No.

THE FOLLOW-UP STUDY
ON
THE REHABILITATION OF
HYDROPOWER STATIONS IN THE
KELANI RIVER BASIN
FOR
HYDROPOWER OPTIMIZATION
IN
SRI LANKA

FINAL REPORT
SUMMARY

JULY 2005

JAPAN INTERNATIONAL COOPERATION AGENCY
ECONOMIC DEVELOPMENT DEPARTMENT

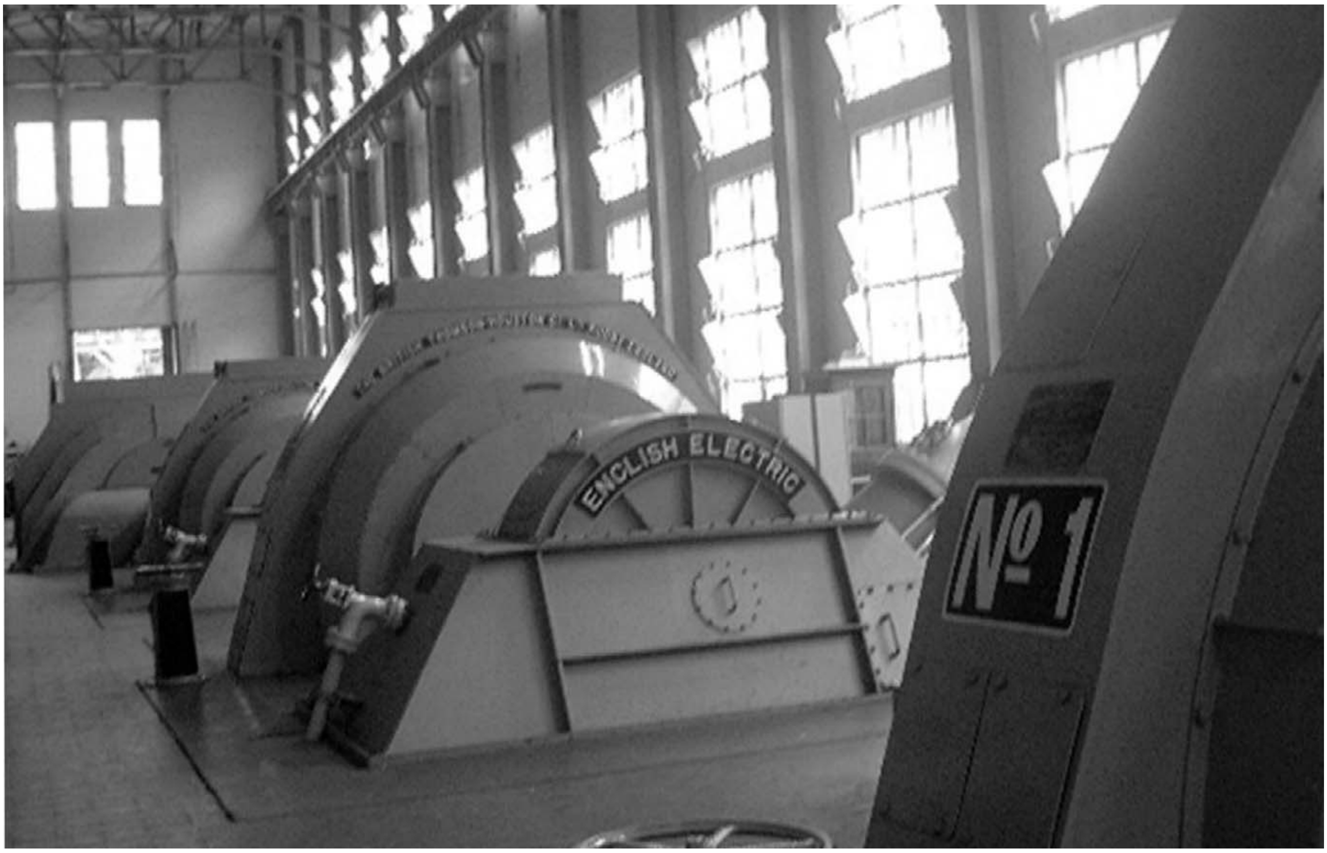
ED
JR
05 - 057

Laxapana Fall

Castlereagh Dam

Laxapana Hydropower Station (Old and New Laxapana Hydropower Station)

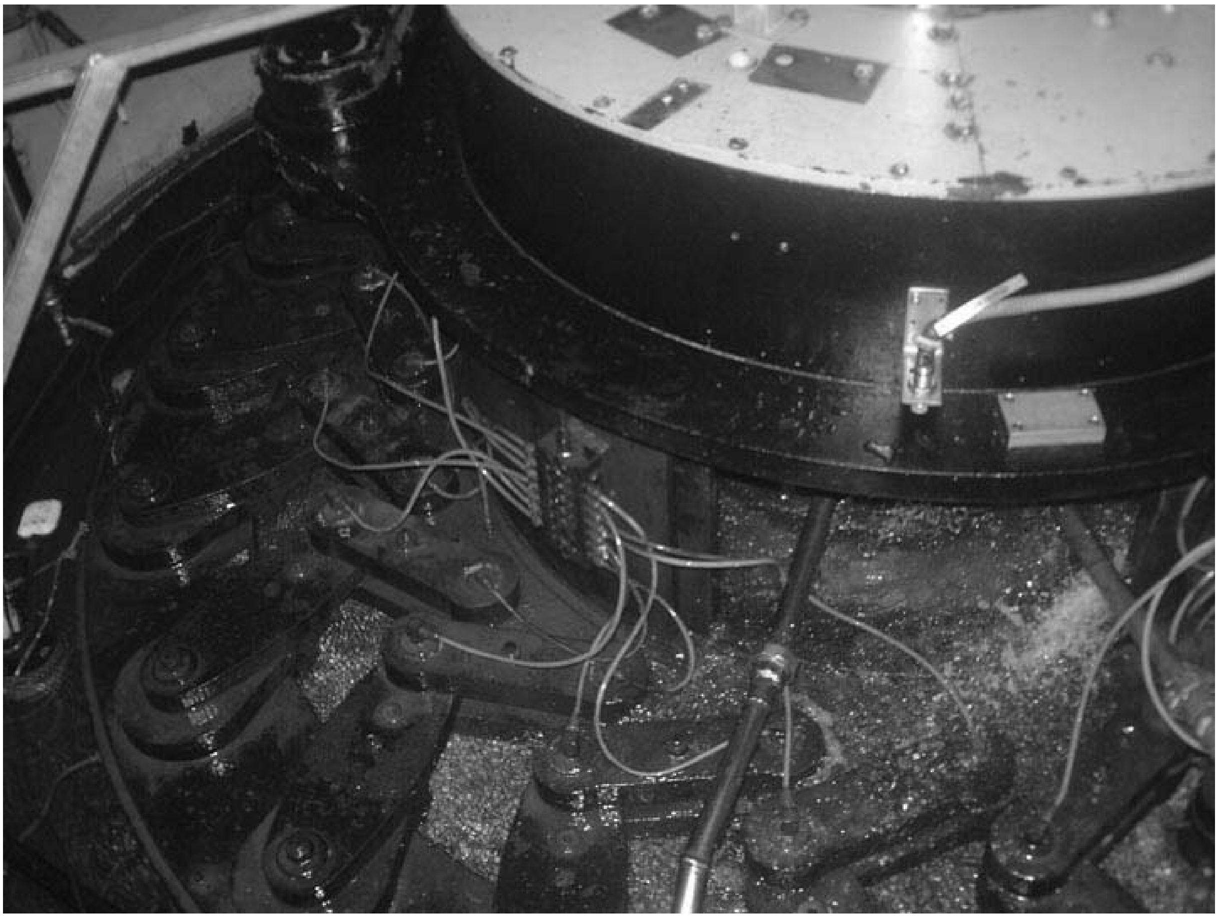
Wimalasurendra Hydropower Station



Turbines and Generators in Old Laxapana Hydropower Station

Efficiency test in New Laxapana Hydropower station

Intake Guard Valve House of Canyon Hydropower Station



Water Leakage from Turbine in Polpitiya Hydropower Station

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CONTENTS

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CONCLUSION

The conclusions described hereunder are based on the results of the Follow-up Study on the Rehabilitation of Hydropower Stations in the Kelani River Basin for the Study of Hydropower Optimization in Sri Lanka (hereinafter referred as "the Study"), conducted from July 2004 to July 2005.

1. Rehabilitation for the Existing Hydropower Stations

Wimalasurendara Hydropower Station

Repair of Headrace Tunnel

A collapse in the headrace tunnel has been worried since muddy water from outlet of powerhouse was recognized in the past. The CEB carried out the dewatering and inspection of the tunnel in February 2005, and the Study Team also participated in the inspection. Through the inspection, a cause of the muddy water was suspected most likely due to a tunnel collapse, and the Study Team proposed the repair plan of it. Since the scale of the collapse was fortunately small, the CEB conducted repair works after the inspection and finished the works by April 2005, and the power station restarted its operation after filling water into the tunnel.

Replace of Generators

Downward movement of stator coil caused by loosening of the wedges in the Unit 1 generator was recognized and that in the Unit 2 has been worried. Two alternatives, one is to replace the stator coils and the iron cores and the other is to replace the whole generators, are recommendable.

It was recognized that the insulation resistance values in the most of transformers are largely decreasing. Therefore, it is recommended to replace all the transformers urgently to avoid earth fault and short circuit fault which may occur in case the power plants are operated continuously.
In addition, the control equipment of the plants has some troubles due to degrading and it also has entered an era of replace.

Old Laxapana Hydropower Station

Replace of Turbines and Generators

The Stage I plants (Units 1 to 3 with capacity of 8.33MW for each) of the Old Laxapana Hydropower Station has been operated for more than 54 years. It is recommended to replace all the turbines and generators, because the efficiency of the turbines has decreased by more than 10% than the original and supply of the spare parts of the plants can not be expected because the original manufacturer closed its business.

Incremental capacity from 8.33MW to 9MW due to improvement of their efficiencies is expected in case of the replacement.

It is desired for the CEB to continue to monitor the deterioration degree of the Stage II plants (Units 4 and 5 with capacity of 12.5MW for each).

Canyon Hydropower Station

Improvement of Anti-negative Pressure Valve

Anti-negative pressure valves locate in headrace just downstream of the dam. The valves operated and water belched out twice in the past under conditions where the reservoir water level was almost near the minimum operation level and the discharge for the turbines was almost the maximum, and .there was much difficulty in stopping water.

Since a drastic improvement of the waterway structure to prevent occurrence of negative pressure will be huge works and the operation of the valves is not so often, it will be better to relocate the valves from inside to outside of the valve house to avoid the effect of spring water to other surrounding equipment and to make the operation of intake valves, which locate just upstream, easy.

New Laxapana Hydropower Station

Water Leakage from headrace Tunnel

Water, which seems to be from the headrace tunnel near the surge chamber, has been observed since commissioning of the power station. During the Study, it was confirmed that water has been coming from the tunnel. Anti-negative pressure valves locate in headrace just downstream of the dam.

It is recommended to specify the location of leakage points and to take measures to shut out them if an opportunity of dewatering occurs, because it is considered that immediate land slide nearby caused by the water leakage is unlikely.

Replace of Generators

As well as the Wimalasurendra Hydropower Station, downward movements of stator coil caused by loosening of the wedges were recognized and urgent measures are required for them. In spite that two alternatives, one is to replace the stator coils and the iron cores and the other is to replace the whole generators, also are recommendable, the latter, which can shorten the operation stop period, will be more practical because the New Laxapana Station has a function of frequency control of the Sri Lankan system and it is difficult to stop operation over the long term.

In addition, the control equipment of the plants has some troubles due to degrading and it also has entered an era of replace.

Polpitiya Hydropower Station

Vibration in Turbines

In spite the Polpitiya Station is having a restriction on its operation due to vibration in the turbines under low load, the Study Team could not get a conclusion of replacement of the turbines during the Study. . Further detailed investigation is required.

2. Environmental Impact Assessment for Rehabilitation

EIA will not be required for the above-mentioned rehabilitation works because they do not introduce a large scale change in original lands, and replacement works of turbine and generator can be done in the existing powerhouses.

But, development works within a distance of 100m from full supply level of existing reservoir belong to the projects which are necessary to obtain an approval of project implementation by the Project

Approving Agency (PAA) based on the National Environmental Act. The rehabilitation works of the hydropower stations in the Kelani River basin correspond to such projects.

Therefore, it is essential to inquire of the Central Environmental Authority (CEA) about the necessity of EIA procedure before project implementation.

3. Schedule of Rehabilitation Implementation

Since shut-down of the existing power station is inevitable for the rehabilitation works under the circumstances that the power balance of the country is so tight, it is importance to weigh the timing of the works.

Although dewatering and internal inspection of the tunnel of the Wimalasurendra Hydropower Station had originally been scheduled to do in 2004 and postponed, fortunately they were carried out during the Study Period (in February 2005). Also just before, the dewatering was likely to be postponed again.

In this way, the power balance in the country is so fragile and development of new power stations is expected before the rehabilitation works. It is very importance especially for the rehabilitation of the New Laxapana Station to weigh the timing of the works, because the function of frequency control equipped with it must be transferred to other power stations before shut-down, and the capacity of 100MW is relatively large and generator with 50 MW capacity must be shut-down even if two generators are schedule to be replaced one by one.

