to establish a more comprehensive storage system. However, the most serious problems EDP is facing at present are: the lack of funds for procurement of parts; impossibility of procuring parts compatible to the specifications of existing old power stations; and unavailability of parts matching the standards because of the reuse of a variety of parts. In other words, the problem of inappropriate and inadequate spare parts is so serious that the less appropriate storage system has not yet become a serious problem for EDP.

(4) Countermeasures for preventing failures

If a power failure has occurred on the distribution lines, a consumer will directly visit EDP and inform it of the failure without using the telephone system since prompt telephone service is hardly even available. The Distribution Office of the EDP's organization has been dealing with distribution line failures by organizing a shift work system on a twenty-four hour basis. After receiving a report of a failure, the person in charge of distribution will visit the site by car and confirm the failure, and disconnect the line leading to power stations by turning off the

switching gear. Thereafter, the repair staff members of the Public Light and Network Office will visit the site to repair the failure. The repair work is carried out by using a crane basket truck. Furthermore, the person in charge of dispatching operation will report the failure to the power station by radio communications in order to adjust the output from the power station. Should a power failure occur during the night time, the person in charge of shift work will visit and confirm the site of the failure, disconnect the line leading to the power station, and report the failure to the power station. However, the repair work will not be carried out at night but carried over to the next day.

(5) Safety control system

A person in charge of safety control has not been appointed for all the power stations and workshops. Moreover, the zones to be cautioned within power station are not indicated properly, arrangement of equipment and materials is not in good order, and lighting systems are all insufficient. Therefore, it is judged that the safety control system has not been well established.

(6) Training system

There is no officially established training system. Training of new employees has to be carried out basically at the respective work places on an on-the-job (OJT) basis. However, neither a manual nor other satisfactory training material prepared in local language by EDP are available. At present, the staff members, including those who have retired, who have acquired knowledge on operation and maintenance through experience gained during power plant construction, orally convey the knowledge to new employees.

(7) Diesel fuel consumption and maintenance plan for generating equipment

In order to evaluate the efficiency of power generating equipment of EDP, the amount of diesel fuel needed to generate one kilo-watt-hour has been calculated based on EDP statistical data of electric power generated and fuel consumed since 1985. The result is shown in Table I.5.11. In the same table, the fuel consumption rate of diesel generating equipment, which supply electricity on isolated islands in Japan, is also shown for reference.

According to Table I.5.11, the fuel consumption rate of the power generating equipment of EDP was the lowest in 1985. Thereafter, the consumption rate

According to Table I.5.13, the fuel consumption rate of the power generating equipment of EDP was the lowest in 1985. Thereafter, the consumption rate tended to rise; in 1992 the rate was at the highest level. The increasing fuel consumption rate is considered to be one consequence of insufficient maintenance caused by an acute shortage of spare parts. On the other hand, the fuel consumption rate on the isolated islands in Japan is roughly 80% of that of EDP. At the same time, the consumption rate has been decreasing since 1965.

Although one of the roles of the Planning and Technical Office is to formulate maintenance plans for electric power facilities, it is nearly impossible to implement maintenance according to the prepared maintenance plans because of the acute shortages of spare parts. Therefore, it is nearly impossible to regularly replace the parts that are past their working lives, which inevitably worsens the efficiency of fuel consumption. Such adverse situations have made it impracticable for EDP to formulate long-term maintenance plans.

5.5 Electric Power Sales/Marketing System

5.5.1 Electricity Charge

(1) Changes in electricity charges

The electricity charge being applied by EDP at present has not been stratified according to the consumer categories. The present electricity charge of EDP varies depending on the payment conditions; payment is made in local currency (Riel), U.S. dollar, by direct payment to EDP, and through a regional electricity wholesaler called a "Collective Group". The electricity charge is 170 Riel/kWh in the case of direct payment in local currency and US$0.21/kWh in the case of direct payment in U.S. dollars. When the electricity charge is paid through the regional Collective Group, the charge is 180 Riel/kWh or US$0.224/kWh. This electricity charge payment structure is presented in Figure I.5.20.

When the electricity charge was revised in August 1991, the regional electricity wholesaler or Collective Group system was introduced. From January through July 1991 before the revision, the electricity charge was US$0.11/kWh or 37 Riel/kWh. In 1990, the charges were paid only in local currency at 11 Riel/kWh. The electricity charge was 4 Riel/kWh from April 1988 through 1989, and 3 Riel/kWh from 1983 through March 1988.

(2) Average unit electricity sales price and sales cost

The average electricity sales price indicated in the EDP income statement in Table I.5.5 from 1989 through June 1992 obtained from EDP was converted into the 1989 price level using a deflator, and as shown in Table I.5.7. In addition, the unit operation cost of fuel, etc. per kWh was calculated using the same data and converted similarly into the 1989 price level using the deflector and is shown in Table I.5.9. By comparing the deflated average unit electricity sales price and deflated sales cost obtained in Table I.5.7 and Table I.5.9 respectively, it is possible to assess whether the electricity charge can cover the cost required to supply electric power.