RECOMMENDATION

In Sri Lanka, more than 55% of the potential hydropower has already been harnessed, and the remaining potential hydropower that is economically efficient and environmentally acceptable is very limited. Therefore, as described in the Long-Term Generation Expansion Plan, large-scale thermal power stations will be constructed to meet the increases in demand in the future, and the composition of power sources will change from "hydropower dominated" to "thermal power dominated". In parallel with this change, the role of hydropower stations, regardless of whether they are existing or newly constructed, should also change.
Amid call for necessity of large scale thermal power station, it is very difficult to develop any types of new power station and the power balance become fragile, then shut-down of existing power stations for inspection or repair works become more and more difficult.

Rehabilitation of the Existing Hydropower Stations

As the result of the Study, it was recognized that all hydropower stations in the Kerani River basin has been deteriorated badly and some of them are likely to be shut-down at any time.

Stoppage of existing power station under the condition of tight power balance leads to increase of loss of load probability (LOLP) or power cut in some area. In case the shut-down lasts for long period, the CEB will prepare some emergency power with commonly high generation cost, which accelerates the financial balance of the CEB worse.

Although development of new power station is essential for the CEB, continuous proper operation of the existing hydropower stations is as important as, or more than that.

As stated above, the CEB should implement the rehabilitation works of hydropower stations in the Kelani River basin after designing a schedule of appropriate planned outage taking into account the power balance of the system in the future.

Maintenance Management

The CEB has been very well operating and maintaining all the existing hydropower stations in spite of limited budget and constrain on outage under the tight power balance situation. Especially as for electro-mechanical equipment, the CEB`s staffs have repaired some equipment by themselves without any supply of spare parts from the original manufacturer.

The tight power balance set off a vicious cycle; i.e., the tight power balance creates a difficulty in having outage of power plants for inspection and repair, which leads to derogation of reliability in stable operation of power plants, and which make the power balance tight.

As for civil structures, daily visual inspection is most effective to find defect early. It is desired to make monthly patrol inspection by civil engineer in the CEB headquarter even though daily inspections has no alternative but to be made by other engineer on behalf of civil engineer because no civil engineer is allocated to the Laxapana Complex. Furthermore, tunnel inspection after dewatering is also required every ten or twenty years.

In spite that periodic inspections for hydro-mechanical and electro-mechanical equipment have been done so frequently, deterioration degree cannot be estimated accurately because different methods has been applied in each case. Therefore it is recommended to standardize the frequency and method of measurements. Furthermore, it is recommended to make an overhaul for all the plants too because it has never been made for more than twenty-five years since their commissioning.

1. INTRODUCTION

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1.1 Background of the Study

The Follow-up Study on the Rehabilitation of Hydropower Stations in the Kelani River Basin for the Study of Hydropower Optimization in Sri Lanka (hereinafter referred to as the Study) was conducted under the Minutes of Meetings and the Scope of Work signed by the Department of External Resources (on behalf of the Ministry of Finance and Planning), Ministry of Power and Energy, the Ceylon Electricity Board (hereinafter referred to as the CEB) and the Japan International Cooperation Agency (hereinafter referred to as JICA) on April 28, 2004.

1.1.1 Social and Economic Background

In Sri Lanka, no fossil fuel deposits have been found except a small amount of peat to the north of Colombo, and analysis of the peat shows its unfitness for the purpose of thermal power generation. Therefore, hydropower and biomass such as firewood are the main domestic energy sources in the country.

The economy of Sri Lanka has had an expanding tone since it escaped the stagnation of the 1980s. The country remained nearly unaffected by the economic crisis that hit almost all countries in Asia, and its annual growth rate of GDP exceeded 5% in the 1990s. Electric power generation has also increased in proportion to the growth of the economy, and power demand elasticity (power demand growth rate/GDP growth rate) has been close to 2.0. This indicates that power demand has been increasing at a high rate in recent years, and an active growth rate exceeding 7 to 8% a year is predicted in the 20-year power demand forecast.

However, the circumstances surrounding the development of new power projects, regardless of whether they are hydropower or thermal power projects, have been worsening mainly because of environmental concerns. Therefore, since 1997, the CEB has had no choice but to purchase relatively expensive electricity from IPPs. Moreover, combined with the effects of droughts, the power supply had not been able to meet the demand in the past few years, in the late 1990s and early 2000s, and scheduled power cuts had to be introduced. Furthermore, these circumstances, in which a stable power supply is not ensured, could cast a shadow on the economic growth of the country.

Development of new power plants is one of the crucial issues for the Government of Sri Lanka, and inauguration of large-scale thermal power plants in particular is expected. On the other hand, development of hydropower resources is also an important issue to ensure energy security for the country, which heavily depends on overseas sources for fossil fuel.

1.1.2 Necessity of Rehabilitation of Hydropower Stations in the Kelani River Basin and Request for Technical Assistance

As of January 2004, the total capacity of generating facilities owned by the CEB was 1,680MW, which consisted of 1,205MW at 16 hydropower stations and 475MW at five thermal power stations. Annual output in 2003 by hydropower generation and that by thermal power generation were 3,314GWh and 4,293GWh, respectively. In addition to the CEB's facilities, IPPs have, as of 2003, 26 small scale hydropower stations with total capacity of 40MW and seven thermal power stations with a total capacity of 434.5MW. As shown by these figures, the Sri Lankan power sector depends on hydropower, which accounts for over 70% of the total generating capacity of the CEB as of 2003.

According to the Long Term Generation Expansion Plan worked out in 2004, the growth rates of maximum power demand over the next 20 years are predicted to be 7 to 8% annually. However, expectations for future development of hydropower are low because of economic efficiency and environmental constraints. Thus, it is obvious that thermal power generation will necessarily take a major role in the long term.

To cope with these problems, the role of hydropower in Sri Lanka should be altered from the power source for base demand to that for middle and/or peak demand. Although the potential hydropower in Sri Lanka is said to be around 2,000MW, more than 1,100MW has already been developed, and the number of remaining project sites that have potential from the viewpoints of economic efficiency and the natural/social environment is limited. However, development of hydropower is strongly expected from the viewpoint of the energy security of the country, which has limited domestic energy resources.

In these circumstances, the Government of Sri Lanka in September 1999 requested the Government of Japan to conduct a feasibility study regarding the optimization of hydropower in Sri Lanka. In response to the request, the Government of Japan conducted a project formation study in December 2000 and a preliminary study in November 2001, and the Scope of Work was determined between the CEB and JICA on November 16 of the same year.

The Study on Hydropower Optimization completed in March 2004, and serious deterioration degrees were found in the existing hydropower stations in Sri Lanka, especially those five stations in the Kelani River Basin. Since the power development plan has been made by the CEB under the condition that the existing hydropower stations will be operated properly, shutdown of the existing hydropower stations due to some troubles may leads to review of its power development plan. As a result, the CEB requested JICA to conduct the follow-up study on the rehabilitation of hydropower stations in the Kelani River basin.

1.2 Purposes of the Study

According to the above-mentioned Scope of Work, the purposes of the Study are:

- to comprehend the situations of the existing hydropower stations,
- to establish the rehabilitation program based on the problems found in the above at a feasibility study level, and
- to recommend the methods of deterioration assessment and maintenance inspection to the CEB.

Specifically, the purposes of the Study are in two categories as described below.

The first purpose is to comprehend problems in the exiting hydropower stations and to classify these problems into those required measures immediately and those required measures gradually. Priorities (deterioration degree) are to be given for each problem, and rehabilitation plans with a feasibility study level are to be recommended.

The second purpose is to comprehend the present situations of maintenance and inspection of the CEB and to recommend a realistic operation and maintenance manual excluding overloaded inspection to the CEB.

The entire study flow with the above-mentioned purposes is shown in Figure 1.1.

1.3 Contents of Each Study Stage

(1) The First Study Period in Sri Lanka (July 25 - September 4, 2004)

At the beginning of the first study period, the Study Team submitted the Inception Report to the CEB and made a presentation, and obtained the CEB’s consent regarding the method of the Study.

Following the presentation, the Study Team carried out the following:

- Recognition of problems and inspection of their deterioration degrees for each hydropower station and structure (civil structure, hydro mechanical equipment, and electro-mechanical equipment) under support of the CEB's engineers being based in Laxpapana complex, where the existing five stations are totally operated and controlled, as the home base of the Study.

- Information-gathering on past inspection records and related documents and interview from related person for judging deterioration.

- Preparation of bidding documents and calling for bids on local contracts for topographic and geological survey.

- Survey and hearing from related person for EIA procedure by the member in charge of environment.

- Geological site reconnaissance in the project area by the geologist.

- Data collection for economic and financial analysis by the member in charge.

(2) The First Study Period in Japan

Based on the outcome obtained in the first study period in Sri Lanka, the Study Team made the rehabilitation plan taking into consideration of location and deterioration degree of problem for each hydropower station and structure, and prepared the Progress Report.

(3) The Second Study Period in Sri Lanka (October 17 - 31, 2004)

The Study Team submitted the rehabilitation plan of the hydropower stations in the Kelani River Basin to the CEB based on the Progress Report that was prepared in the First Study Period in Japan, and the CEB and the Study Team had something in common on it.

The seminar was fold inviting related person from the Ministry of Power and Energy, the CEB, JICA, JBIC etc. and the problems and their deterioration degrees were introduced.
Moreover, the Study Team collected additional data missing in the First.

The Study Team negotiated with the selected bidders for the topographic survey and geological investigation and concluded contract.

At the start of the site work by the contractors, the team members in charge of these contracts went to the site with the contractors' engineers to give them detailed instructions.

(4) The Second Study Period in Japan

The Study Team made a conclusive rehabilitation plan in which items and their priorities, costs and schedules were included based on the result of the Second Study Period in Sri Lanka.

Maintenance manuals by structures and equipment were prepared.

The Progress Report, which included the above results, was prepared.

(5) The Third Study Period in Sri Lanka (January 30 – February 13, 2005)

The Study Team concluded the rehabilitation plan after negotiation with the CEB. Moreover, the maintenance manuals were introduced to the CEB and were understood by the CEB.

The Study Team members in charge of the contract visited the site and accepted the results after confirming the site situations.

(6) The Forth Study Period in Sri Lanka (February 23 – March 9, 2005)

The Study Team carried out the tunnel site inspection of the Wimalasuendra hydropower station together with the CEB staffs after dewatering, and gave the suggestions to the CEB about the method to repair the recognized problems such as the tunnel collapse.

(7) The Third Study Period in Japan

The Study Team prepared the Draft Final Report, in which some measures to be taken especially for troubles in civil structures, based on the results of topographic survey, geological investigation and the Fourth Study Period in Japan.

(8) The Fifth Study Period in Sri Lanka (May 23 – June 3, 2005, tentative schedule)

The Study Team will explain and confirm the content of the Draft Final Report.
The Study Team will confirm the degree of understanding of the Study result transferred to the counterparts.

1.4 Persons related to the Study (Positions are as of the time of the Study)

(1) Ministry of Power & Energy

Mr. P. Weerahandi	Secretary

(2) Ceylon Electricity Board

Mr. Ananda S. Gunasekara	Chairman
Mr. Wijeratne	General Manager
Mr. Ranjit F. Fonseka	General Manager
Mr. K. S. P. Jayawardena	AGM, Generation Projects
Mr. M. C. Wickramasekara	DGM, Generation Projects
Mr. C. P. W. Akarawita	DGM, Laxapana Complex
Ms. Kamani Jayasekera	Chief Engineer, Generation Planning
Mr. S. D. G. L. Jayatilaka	Electrical Engineer, Generation Projects
Mr. R.K.W. Wijeratne	Environmental Officer
Mr. H. M. Anura Herath	Chief Engineer, Laxapana Power Station
Mr. D. M. D. B. Dissanayake	Mechanical Engineer, Laxapana Power Station
Mr. S. K. S. Chandrasoma	Mechanical Engineer, Laxapana Power Station
Mr. Saumya Kumara	Electrical Engineer, Wimalasurendra Power Station
Mr. G. Athula Kumara,	Electrical Engineer, Polpitiya Power Station
Mr. Liyanage	Electrical Engineer, Canyon Power Station
Mr. K.K. Kithsiri	Civil Engineer, Generation Projects

(3) Embassy of Japan

Mr. Koji Iwashita	First Secretary

(4) Japan Bank for International Cooperation (Representative Office in Colombo)

Mr. Shinya Ejima	Chief Representative

(5) Japan International Cooperation Agency (Sri Lanka Office)

Mr. Toshio Sugihara	Resident Representative
Mr. Takumi Ueshima	Resident Representative
Mr. Jituya Ishiguro	Assistant Resident Representative
Mr. Jiro Komatsu	JICA Expert

(6) JICA Study Team

Mr. Tsuyoshi Nakahata	Team Leader / Hydropower Facility /Power Development Plan
Mr. Yoshiyuki Kaneko	Civil Facility / Environmental Impact Assessment
Mr. Nobuo Hoshino	Geology
Mr. Koichi Hakamatsuka	Hydro mechanical Facility
Mr. Joshiro Sato	Hydro turbine
Mr. Shinichi Inaba	Generator
Mr. Mototaro Okada	Control facility for Power Station
Mr. Toshiro Nakano	Economic and Financial Analysis
Mr. Koji Tabata	Operation Coordination

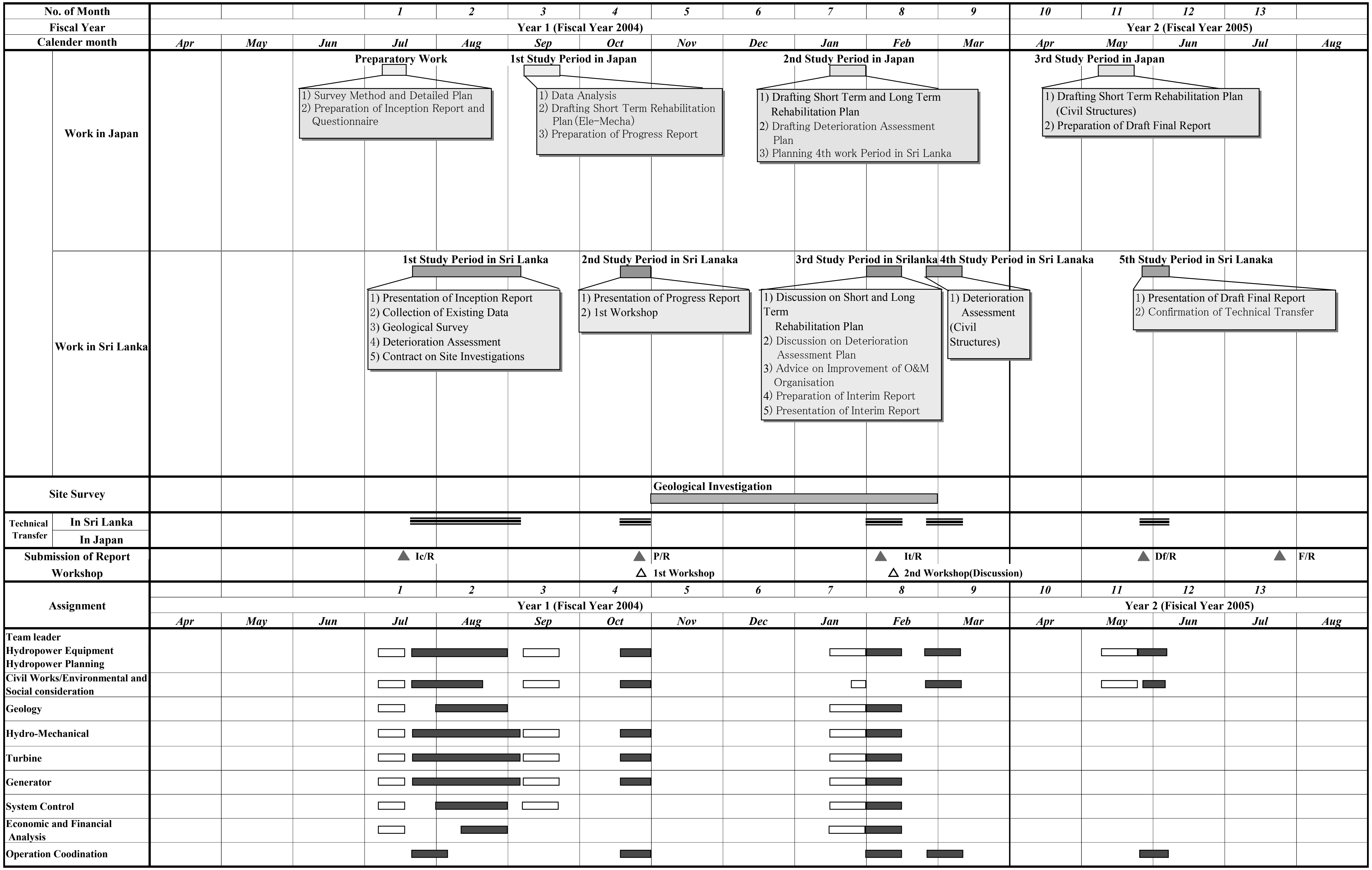

Figure. 1.1 The Follow-up Study on the Rehabilitation of Hydropower Stations in the Kelani River Basin for The Study of Hydropower Optimization in Sri Lanka

2. GENERAL FEATURES OF SRI LANKA

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2.1 Topography

The Democratic Socialist Republic of Sri Lanka (hereinafter referred as "Sri Lanka") is an island country in the Indian Ocean, located to the south of the Indian subcontinent. The main island lies between 5°55′ and 9°55′ north latitude and between 79°42′ and 81°52′ east longitude, and stretches for about 240 km in the east-west direction and 435 km in the north-south direction. The area of the country is 67,095 km^2 including the internal waters of 1,170 km^2.

The administrative capital was relocated from Colombo to Sri Jayewardenepura in 1984, on the outskirts of Colombo. However, in practice, capital city functions remain in Colombo.

The topographic feature of Sri Lanka are categorized in three zones on the basis of elevation: a central mountainous area called as the Central Highlands, the plains, and the coastal belt.

The Central Highlands area is in the south-central part of Sri Lanka. The core of this area is a high ridge, running north-south for approximately 65 km. This area includes some of Sri Lanka's highest mountains. Mt. Pidurutalagala is the highest at 2,524 m. At the plateau's southern end, mountain ranges stretch 50 km to the west toward Adams Peak (2,243 m) and 50 km to the east toward Mt. Namunakuli (2,036 m). Flanking the high central ridges are two plateaus. On the west is the Hatton Plateau, a deeply dissected series of ridges sloping downward the north. On the west, the Uva Basin consists of rolling hills traversed by some deep valleys and gorges. To the north, separated from the main body of mountains and plateaus by broad valleys, lies the Knuckles Massif, with steep escarpments, deep gorges, and peaks rising to more than 1,800 m. South of Adams Peak lies the parallel ridges of the Rakwana Hills, with several peaks over 1,400 m.

Most of the island's surface consists of plains between 30 and 200 m above sea-level. In the southwest, ridges and valleys rise gradually to merge with the Central Highlands, giving a dissected appearance to the plain. Extensive erosion in this area has worn down the ridges and deposited rich soil for agriculture downstream. In the southeast, a red, lateritic soil covers relatively level ground that is studded with bare, monolithic hills. The transition from the plain to the Central Highlands is abrupt in the southeast, and the mountains appear to rise like a wall. In the east and the north, the plain is flat, dissected by long, narrow ridges of granite running from the Central Highlands.

A coastal belt about 30 m above sea-level surrounds the island. Much of the coast consists of sandy beaches indented by coastal lagoons. In the Jaffna Peninsula, limestone beds are exposed to the sea as low-lying cliffs in a few places. In the northeast and the southwest, where the coast cuts across the stratification of the crystalline rocks, rocky cliffs, bays, and offshore islands can be found: these conditions have created natural harbors at Trincomalee on the northeast coast and Galle on the southwest coast.

The rivers of Sri Lanka radiate from the Central Highlands to the sea. There are 16 principal rivers longer than 100 km in length, with 12 of them carrying about 75 percent of the mean river discharge in the entire country. The longest river is the Mahaweli Ganga (335 km), and the Aruvi Aru (164 km) follows. In the Highlands, river courses are frequently broken by discontinuities in the terrain, and where they encounter escarpments, numerous waterfalls and rapids have eroded a passage. Once they reach the plain, the rivers slow down and the waters meander across flood plains and deltas. The upper reaches of the river are wild and usually unnavigable, and the lower reaches are prone to seasonal flooding.

2.2 Climate

The climate of Sri Lanka is categorized as tropical as a whole. The annual average temperature in Colombo is about 27°C. At higher elevations, however, it is quite cool, and the annual average temperature goes down to about 15°C in Nuwara Eliya at about 1,800 m above sea-level.

The rainfall pattern is influenced by the monsoon winds of the Indian Ocean and Bay of Bengal and is marked by four seasons. The first season is from mid-May to October, when winds originate in the southwest, bringing moisture from the Indian Ocean. When these winds encounter the slopes of the Central Highlands, they unload heavy rains on the mountain slopes and the southwestern sector of the island. However the leeward slopes in the east and northeast receive little rain. The second season occurs in October and November, the inter-monsoon season. During this season, periodic squalls occur and sometimes tropical cyclones bring overcast skies and rains to the southwest, northeast and eastern parts of the island. During the third season, December to March, monsoon winds come from the northeast, bringing moisture from the Bay of Bengal, unloading heavy rains on the northwestern slopes of the mountains. Another inter-monsoon period occurs from March to mid-May.

2.3 Government

The president, who is elected directly for a six-year term, serves as the head of state. In Sri Lanka, the president also serves as the head of government and appoints cabinet ministers in consultation with the prime minister. As of the end of 2001, there were 25 ministries of cabinet rank; the CEB belongs to the Ministry of Power and Energy.

The legislative branch of the government is unicameral and the Parliament consists of 225 seats. The members of Parliament are elected by popular vote on the basis of a modified proportional representation system and serve six-year terms.

The administrative divisions of the country consist of nine provinces, and 25 districts under these provinces. The smallest administrative unit is the Assistant Government Agent of Divisions (AGA Division), and there are 247 AGA Divisions in the country. The Broadlands Hydropower Project is located on the boundary between Nuwara Eliya District in Central Province and Ratnapura District in Sabaragamuwa Province.

Fig. 2.1 and 2.2 show these administrative boundaries and administrative structures.

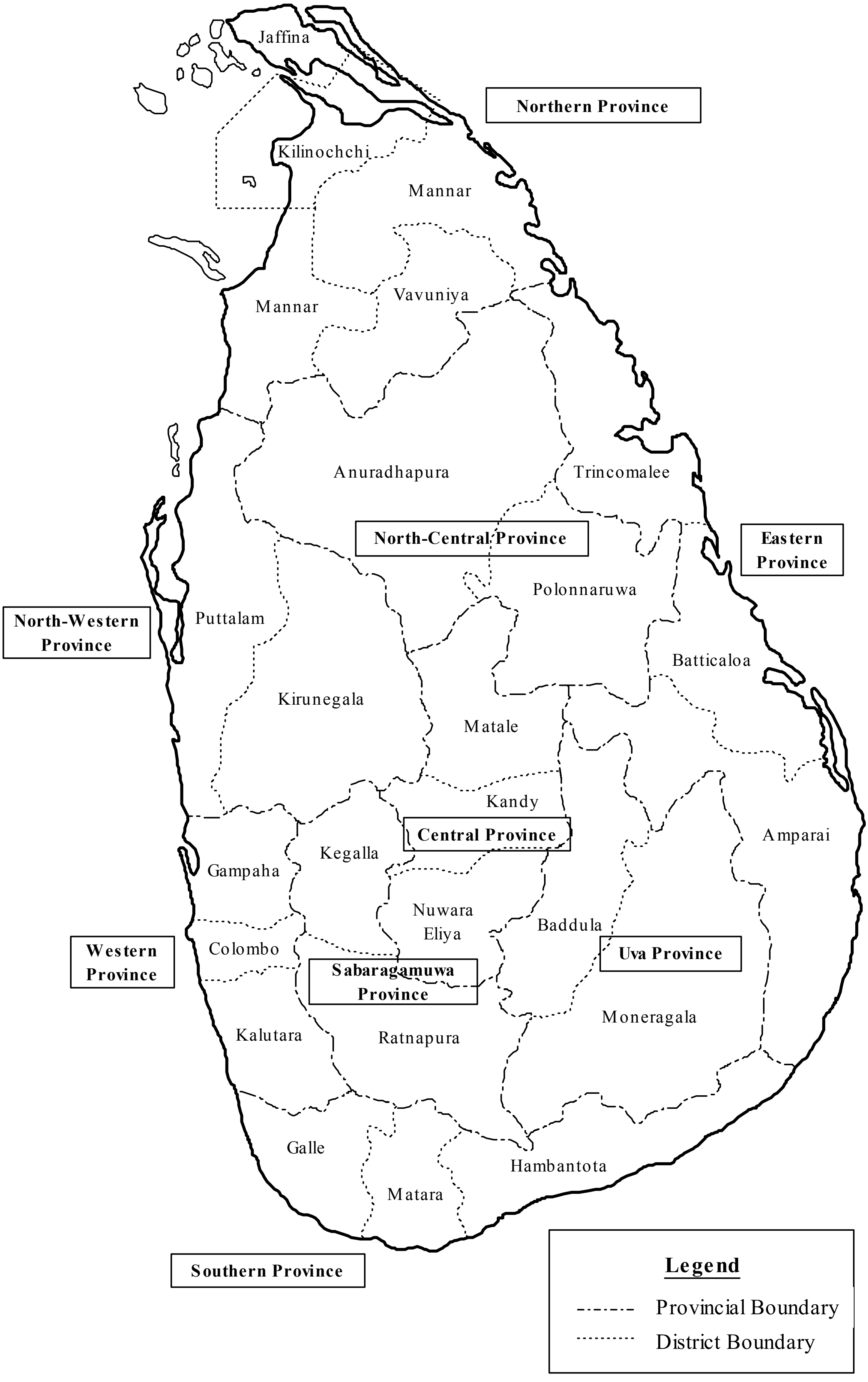
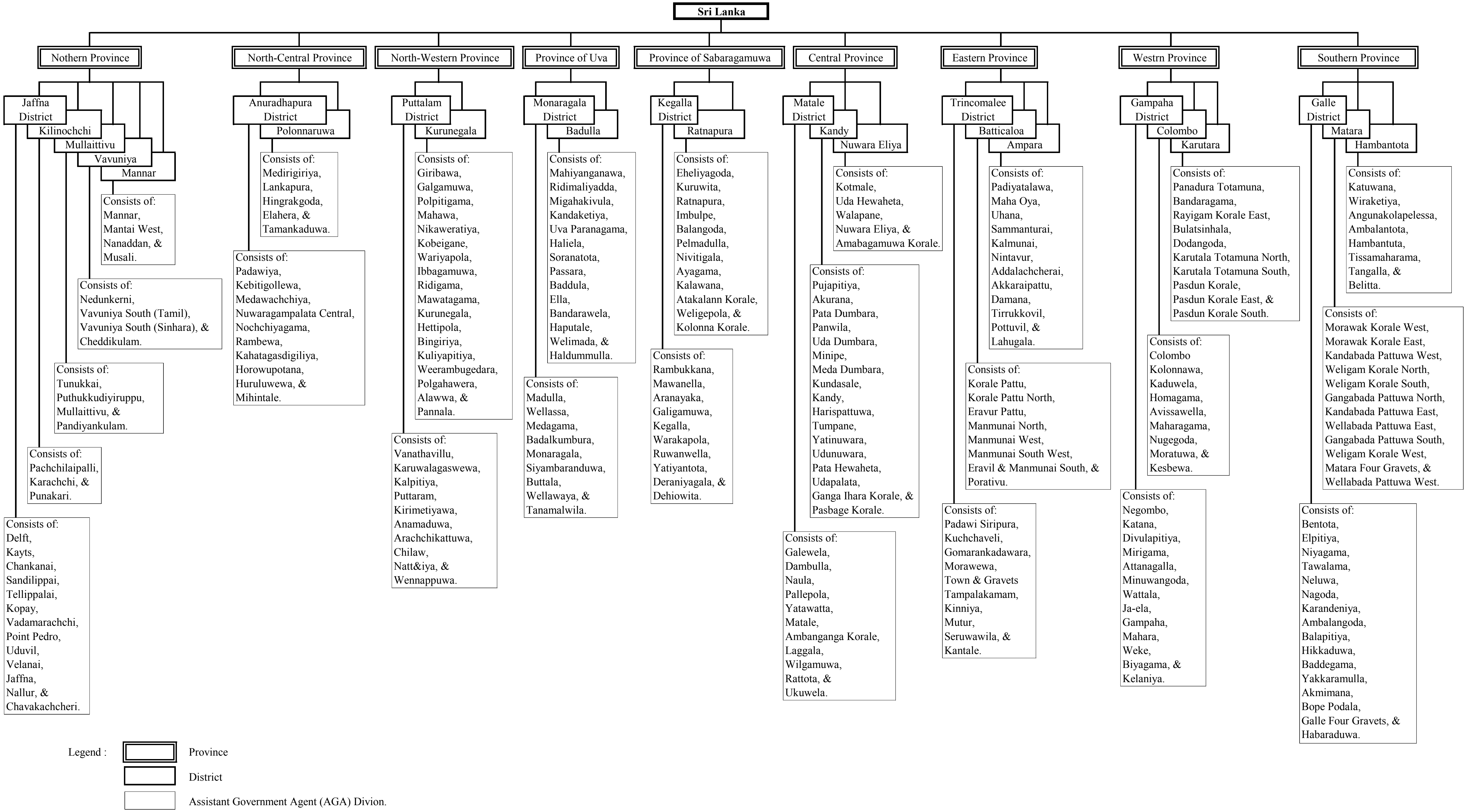