While the deflated electricity sales price was 4 Riel/kWh in 1989 and 1990, the deflated sales cost was 7.1 Riel/kWh and 5.9 Riel/kWh in 1989 and 1990 respectively. From this fact, shows that the sales cost per kWh exceeded the average electricity sales price, that is, the unit sales price. In 1991, the deflated unit electricity sales price and the deflated sales cost were 22.18 Riel/kWh and 24.25 Riel/kWh, respectively which shows that it was impossible to cover the sales cost by the unit electricity sales price even in 1991. In contrast to these years, the deflated unit electricity sales price, which was 10.08 Riel/kWh, exceeded the deflated unit sales cost of 6.64 Riel/kWh for the first time during the period from January through June 1992. However, the operation cost items used in calculating the sales cost includes the fuel and maintenance costs, labor cost and wages, administration expenses, and so forth, but do not include the depreciation of the electric power equipment for power generation, transmission, distribution, and others.

The difficulty to estimate the cost required to invest in the electric power facilities is related to the future power equipment extension program together with the depreciation cost related to the existing electric power equipment. Therefore, how to reflect this capital cost into the electricity charge at the time of setting the electricity charge is an essential to be studied. When considering the present social and economic situations of Cambodia and positions of EDP, it is very difficult to judge to what extent the capital cost of electric power facilities has been reflected appropriately in the present electricity charge.

(3) Electricity charge revision process

As EDP belongs to the People's Committee of Phnom Penh, the application for revision of electricity charge is submitted to the Ministry of Planning of the Government from People's Committee. The revision of electricity charge is planned by the Ministry of Planning and, after undergoing examinations by the Prime Minister's Office together with the relevant ministries and agencies, an electricity charge applicable throughout the country is determined with a certain margin. At the time of the previous revision in 1991, the assets of EDP were reevaluated specially by the Ministry of Finance. The draft electricity charge is determined finally by the People's Committee within the margin and the new electricity charge will be applied.

5.5.2 Sales System

(1) Overall sales system

Until August 1991, electric power had been sold directly by EDP. Although meter reading and charge collection were carried out by the staff members of the Sales Office, a considerably large amount of unpaid charge has accumulated because of the insufficient management system of meter reading and charge collection.

Along with revision of the electricity charge in August 1991, a new system wherein electric power sold to the Collective Group from EDP and retailed by the group was adopted. This Collective Group has been established in the respective blocks of the town. According to this system, electric power is sold wholesale to the respective Collective Groups from EDP and distributed to consumers from the groups. Consumers who receive this power pay the respective group for it directly.

At the point where electric power is sold to a wholesaler or Collective Group, a watthour meter is installed in a substation or the nearest low voltage distribution line. Twenty percent of the electrical energy metered with this watthour meter is deducted, and the electrical energy less the 20% deduction is multiplied by 170 Riel/kWh to determine the electricity charge to be paid directly to EDP. This deduction is made taking into account the distribution loss from the watthour meter to consumers. The electricity charge is invoiced to the Collective Group from EDP. The personnel of the respective Collective Groups read watthour meters installed by individual consumers.

In addition to the consumers receiving power through the Collective Groups, there are also consumers receiving power directly from EDP. Watthour meters are installed by the consumer.

One problem is that watthour meters being used at present are not necessarily precise. There is no third party organization that undertakes checking and calibration of watthour meters. The error of such watthour meters is also deemed to be included in the electrical energy loss in distribution lines.

(2) Electricity sales by collective groups

As mentioned previously, the electricity sales system using collective groups was introduced in August 1991 when the electricity charge was revised. In February 1992, there were 159 such groups through out Phnom Penh city. Each collective group purchases electricity at a low voltage transformer, and maintains the distribution lines from the transformer to the feeder lines of their consumers including watt-hour meters. Collective groups are a kind of association organized by the residents around a low voltage transformer. The residents become members of the association after paying a membership fee. When EDP receives a request from such an association, EDP sends an evaluation team to examine whether the association qualifies as a collective group. If the association qualifies, a contract between EDP and the association is made and the association pays a bond to EDP.

Before introduction of the collective group system, many distribution lines were stolen, and many consumers used electricity illegal by manipulating their watt-hour meters. However, the introduction of the system reduced theft of distribution lines and illegal consumption of electricity. At the same time, transformer failures that were caused by excess load have reduced significantly because the excess load, which was a consequence of illegal connection of feeder lines, was successfully controlled by the system. When the capacity of a transformer that a collective group uses becomes insufficient, the collective group applies for a capacity increase to EDP.

Collective groups collectively install and maintain consumers' watt-hour meters in a box fixed to a high place on an electric pole or in a hut when there are many meters. In such a hut, a night guard is engaged to prevent theft and manipulation.