Figure 2.1 Administrative Boundary Map



Source : CEB

Figure 2.2 Administrative Structure of Sri Lanka

3. SOCIO-ECONOMY

3. SOCIO-ECONOMY

3.1 Population

3.1.1 Census Population

As the following table showing, the population of 19 million in 2003 increased from 18 million in 1998, and it has been rising at annual rate of about 1.3%.

3.1.2 Labor Force

A labor force was amounted as 7.6 million persons as of 2003, of which around 91.5% was actually employed. Thus, an unemployed rate was 8.5 % in the same year. Since the unemployment rate was more than 12% in 1995, the rate has been improved by around 8% after 2000.

3.1.3 Ethnic Group

Sri Lanka is essentially composed of three ethnic groups, that is, the Sinhalese, Tamil and Muslim. They make up more than 99% of the country population. These groups are corresponding to religious and linguistic distinctions. The Sinhalese account for nearly three-fourths of the people.

3.2 Macro Economic Features

3.2.1 National Accounts

The gross domestic product (GDP) in Sri Lanka was Rs.1,561 billion at current factor cost prices in 2003, as shown in Table 3.1. Among major economic sectors, “wholesale, retail trade” sector recorded the largest gross value added (GVA) of Rs.314 billion, the highest contribution to the national economy. An economic sector of "agriculture, forestry and fishing" accounted for Rs.297 million. And "manufacturing" sector occupied the third position, accounting for Rs.242 million. GDP per capita has grown continuously and recorded US$947 in 2003.

3.2.2 Economic Sector Profile

In terms of economic performance, “trade” sector recorded the largest contribution to GDP as 20 % in 2003. The second largest contributing sector was “agriculture, forestry, fishing” sector, accounting for 19% in the same year. The third one was the manufacturing sector accounting for 16% in 2003.

3.2.3 External Trade and Balance of Payment

Sri Lanka has run a deficit in current account for many years. The cause of this is deficit of a trade balance. Capital account has exhibited a surplus. Then, the over-all balance of external trade by current account and capital and financial account has been keeping a surplus since 2001 to 2003, and it recorded US$500 million surplus in 2003.

3.2.4 Government Finance

In 2002 and 2003, regarding the Government finances of Sri Lanka, the balance of these fiscal operations was resulted in deficit as -141.1 billion in 2002 and -141.2 billion in 2003.

3.2.5 External Debt and Outstanding

(1) The foreign assistance

Sri Lanka has received most grants from Japan, has built important relationship between Japan in loan and grants assistance. It is still continued for a long time until now.

(2) The external debt

The total external debt of the country increased by 14% from 2002, it was US$10.6 billion in 2003. It corresponds to 58.4% of the GDP. On the other hand, the improvement is found in Debt Service Ratio (DSR) 11.6% in 2003 from 13.2% in 2002. Usually, from 20% or less of this index is desirable, thus Sri Lanka has an enough capability to repay the external debt.

3.2.6 Price Indices and Exchange Rates

(1) Price Indices

The consumer price index (CPI) in Sri Lanka increased to 158 (base: 1995 to 1997 =100) in 2003. While, the wholesale price index (WPI) in Sri Lanka increased to 147 (base: 1996=100) in 2003.
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(2) Foreign Exchange Rates

The value of Rupee dropped from Rs.40.27 per US$1 in 1990 to Rs.96.52 in June 2003. Also the value of Rupee dropped from Rs.0.292 per JP¥1 in 1990 to Rs.0.833 in June 2003.

3.3 Projection of Socio-Economic Structures

3.3.1 Population and GDP Projection

The table below shows the projections of population and GDP growth rate, which are reported in Annual Report 2003 of Central Bank of Sri Lanka.

Item	2003	Projection			
		2004	2005	2006	2007
GDP (%) Growth Rate	5.9	5.5	6.5	7.0	7.2
Population（million）	19.3	19.4	19.6	19.8	20.0

4. PRESENT SITUATION OF POWER SECTOR IN SRI LANKA

4. PRESENT SITUATION OF POWER SECTOR IN SRI LANKA

4.1 Formation of Power Sector

(1) Ministry of Power and Energy (MPE)

The MPE is the main government body handling power and energy policy in Sri Lanka.

(2) Ceylon Electricity Board (CEB)

The CEB is a state-owned vertically integrated organization handling generation, transmission and distribution functions. There are seven divisions: the generation, transmission, distribution and operation, distribution development, commercial, headquarters, and finance manager divisions, under the board members such as the Chairman and General Manager. Though the CEB has been established as an independent body, executives are to be the assigned by the Ministry of Power and Energy, and approval by the Government is required for investments and setting tariffs.

(3) Energy Supply Committee

The Energy Supply Committee (ESC) under the Ministry of Power and Energy was set up in March 2002, based on the Energy Supply Act No. 2 of 2002, with a two-year mandate to find immediate solutions to the existing problems of the energy sector.

(4) Board of Investment (BOI)

The Board of Investment (BOI) was established in 1978, and is structured to function as a central facilitation point for foreign and local private investors.

4.2 Power Demand and Supply Balance

In 2003, the total generated electricity in Sri Lanka at the generating end amounted to 7,612GWh (excluding captive power). Electricity sales amounted to 6,209GWh and the remaining electricity was station use and losses at transmission and distribution lines and so on.

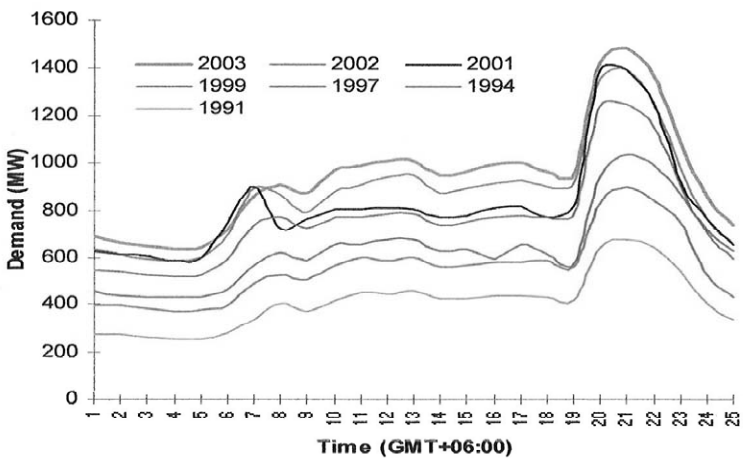
In 1996, the maximum peak demand (968.4MW) in the country decreased compared to that in the previous year due to the effect of drought, but since then it has been growing steadily. The recorded maximum demand in 2003 was 1,516MW. The average growth rate over the five years up to 2003 was about 7% per annum. Then, rotating power cuts were conducted due to insufficient power supply capability in 2001 and in 2002. In 2003, rotating power cuts were not carried out due to high water flow.

Table 4.1 Demand and Supply Balance

		1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Generation (GWh)	Hydro	4,089	4,514	3,249	3,443	3,909	4,152	3,154	3,045	2,589	3,190
	Thermal	275	269	1,126	1,450	1,264	1,396	2,569	2,237	2,866	2,587
	Wind	-	-	-	-	-	3	3	3	4	3
	Hydro (IPP)	-	-	3	5	6	18	43	65	104	120
	Thermal (IPP)	-	-	-	13	390	507	916	1,170	1,248	1,711
	Captive	22	17	152	235	114	108	167	105	141	-
	Total	4,387	4,800	4,529	5,146	5,683	6,185	6,853	6,625	6,951	7,612
Sectoral Electricity Sales (GWh)	Industrial	1,406	1,527	1,361	1,430	1,614	1,613	1,731	1,719	1,866	2,159
	Commercial	582	631	592	689	758	829	895	859	921	1,042
	Domestic	928	1.034	1,046	1,213	1,378	1,555	1,755	1,798	1,821	2,030
	Others	649	723	589	707	771	812	877	862	894	977
	Total	3,565	3,915	3,588	4,039	4,521	4,809	5,258	5,236	5,502	6,209
Peak (MW)		910	980	968	1,037	1,137	1,291	1,405	1,445	1,422	1,516

Source: CEB Statistical Digest 2003

Daily peak demand occurs from the evening until 10 p.m. because of lighting requirements. The disparity between the daily peak and the base load is around 2.4 to 1. In Sri Lanka, seasonal changes in load are minimal as are temperature variations. The maximum demand has been recorded month by month (refer to the figure below).



Source: CEB Report on Long-Term Generation Expansion Planning Studies 2005-2019

Figure 4.1 Daily Load Curve over the Year

4.3 Electricity Generation

Electricity generation in Sri Lanka has been growing steadily except for in dry years. The annual growth rate of electricity generation averaged 6.7% during the last 10 years (from 1993 to 2003).

As for the composition of generation by source, dependence on hydropower has been eased since the power crisis in 1996 due to drought, and the share of hydropower is less than 50% at present.

Table 4.2 Electricity Generation 1989 - 2003

Year	Hydro Generation (GWh, %)	Thermal Generation (GWh, %)	Self Generation (GWh, %)	Total (GWh)	Growth Rate (%)
1989	2,801 (98.0)	57 (2.0)	-	2,858	2.1
1993	3,796 (95.4)	183 (4.6)	-	3,979	12.4
1994	4,089 (93.2)	275 (6.3)	22 (0.5)	4,386	10.2
1995	4,514 (94.0)	269 (5.6)	17 (0.4)	4,800	9.4
1996	3,249 (71.8)	1,126 (24.9)	152 (3.4)	4,527	-5.7
1997	3,448 (67.0)	1,463 (28.4)	235 (4.6)	5,146	13.7
1998	3,915 (68.9)	1,654 (29.1)	114 (2.0)	5,683	10.4
1999	4,175 (67.6)	1,901 (30.8)	97 (1.6)	6,173	8.6
2000	3,197 (46.7)	3,486 (50.9)	158 (2.4)	6,841	10.8
2001	3,113 (47.0)	3,407 (51.4)	105 (1.6)	6,625	-3.2
2002	2,696 (38.8)	4,114 (59.2)	136 (2.0)	6,946	4.8
2003	3,314 (43.5)	4,298 (56.5)	-	7,612	9.6

Note: Total generation figures since 2000 exclude wind power
Source: CEB Report on Long Term Generation Expansion Planning Studies 2005~2019

Total system losses, which include technical losses in generation, transmission and distribution, and other non-technical losses, and load factors in the past year are shown in the table below.

Table 4.3 Gross System Losses and Load Factor

Year	Generation* (GWh)	Sales* (GWh)	Peak (MW)	Losses (%)	Load Factor* (%)
1989	2,858	2,353	617.9	17.7	52.8
1990	3,150	2,608	639.7	17.2	56.2
1991	3,377	2,742	685.1	18.8	56.3
1992	3,540	2,869	742.0	19.0	54.5
1993	3,979	3,270	812.0	17.8	55.9
1994	4,365	3,565	910.0	18.3	54.8
1995	4,783	3,915	979.7	18.1	55.7
1996	4,377	3,588	968.4	18.0	51.6
1997	4,911	4,039	1,037.0	17.8	54.1
1998	5,569	4,521	1,136.5	18.8	55.9
1999	6,076	4,809	1,291.0	20.9	53.7
2000	6,687	5,258	1,404.0	21.4	54.2
2001	6,520	5,236	1,444.5	19.7	51.5
2002	6,810	5,502	1,421.8	19.2	54.7
2003	7,612	6,209	1,515.6	18.4	57.3

Generation, Sales and Load Factor exclude self generation
Losses include those at all levels, generation, transmission and distribution and any non-technical losses.
(Sources: CEB Report on Long Term Generation Expansion Planning Studies 2005~2019 and Statistical Digest 2003)

4.4 Electricity Tariff

In order to raise funds for the expansion of thermal generation and construction of new projects to resolve the power shortage, the electricity tariff was increased in September 1997. Consequently, the financial situation of the CEB was improved temporarily, but the rates of return in 2000 and 2001 became negative because of the increase in fuel costs due to the sudden rise in oil prices, and due to expensive power purchases from IPPs. Therefore, the electricity tariff was raised repeatedly in June 2000, March 2001 and April 2002.

Table 4.4 Ceylon Electricity Board Tariff (effective from 1st August 2002)

	Fixed Charge (Rs/month)	Unit Charge (Rs/kWh) 1~30	31~60	61~90	91~180	180<
Domestic	30.0	3.0	4.0	4.4	10.6	15.8
Religious Purpose	30.0	2.5	2.7		4.0	7.2

			Fixed Charge (Rs/month)	Demand Charge (Rs/kVA)	Unit Charge (Rs/kWh)
General Purpose	Low Voltage (400/230V)	Contract Demand <42kVA	30.0 (~10kVA) 230 (10kVA<)	—	10.9
		>=42kVA	800	480	10.8
	High Voltage (11/33/132kV)		800	460	10.7
Industrial	Low Voltage (400/230V)	Contract Demand <42kVA	30.0 (~10kVA) 230 (10kVA<)	—	7.5
		>=42kVA	800	400	7.1
	High Voltage (11/33/132kV)		800	380	7.0
Industrial (time-of-day)	Low Voltage (400/230V)	Contract Demand <42kVA	30.0 (~10kVA) 230 (10kVA<)	—	15.0 (peak) 6.9 (off peak)
		>=42kVA	800	380	14.7 (peak) 6.5 (off peak)
	High Voltage (11/33/132kV)		800	360	14.0 (peak) 6.1 (off peak)
Bulk Supplies to LECO		Low Voltage (400/230V)	—	240	7.2
		High Voltage (11/33/132kV)	—	220	5.4
Street Lighting			—	—	7.8

Source: CEB Statistical Digest 2003

4.5 Existing Power Plants

The CEB's existing generating power plants in January 2005 consist of 16 hydropower plants with a total capacity of 1,205MW and five thermal power plants with a total effective capacity of 475MW; the total capacity is 1,680MW.

Table 4.5 (1) Existing Hydropower Plants (connected to the national grid, as of Jan. 2005)

Hydro Project	Capacity (MW)	Annual Energy (GWh)	Plant Factor (%)	Storage Capacity (MCM)	Commissioning
Laxapana (KM*) Complex					
Canyon	60 (30 x 2)	160	30	123.4	#1 Mar.'83, #2 '88
Wimalasurendra	50 (25 x 2)	112	26	44.8	Jan.'65
Old Laxapana	50 (8.33 x 3 + 12.5 x 2)	286	65	0.4	8.33MW x 3 Dec.'50 12.5MW x 2 Dec.'58
New Laxapana	100 (50 x 2)	552	63	1.2	#1 Feb.'74, #2 Mar.'74
Polpitiya	75 (37.5 x 2)	453	69	0.4	Apr.'69
Laxapana Total	335	1,432			
Mahaweli Complex					
Victoria	210 (70 x 3)	865	47	721.2	#1 Jan.'85, #2 Oct.'84, #3 Feb.'86
Kotmale	201 (67 x 3)	498	28	172.6	#1 Apr.'85, #2,3 Feb.'88
Randenigala	122 (61 x 2)	454	42	875.0	Jul.'86
Ukuwela	38 (19 x 2)	154	46	1.2	#1 Jul.'76, #2 Aug.'76
Bowatenna	40 (40 x 1)	54	15	49.9	Jun.'81
Rantambe	49 (24.5 x 2)	239	56	21.0	Jan.'90
Mahaweli Total	660	2,258			
Other Hydro					
Samanalawewa	120 (60 x 2)	344	32	278.0	Oct.'92
Kukule	70 (35 x 2)	300	49	1.7	Jul.'03
Other Hydro Total	190	644			
Small Hydro Plants					
Inginiyagala	11 (2.475 x 2 + 3.15 x 2)				Jun.'63
Uda Walawe	6 (2 x 3)				Apr.'69
Nilambe	3 (1.6 x 2)				Jul.'88
Small Hydro Total	20				
Hydro Total	1,205	4,465			

*KM: Kehelgamu Oya - Maskeliya Oya
Source: CEB, Report on Long Term Generation Expansion Planning Studies 2005~2019

Table 4.5(2) Existing Thermal Power Plants (connected to the national grid, as of Jan. 2005)

Thermal Power Plant	Name Plate Capacity (MW)	Capacity used for Studies (MW)	Annual Max. Energy (GWh)	Commissioning
Kelanitissa Power Station				
Gas Turbine (Old)	60 (20x3)	51 (17x3)	328	Dec.'81, Mar.'82, Apr.'82
Gas Turbine (New)	115 (115x1)	115 (115x1)	707	Aug.'97
Combined Cycle (JBIC)	165 (165x1)	165 (165x1)	1,290	Aug.'02
Kelanitissa Total	340	331	2,325	
Sapugaskanda Power Station				
Diesel	80 (20x4)	72 (18x4)	472	May.'84, May.'84, Sep.'84, Oct.'84
Diesel (Extension)	80 (10x8)	72 (9x8)	504	4 Units Sep.'97, 4 Units Oct.'99
Sapugaskanda Total	160	144	976	
Total Thermal	500	475	3,301	

Source: CEB, Report on Long Term Generation Expansion Planning Studies 2005~2019

4.6 Introduction of Independent Power Producers (IPPs)

As of 2004, IPPs have in operation seven thermal power plants with a total capacity of 434.5MW and as of 2003, 26 small scale hydropower plants with a total capacity of 40MW. The features of seven thermal power plants operated by IPPs are as shown in the table below.

Table 4.6 Features of Existing IPP Plants

Plant Name	Name Plate Capacity (MW)	Capacity used for Studies (MW)	Annual Energy (GWh)	Commissioning	Contract Period (Years)
IPPs					
Lakdhanavi	22.5	22.5	156	1997	15
Asia Power	51	41	330	1998	20
Colombo Power	64	60	420	Mid. '00	15
Diesel Plant Matara	24.8	20	167	Mar. '02	10
Diesel Plant Horana	24.8	20	167	Dec. '02	10
Kelanitissa AES CCY	163	163	1,314	GT-Jan. '03 Steam-May '06	20
Heladanavi	100	100	698	Oct.'04	10
IPPs Total	450.1	434.5	3,252		

Source: CEB, Report on Long Term Generation Expansion Planning Studies 2005~2019

4.7 Present Status of Transmission and Distribution Lines

In 2003, the total length of transmission lines was about 1,800km (excluding 242 route km of 132kV transmission lines in the North and East), and about 80% of the total was 132kV lines and 220kV lines connecting hydropower plants in the Mahaweli River basin with industrial areas near Colombo.

The voltage of distribution lines is 33kV or 11kV for medium-voltage lines, and it is stepped down to 400V or 230V lines for distributing power to consumers. There were 14,938 substations as of 2003.

Table 4.7 Length of CEB Transmission and Distribution Lines

(Unit: km)

	220kV	132kV	33kV	11kV	400/230V
2002	315	1,501	17,784	2,420	68,810
2003	315	1,531	18,639	2,390	74,478

Note: Excludes 242 route km of 132kV transmission lines in the North and East
Source: CEB, Statistical Digest 2003

Table 4.8 Number and Capacity of Substations

	220/132/33kV	220/132kV	132/33kV	132/11kV	33/11/3.3kV	33/11/LV
Number	5	1	33	2	125	14,772
Capacity（MVA）	2,100/500	105	2,154	180	1,056	3,657

Source: CEB, Statistical Digest 2003.

4.8 Forecast of Power Demand and Supply

The CEB's Generation Planning Branch releases the "Report on the Long-Term Generation Expansion Plan (LTGEP)" every year. In the LTGEP published in 2004 in forecasting future demand for electricity, the CEB prepared scenarios having medium (7.8%), low (7.0%) and high (8.7%) growth rates and made power development plans for each case.

Table 4.9 Load Forecast from 2004 to 2024 (Base Case)

Year	Demand (GWh)	Growth Rate (%)	Gross* Losses (%)	Generation (GWh)	Load Factor (%)	Peak (MW)
2004	6,573	5.9	18.2	8,038	55.0	1,668
2005	7,032	7.0	17.3	8,506	55.0	1,765
2006	7,567	7.6	15.3	8,937	55.0	1,855
2007	8,149	7.7	14.8	9,565	55.0	1,985
2008	8,804	8.0	14.1	10,245	55.0	2,126
2009	9,515	8.1	14.1	11,072	55.0	2,298
2010	10,284	8.1	14.1	11,967	55.0	2,484
2011	11,112	8.1	14.1	12,931	55.0	2,684
2012	12,005	8.0	14.1	13,970	55.0	2,900
2013	12,965	8.0	14.1	15,087	55.0	3,131
2014	13,995	7.9	14.1	16,286	55.0	3,380
2015	15,100	7.9	14.1	17,571	55.0	3,647
2016	16,283	7.8	14.1	18,948	55.0	3,933
2017	17,556	7.8	14.1	20,429	55.0	4,240
2018	18,920	7.8	14.1	22,017	55.0	4,570
2019	20,383	7.7	14.1	23,719	55.0	4,923
2020	21,949	7.7	14.1	25,541	55.0	5,301
2021	23,627	7.6	14.1	27,494	55.0	5,707
2022	25,429	7.6	14.1	29,591	55.0	6,142
2023	27,361	7.6	14.1	31,839	55.0	6,608
2024	29,431	7.6	14.1	34,248	55.0	7,108

*Gross losses include those at all levels: generation, transmission and distribution and any non-technical losses.
Source: CEB, Report on Long Term Generation Expansion Planning Studies 2005~2019

4.9 Power Development Plan

According to the latest LTGEP, the power development plan up to 2019 is as shown in Table 4.10. Power generation facilities with a total capacity of 4,180MW are planned to be commissioned over the next 15 years.

The relationship of LTGEP, peak demand, reserve margin and LOLP is shown in Table 4.11. The target figure of LOLP will be attained after 2005 according to the LTGEP, but a key question is whether new power generation projects will be able to be started in accordance with the LTGEP or not. The relationship between the LTGEP and peak demand is shown in Figure 4.2.

Table 4.10 Generation Expansion Plan Sequence

Year	Hydro Additions	Thermal Additions	Thermal Retirements	Capacity (MW)	Present Status
2005		Heladhanavi Diesel Power Plants at Puttalam ACE Power Diesel Power Plant at Embilipitiya		100 100	Commissioned in October 2004 Under construction Expected in March 2005
2006					
2007		GT part of Kelawalapitiya CCY		200	Under Evaluation
2008		ST part of Kelawalapitiya CCY Gas Turbines		100 105	Under Evaluation
2009		Gas Turbines		140	
2010	Upper Kotmale	Coal Steam	Kelanitissa Gas Turbine (Old)	150 300 -51	JBIC Pledged
2011		Coal Steam		300	
2012		Coal Steam	Lakdhanavi plant Matara diesel plant	300 -22.5 -20	
2013		Coal Steam	Sapugaskanda diesel plant Horana diesel plant	300 -72 -20	
2014		Coal Steam		300	
2015		Gas Turbines	Colombo power barge plant Medium-term Diesel Power Plants	285 -60 -200	
2016		Coal Steam		300	
2017		Coal Steam	Kelanitissa Gas Turbine (New)	300 -115	
2018		Coal Steam Gas Turbines	Asian power plant	300 180 -49	
2019		Gas Turbines		420	

Source: CEB Data

Table 4.11 Generation Expansion Plan and Reserve Margin

Year	Total Installed Capacity (MW)	Peak Demand (MW)	Reserve Capacity (MW)	Reserve Margin (%)	LOLP (%)
2005	2,194.5	1,668	526.5	31.6	0.245
2006	2,194.5	1,765	429.5	24.3	0.850
2007	2,394.5	1,855	539.5	29.1	0.465
2008	2,599.5	1,985	614.5	31.0	0.515
2009	2,739.5	2,126	613.5	28.9	0.740
2010	3,138.5	2,298	840.5	36.6	0.124
2011	3,438.5	2,484	954.5	38.4	0.064
2012	3,696.0	2,684	1,012.0	37.7	0.061
2013	3,904.0	2,900	1,004.0	34.6	0.093
2014	4,204.0	3,131	1,073.0	34.3	0.080
2015	4,229.0	3,380	849.0	25.1	0.509
2016	4,529.0	3,647	882.0	24.2	0.545
2017	4,829.0	3,933	896.0	22.8	0.660
2018	5,145.0	4,240	905.0	21.3	0.717
2019	5,565.0	4,570	995.0	21.8	0.618

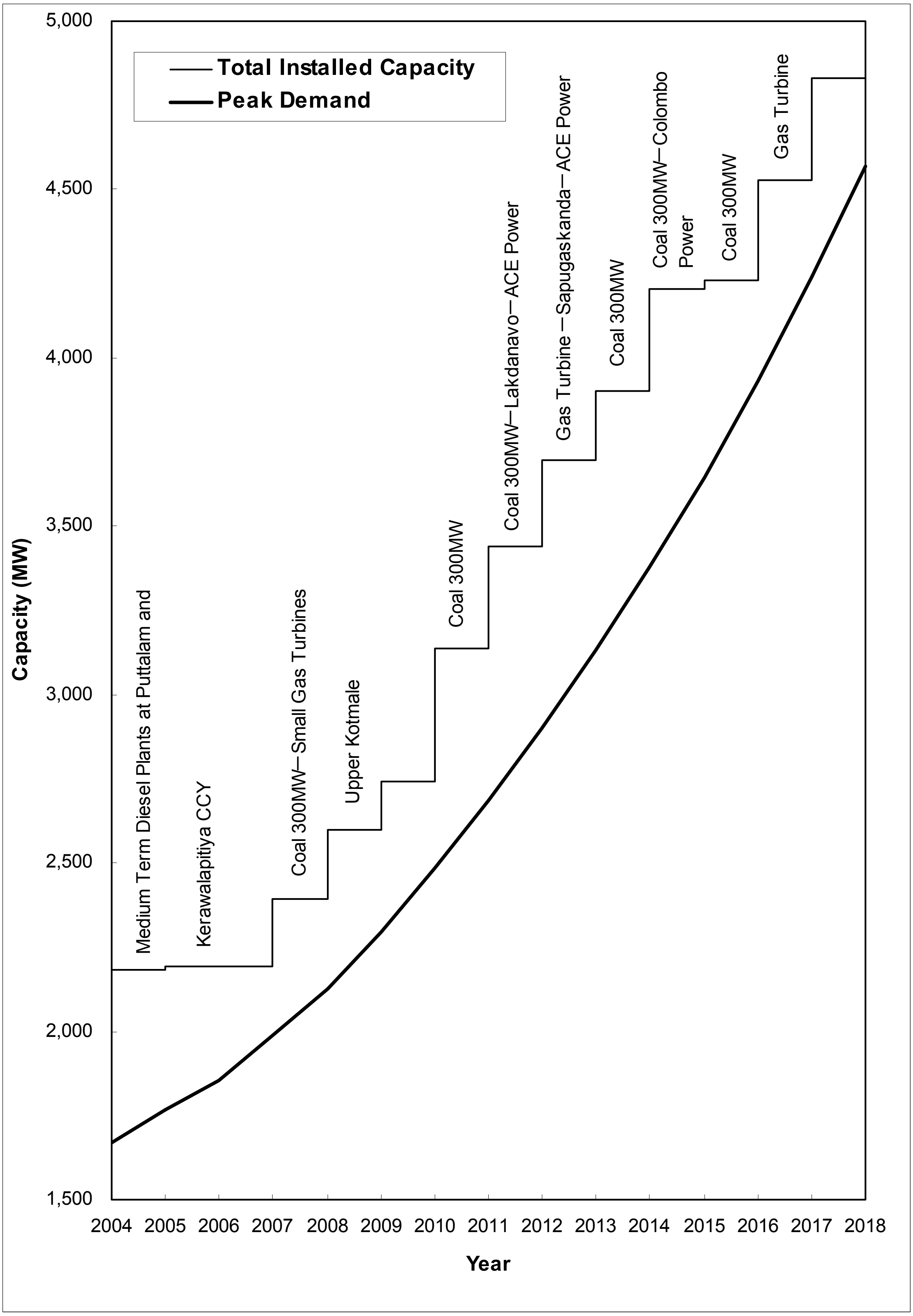
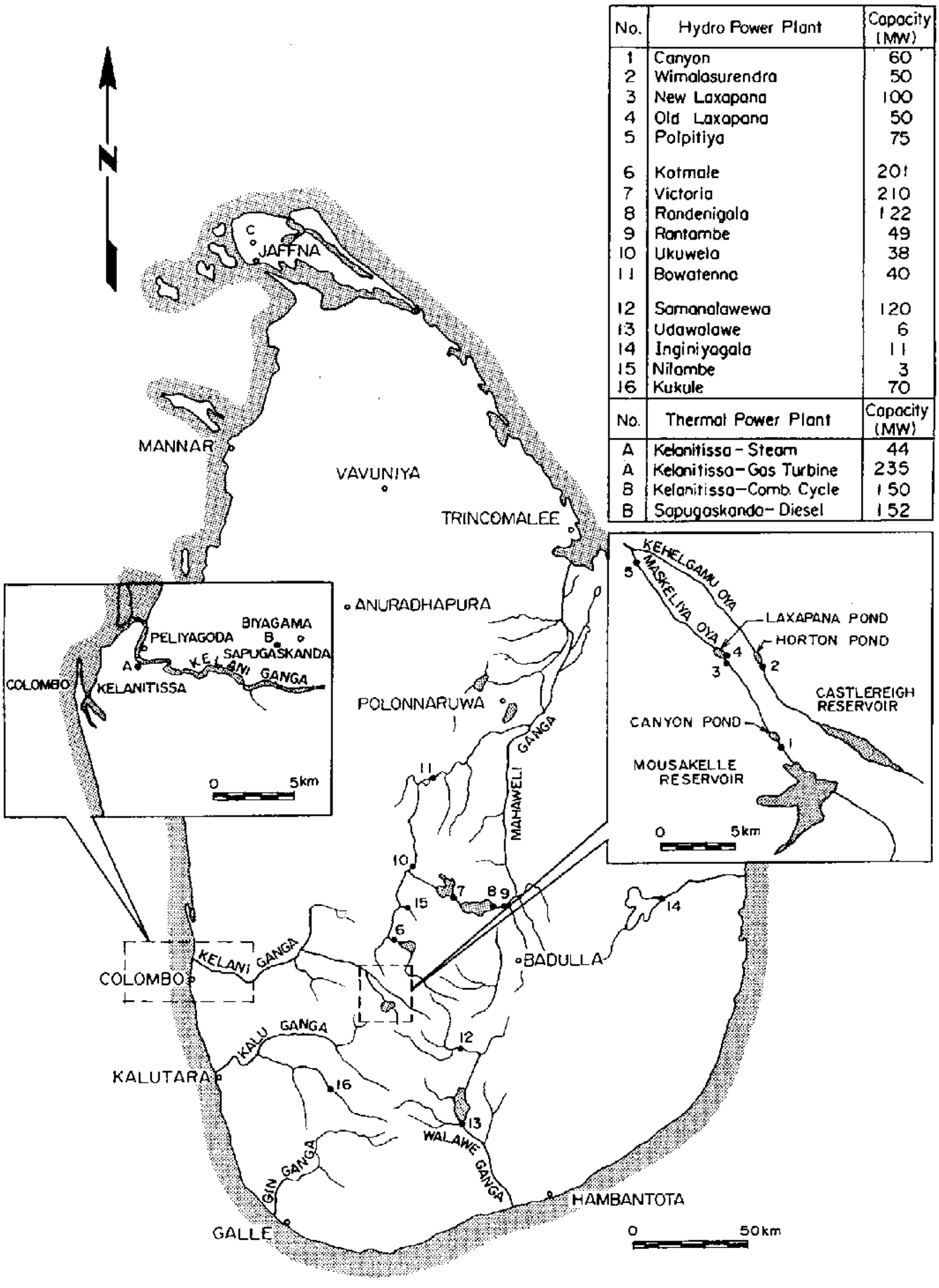


Figure 4.2 Expansion Plan and Peak Demand

4.10 Present Situation of Hydropower Stations in Kelani River Basin

There are five hydropower stations with a total capacity of 335MW in the Kelani River basin, which have the single purpose of power generation, and they are called the Laxapana Complex. Although facilities of the hydropower stations in Sri Lanka have been well maintained as a whole under the limited budget for overhaul and maintenance, many defects of the hydropower stations in the Kelani River basin have become obvious recently. These defects are causing deterioration of power supply capability and inefficient power operation, which accelerate power shortage.

The Kelani Rriver radiates from the Central Highlands to the Indian Sea passing through Colombo City located in western part of Sri Lanka. The catchment of the river system is 2,278km^2. The river basin is located on heavy rainfall zone, and especially the area in which the five hydropower stations lie is one of the foremost among heavy rain zones in Sri Lanka, annual rainfall at the area exceeds 4,000mm and that at the most upstream of the area exceeds 5,000mm. The five hydropower stations is located in about 80km east from Colombo City, and is relatively close from electric power consuming region. Therefore development of these hydropower stations has started at an early stage. The history of hydropower development in Sri Lanka began with the construction of the Old Laxapana Hydropower Station in the Kelani River basin, which commenced its commercial operation since 1950. The location of the five power station in the Kelani River basin is shown in Figure 4.6 to 4.8.



No.	Hydro Power Plant	Capacity (MW)
1	Canyon	60
2	Wimalasurendra	50
3	New Laxapana	100
4	Old Laxapana	50
5	Polpitiya	75
6	Kotmale	201
7	Victoria	210
8	Randenigala	122
9	Rantambe	49
10	Ukuwela	38
11	Bowatenna	40
12	Samanalawewa	120
13	Udawalawe	6
14	Inginiyagala	11
15	Nilambe	3
16	Kukule	70

No.	Thermal Power Plant	Capacity (MW)
A	Kelanitissa - Steam	44
A	Kelanitissa - Gas Turbine	235
B	Kelanitissa - Comb. Cycle	150
B	Sapugaskanda - Diesel	152

Figure 4.6 Location Map of Power Stations in Sri Lanka

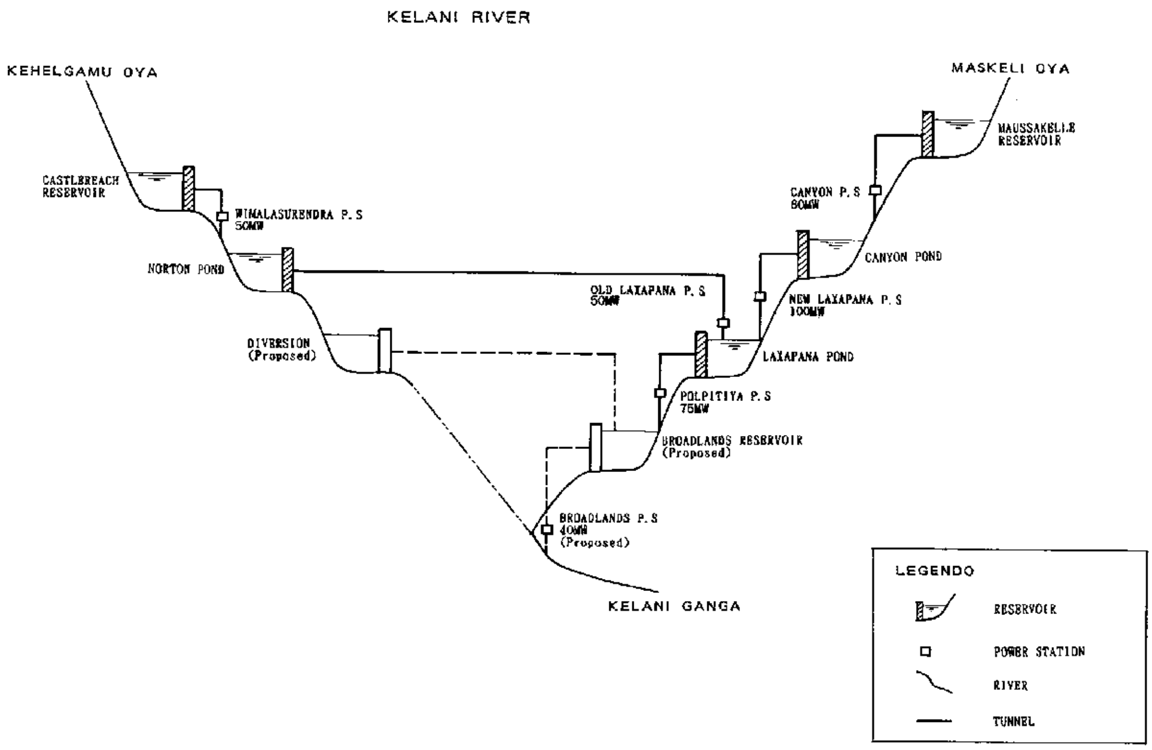


Figure 4.7 Longitudinal Section of Kelani River Basin

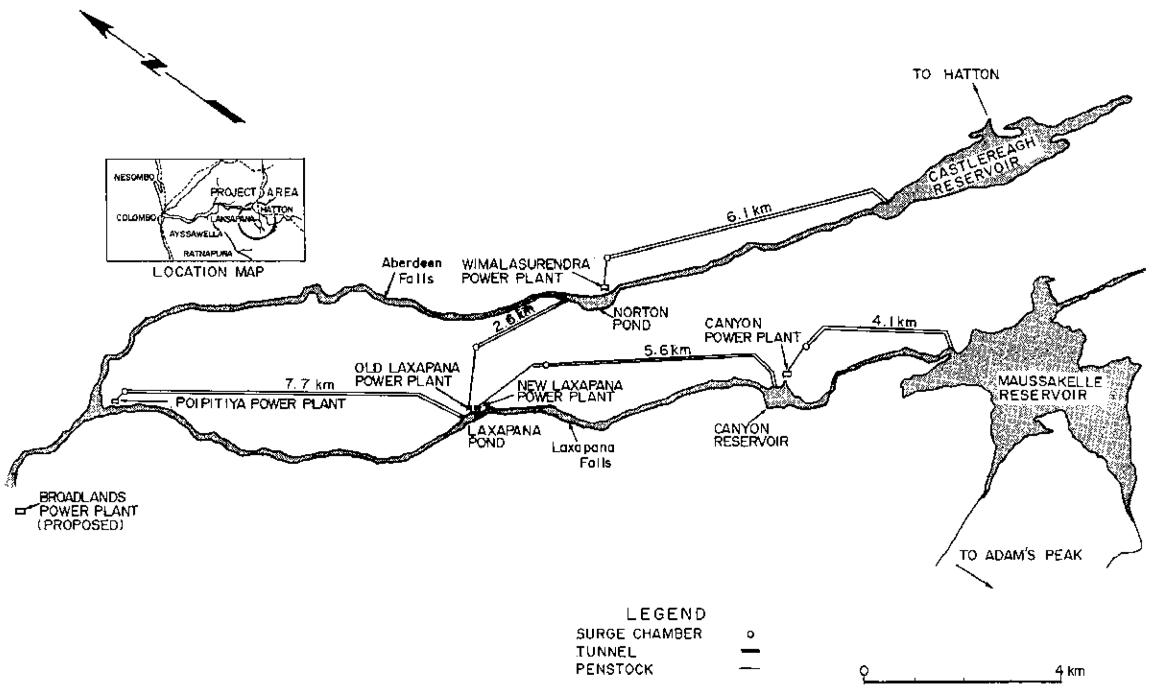


Figure 4.8 Laxapana Complex

(1) Wimalasurendra Hydropower Station

This power station was constructed with the assistance of the International Bank for Reconstruction and Development (IBRD). In 2002, a muddy discharge was recognized at the outlet of the power station. The chief engineer of the power station is presuming that the reason is a collapse somewhere inside the pressure headrace tunnel. As a basis, muddy water ceased under partial operation of the plants at 25MW, to say decreasing water velocity in the tunnel by reducing discharge. Although it is essential to stop the operation and to dewater the tunnel to inquire into the real cause of the muddy water, the plants have been operated according to the instruction of the CEB's headquarters. No options are left for the investigation except dewatering, in spite the chief engineer is afraid of enlargement of the tunnel collapse. No other significant problems, which may cause a plant shutdown, have been recognized.

The Wimalasurendra power station started commercial operation in 1965. Its electrical and mechanical equipment has been operated for 39 years. Therefore it is recommended that the inspections to check for deterioration of electro-mechanical generating equipment shall be done periodically and their conditions shall be observed continuously. Nevertheless CEB had already prepared the replacement plan for the control and protection system, the plan has not been implemented due to the financial difficulties.

(2) Old Laxapana Hydropower Station

This power station was constructed with the assistance of IBRD and others. The 1, 2 and 3 Units started commercial operation in 1950 and have been operated for 53 years. Meanwhile the 4 and 5 Units started operation in 1958 and have been operated for 45 years. No notable defects have found in civil structures.

Control and protection system of electrical equipment, exciter systems of generators, governors of hydro turbines were replaced step by step (in first stage (1994-1995) and in second stage (2003-2004)) by CEB. However, other equipment such as inlet valve, needle valve and oil lifter is still facing serious troubles and these problems have spoiled the plants' sound operation. Like the above mentioned power station, CEB had already prepared the replacement plan for inlet valve and runner which were installed at the first construction stage (for the unit No. 1, 2, 3), however, the plan has not been implemented by financial difficulties.

(3) Canyon Hydropower Station

This power station was constructed with the assistance of the Asian Development Bank (ADB) and Organization of Petroleum Exporting Countries (OPEC). According to interviews at the site, the capacity of the power station was increased from the original plan during construction. Therefore, the waterway structures of the power station were not suitably designed for a 60MW-capacity power station and heavy friction losses caused by their too-small waterway diameters are arising. Because the tunnel diameter between the intake and the portal of the headrace tunnel is especially small, negative pressure has been arising. In spite of the fact that an anti-negative pressure valve has been installed to prevent a breakdown of the pipe caused by the appearance of negative pressure, it has malfunctioned from time to time.

This power station was constructed in 1983 and has been operated for more than 20 years, so far no serious problem in the machinery has been observed. It is noted that the hydro turbines, generators and main transformers were manufactured in Japan.

(4) New Laxapana Power Station

This power station was constructed with the assistance of the IBRD and others and has been operated since 1974.A massive amount of water, 0.1 m^3/s, is leaking from the vicinity of the surge chamber located at the downstream end of the headrace, and is flowing down the slope, which may cause not only economic losses but also a negative impact on slope stability if it remains uncorrected over the long term. Additionally, the cavity below the toe of the spillway of the Canyon Dam is recognized.

The governor of unit 1 faces the trouble and this unit frequently stuck at start-up of generation. Therefore CEB has to keep this unit on running even in light load period at night. Because the trouble of governor deprives the frequency regulating function from unit 1, frequency fluctuation has been stabilized only by the unit 2. The governor system of this station is extremely old-fashioned. If CEB will require the enhancement of frequency stabilizing capability of this station in future, the governor system of both units shall be replaced in a same time.

(5) Polpitiya Hydropower Station

This power station was constructed with Canadian assistance.

There is fear that sediment originating from surface exfoliation of the unlined headrace tunnel has been flowing into the turbines, but this has not yet been confirmed.

CEB conducted the replacement work of control and protection system, governor and exciter system from 2003 to 2004. But both hydraulic turbines in the Polpitiya power station still have serious mechanical problem (the vibration of turbines and turbine shaft), so that output of generator is allowed only at 5, 32, or 37.5MW per unit to prevent serious vibration. Detailed investigation and suitable countermeasure are required for those two units to solve the existing problems.

5. PRESENT STATUS AND COUNTERMEASURES FOR THE HYDRO FACILITIES

5 PRESENT STATUS AND COUNTERMEASURES FOR THE HYDRO FACILITIES

5.1 Wimalasurendra Hydropower Station

5.1.1 Civil Structures

(1) Collapse in Headrace Tunnel

According to CEB, it is believed that the collapse occurred in the pressurized headrace tunnel, because turbid water discharge was observed at the outlet during the operation in 2001.

In order to verify the present status of the tunnel, CEB decided to dewater the tunnel, and conducted the dewatering and the inspection of the tunnel in February 2005. The location of the collapse was not at the site expected by the people attending the technical meeting in CEB, but was at TD3,350ft of the headrace tunnel. The collapse was rather smaller than that we expected, and the headrace tunnel looks like it is in sound conditions as a whole.

5.1.2 Hydromechanical Equipment

(1) Modification of Spillway

According to CEB, they hope to replace the flashboard which has been provided at the top of the each spillway to increase the reservoir capacity, with a new gate system in order to ensure the safety of the people living along the river and to avoid wasting the reservoir water due to useless spills.

The loading conditions of the pier may change according to this modification, therefore, the strength of existing concrete and reinforcing bar arrangement should be checked. As for the modification of the spillway, further investigation should be required.

An SR gate, a rubber dam and a steel gate were compared, and the SR gate is recommended.

5.1.3 Electro-mechanical Equipment

The deterioration conditions and the recommended countermeasures for the main equipment are described below.

(1) Mechanical Equipment

There are no major problems regarding the turbines and the inlet valves. It is recommended that the consumables and damaged parts be replaced periodically.

The governor is an old-fashioned mechanical type. Most of the original automatic functions are lost and the hydraulic turbines are operated manually. The production has been stopped. In the event of governor failure, there is a strong possibility that a long turbine shutdown will result. . Therefore, it is recommended that the whole mechanical governor system is replaced with the latest numerical system.

The water and air leakage is increased by the deterioration of the water drainage system, the cooling water system, the compressed air system and the grease lubrication system. Therefore, it is recommended that all auxiliary equipment is replaced with new one.

(2) Electrical Equipment

Concerning the generators, a failure happened in 2002 on the Unit 1 stator coil, which was moved downward by 6 mm at maximum.

It was found, in an investigation conducted after the failure that the downward movement was due to superannuated wedges, which caused a loose fit of the stator coil. There is concern that Unit No. 2 is deteriorating as well, because the problem of wedge loosening was found also in Unit No. 2, even though the Unit has not yet suffered from a similar failure.
An 18-month long shutdown will normally be necessary for replacement of the coil and the iron core as the countermeasure. Considering the machine age of 40 years, the most economical option should be selected through a comparison study with the option of replacing the whole generator (14-month shutdown).

It is not necessary to change the specifications of the generators because the existing turbines are not to be replaced.

Since the DC-exciter is old-fashioned, the replacement of the exciters should be carried out together with the generators.

Insulation resistance values are decreasing largely in most transformers judging from the comparisons of the resistance values between 1-minute values in 2002 and 2004 for Unit 1, and from the 3-minute values in 2002 and 2004 for Unit 2. A few of the 1-minute values are close to 100 M Ohm, which is the lower limit to judge the "defect" in the criteria used in Japan. Therefore, the deterioration of the transformers is accelerated considerably. All the transformers should be replaced urgently.

132 kV switchgears have already operated for 25 to 33 years. Since the lifetime of the switchgear is 25 years, all the switchgears have already exceeded their designed lifetime. Accordingly, it is our judgment that all 132 kV switchgears have already reached the time of replacement. It is recommended that all the 132 kV switchgears are replaced with new ones.

(3) Control Equipment

At the generator start and stop, the governor and the excitation equipment have been operated manually by operators. Considering the efficient operation of the whole water basin system, the whole control and protection systems of this power station should be replaced with a new one.

5.2 Old Laxapana Hydropower Station

5.2.1 Civil Structures

(1) Leakage at Right Bank

Leakage was found just downstream of the right bank of the dam during the 2nd site visit. It is believed that the leakage will not have a severe impact on the dam stability judging from the geological aspects of the surrounding area of the dam. Through financial analysis, the following result has been obtained where the discount rate is 10%, electricity selling price is 7.68Rs/kWh, the average amount of leakage is 44 liter/sec, and the depreciation period is 50 years.

That is, the limit amount of investment in the remedial works would be 70 Million Rs.

5.2.2 Hydromechanical Equipment

(1) Modification of Spillway

According to CEB, they hope to replace the flashboard that has been provided at the top of the each spillway to increase the reservoir capacity, with a new gate system.

The loading conditions of the pier may change according to this modification, therefore, the strength of the existing concrete and the reinforcement bar arrangement should be checked. As for the modification of the spillway, further investigation should be required. In addition, an Environmental Impact Assessment (EIA) will be necessary for the change of the reservoir water level.

5.2.3 Electro-mechanical Equipment

The deterioration conditions and the recommended countermeasures for the main equipment are described below

(1) Mechanical Equipment

The turbines and the inlet valves in the Stage I (Units 1 to 3) of the Old Laxapana hydropower station are equipped with very obsolete mechanisms. The turbine efficiency of the existing Unit has deteriorated remarkably as clarified in the simplified efficiency test (Appendix C-1). It is recommended that all the hydraulic turbines and inlet valves are replaced. Unit output of 9 MW is selected in lieu of the current 8.33 MW.

In order to increase the reliability of the turbine control, it is recommended that the governors be replaced.

There is no major problem in the turbine and the inlet valves in the Stage II.

(2) Electrical Equipment

Though the replacement of the generators is not necessary independently, the generators should be replaced if the replacement of turbine is implemented because of the following reasons.

- The generators have already been in operation for more than their lifetime.
- It is necessary for the generators to increase the output from 9.8MVA to 11MVA together with the increase of the turbine output.

(3) Control Equipment

Continuous normal operation will be possible as a whole, because the new control and protection equipment was replaced by 2003.

5.3 Canyon Hydropower Station

5.3.1 Civil Structures

(1) Displacement of Retaining Wall

Displacement was found at the outlet, which was observed from the construction stage and it is not caused by water level fluctuation in the operation stage. The displacement has not been monitored by measurement. Therefore, it is necessary to do so.

5.3.2 Hydromechanical Equipment

(1) Intake Guard Valve

Anti-negative pressure valve located just downstream of the intake guard valve (butterfly type valve). The anti-negative pressure valve may open when the reservoir water level is low and the intake discharge volume is large.

The anti-negative pressure valve position will be changed to the top of the roof, so that the intake guard valve can be closed even if water spouts from the air valve.

5.3.3 Electro-mechanical Equipment

There is no major problem in the electro-mechanical equipment in this hydro power station.

5.4 New Laxapana Hydropower Station

5.4.1 Civil Structures

(1) Leakage in Surge Tank Area

Leakage has been found in the surge tank area. It is believed that the leakage will not have a severe impact on the slope stability judging from the geological aspects of the surroundings area. Through financial analysis, the following results have been obtained where the discount rate is 10%, the electricity selling price is 7.68Rs/kWh, the average amount of leakage is 70 liter/sec and the depreciation period is 50 years.

That is, the limit amount of investment in the remedial works would be 105 Million Rs.

5.4.2 Hydromechanical Equipment

(1) Intake Trash Rake Machine (New Laxapana & Political)

There is no trash rake machine on the intake trashrack. Therefore, the trash rake machine will be provided for efficient maintenance.

(2) Sedimentation Disposal (New Laxapana & Polpitiya)

The water level of the reservoir is lowered, and the sedimentation was discharged from the outlet works regularly. Sand removal is necessary to perform flushing efficiently.

The grab and mobile crane will be used for removing the sand around the intake and bottom outlet works.

5.4.3 Electro-mechanical Equipment

The deterioration conditions and the recommended countermeasures for the main equipment are described below.

(1) Mechanical Equipment

There is no major problem in the turbine and the inlet valves.

In order to increase the reliability of the hydropower station that is obligated to control the system frequency, it is recommended that the governors and accessories be replaced.

(2) Electrical Equipment

It was found that a piece of piled core iron slipped out from the stator core in Feb. 2004. In addition, wedge loosening was also found in the stator in both units as well as in the generators in the Wimalasurendra hydropower station.

Considering the importance of the hydropower station and CEB's desires, the replacement of the generator including the excitation equipment is recommended. It is not necessary to change the specifications of the generators because the existing turbines are not to be replaced.

(3) Control Equipment

The control and protection equipment in the hydropower station is obsolete. The whole control and protection systems of this power station should be replaced with a new one in order to improve the reliability of the hydropower station.

5.5 Polpitiya Hydropower Station

5.5.1 Civil Structures

(1) Installation of Rain Gauge Stations

CEB hopes to install rain gauge stations in consideration of past bad experiences, when overtopping occurred. The following table shows the cost of the rain gauge stations including related costs.

Item	Number/Unit	Price (US$)
Monitoring & Controlling System	1 unit	250,000
Water Level Monitoring Station	1 unit	70,000
Rain Gauge Station	3 units	160,000
Installation & Adjustment	LS	90,000
Shipment	LS	10,000
House	LS	20,000
Consulting Fee	10%	60,000
Contingency	10%	70,000
Total		730,000

5.5.2 Hydromechanical Equipment

(1) Automatic Control System of Spillway Gate (New Laxapana & Polpitiya)

The automatic gate operation system will be provided, because the spillway gates have been operated so many times to discharged floods. The most suitable dam control method will be studied based on the experience in Japan.

5.5.3 Electro-mechanical Equipment

The deterioration conditions and the recommended countermeasures for the main equipment are described below.

(1) Mechanical Equipment

The units have been operated only at 5 MW, 32 MW and 37.5 MW of generator outputs due to turbine vibration. However, remarkable vibration was not identified during this study.
Continuous normal operation will be possible as a whole. Considering the above mentioned condition, it is necessary to inspect the hydro turbine in detail, including the assembly inspection. It is recommended that the hydro turbine is replaced after the turbine inspection.

(2) Electrical Equipment

Three insulation resistance values are less than 100 M Ohm, which is the lower limit to judge the "defect" according to the criteria used in Japan. The insulation resistance values are decreasing largely in all transformers judging from the comparisons of the resistance values between 2002 and 2004.

Since deterioration of the coil was found in all the generator transformers, an urgent replacement of all transformers is recommended.

(3) Control Equipment

Continuous normal operation will be possible as a whole, because the new control and protection equipment was replaced by 2003.

5.6 Common Items

5.6.1 Communication Equipment

Regarding the communication equipment, in order to connect all power stations in the Kelani River Basin into a remote control system by means of Supervisory Control and Data Accusation (SCADA) system from Old Laxapana power station, the communication line of Optical Ground Wire (OPGW) will be installed between Old Laxapana hydropower station and others at the same time as the replacement of the turbines and generators.

5.7 Summary

The main features of each power station are shown in Table 5.1.

The result of the deterioration diagnosis in the Study is shown in Table 5.2, with the indication of whether or not an ODA loan is necessary, and the phase of implementation. The cost and schedule of the recommended rehabilitation plan are shown in Table 5.3, 5.4 and 5.5. The result, the cost and the schedule have already been confirmed with the Generation Projects Branch in CEB.

Table 5.1 Facility Data of the Hydropower Stations in Kelani River Basin

Hydropower Station		Wimalasurendra	Old Laxapana (Stage I)	Old Laxapana (Stage II)	Canyon	New Laxapana	Polpitiya
a. Number of Units	(Unit)	2	3 (Unit No.1-3)	2 (Unit No.4,5)	2	2	2
b. Commissioning Year		1965	1950	1958	Unit 1: 1983 Unit 2: 1989	1974	1969
c. Turbine							
Type		Vertical Francis	Horizontal Pelton	Horizontal Pelton	Vertical Francis	Vertical Pelton	Vertical Francis
Normal Effective Head	(m)	219	449	449	195.8	519.4	264.0
Rated Output	(kW)	29,900	8,330	12,870	32,080kW at 195.8m	51,500	39,100
Rated Discharge	(m^3/s)	14	2.1	3.25	18	11.5	17
Rotating Speed	(rpm)	500	600	500	500	428.5	500
Elevation of W.T. center	(m)	865		389	956.5	384	107
Manufacturer		Neyrpic	English Electric Co.	Societé des Forges et Atélier du Crescent (Usines Schneider)	Fuji	Neyrpic	Dominion Engineering Works Ltd. (Canada)
d. Generator							
Type		Conventional	Horizontal shaft	Horizontal shaft	Conventional	Semi Umbrella	Conventional
Rated Output	(kVA)	31,250	9,800	14,700	37,500	72,000	46,900
Power Factor	(%)	80%	85%	85%	85.0%	80%	80%
Rated Voltage	(kV)	11	11	11	12.5	12.5	12.5
Manufacturer		Le Matériel Electrique	The British Thomson Houston Co.	Le Matériel Electrique	Fuji	Alsthom	Canadian General Electric Company
e. Transformer							
Rated Capacity	(kVA)	10,700	13,330	5,333	38,000	24,000	17,900
Rated Voltage	(kV)	$132/\sqrt{3}/11$	$132/\sqrt{3}/11$	$132/\sqrt{3}/11$	132/12.5	$145/\sqrt{3}-132/\sqrt{3}/12.5$	$139/\sqrt{3}-125/\sqrt{3}/12.0$
Rated Ampere	(A)	140.4 / 1685	174.9/1212	70/485	125/1316	286.3-315 /1920	223.7-247.3 / 1492
Phase	(phase)	single	single	single	3	single	single
Type of Cooling		OFW	ONAN/ONAF	FOW	ONAF	ONAF	OFW
Manufacturer		Le Matériel Electrique	Alsthom (Common transformer for 1,2,3)	Le Matériel Electrique	Fuji	Alsthom Savoisiene	Canadian General Electric Company

Table 5.2 Present Condition of Each Hydro Power Station of the Laxapana Complex (Including Civil and Hydro-mechanical Equipment)

Legend: Deterioration Level
- A: Immediate rehabilitation is required.
- B: Rehabilitation is required as soon as possible.
- C: Rehabilitation is desirable if conditions, such as budget, allow.
- D: Repair will be required in the future.
- E: There is no need for a measure, or observation is required.
- X: To be investigated further (or unknown)

Necessity of ODA Loan
- O: Necessary
- NN: Not Necessary

Phase of Implementation
- SV: Purchase and installation can be started immediately
  - The scope and range of the rehabilitation are clear.
  - The cost can be estimated precisely.
  - The specification is already prepared or can be prepared immediately
- DD: Detailed design work can be started immediately.
  - The scope and range of the rehabilitation is almost clear except for details.
  - The cost can be estimated.
  - The detailed design is necessary before implementing rehabilitation work.
- IN: More detailed inspections, which include disassembly investigation, are needed
  - The scope and range of the rehabilitation are not clear.
  - The cost cannot be estimated.
  - Further inspections are necessary before the detailed design.

Notes:

*1 The equipment is used to control and monitor the turbines, generators, transformers, switchyard and auxiliary circuit.
*2 The equipment is used to protect the turbines, generators, transformers, switchyard and auxiliary circuit.

Table 5.2	Items	No.	Level	ODA	Phase
Common					
Canyon and Laxapana pond	- Removal sedimentation from the ponds Dredging grab 1m^3 Mobile crane 30t	1 lot	C	O	SV
Canyon and Laxapana dam	- Dam control system	2 lots	C	O	SV
Penstock and so on	- Robot for repainting the inside of penstock Blasting and painting machine	1 lot	C	O	SV
General use	- Small blasting and painting machine	1 lot	B	O	SV

Table 5.2	Items	No.	Level	ODA	Phase
Wimalasurendra					
Investigation (hydro-mech.)	- Investigation for modification of spillway	1	A	O	IN
Inspection before the rehabilitation	- Disassemble inspection for the electro-mechanical equipment	1	A	O	SV
Turbine	In conjunction with the governors replacement - Wicket gate stem - Wicket gate stem packing - Wicket gate servomotor - Shaft seal packing - Facing plate in bottom ring - Whole stationary wearing ring	2	A	O	DD
Inlet valve	In conjunction with governors replacement - Modification of the controllers	2	A	NN	-
	- Seals	2	A	NN	-
Governor	- Whole	2	A	O	DD
Pressure oil supply system	In conjunction with the governors replacement - Whole	2	A	O	DD
Air supply system for governor	In conjunction with the governors replacement - Whole	2	A	O	DD
Air supply system for brake	In conjunction with the generators replacement - Whole	2	A	O	DD
Grease lubrication system	In conjunction with the governors replacement - Whole	2	A	O	DD
Water supply system	In conjunction with the generators replacement - Whole	2	A	O	DD
Drainage system	- Whole	2	A	O	DD
Generator	Repair or replacement Case 1: Repair (rewinding and replacement of the core) Case 2: Replacement	2	A	O	DD
Exciter	Repair or replacement in conjunction with the generators Case 1: Repair Case 2: Replacement	2	A	O	DD
AVR	- Whole	2	A	O	DD
Generator transformer	- Whole	7	A	O	SV
11kV main circuit	- Whole	2	A	O	SV
132kV switchgear	- Whole	6	B	O	SV
Plant control equipment	- Whole *1	4 lots	A	O	DD
Protection equipment	- Whole *2	4 lots	A	O	DD
LV auxiliary circuit	- Whole	1	A	O	DD
Control power source equipment	- Whole - Installation of UPS	1	A	O	DD
Diesel generator	- Inspection and repair for control equipment of diesel generator	1	C	NN	-
Communication equipment	- Installation of OPGW and new communication equipment between WPS and Old Laxapana P/S	1	C	O	DD
Dam distribution equipment		1	D	-	-

Table 5.2	Items	No.	Level	ODA	Phase
Wimalasurendra					
Dam (hydro-mech.. and civil)	- Modification of spillway	14	B	O	IN
Dam (civil)	- Re-drilling of drainage relief holes	-	A	NN	-
Headrace tunnel (civil)	- Possible collapse	-	A	NN	-
Outlet (civil)	- Turbulent	-	X	NN	-

Table 5.2	Items	No.	Level	ODA	Phase
Old Laxapana	(Stage I)				
Investigation (hydro-mech.)	- Investigation for installation of flashboard	1	A	O	IN
Inspection before the rehabilitation	- Disassembly inspection for electro-mechanical equipment	1	A	O	SV
Turbine	- Whole	3	A	O	DD
Inlet valve	- Whole	3	A	O	DD
Governor	In conjunction with turbines replacement - Whole	3	A	O	DD
Pressure oil supply system	In conjunction with turbines replacement - Whole	3	A	O	DD
Air supply system for governor	In conjunction with turbines replacement - Whole	3	A	O	DD
Air supply system for brake	In conjunction with generators replacement - Whole	3	A	O	DD
Oil lubrication system	In conjunction with generators replacement - Whole	3	A	O	DD
Water supply system	In conjunction with generators replacement - Whole	3	A	O	DD
Generator	In conjunction with turbines replacement - Whole	3	A	O	DD
Exciter	In conjunction with generators replacement - Whole	3	A	O	DD
AVR	In conjunction with generators replacement - Whole	3	A	O	DD
Generator transformer		4	D	-	-
11kV main circuit	In conjunction with generators replacement - Whole	3	A	O	DD
132kV switchgear	- Repair for operation mechanism of isolators	13	C	NN	-
Control equipment for Units 1, 2, 3	In conjunction with turbines and generators replacement - Modification	3 lots	C	NN	-
Control equipment for switchyard and auxiliary circuit	In conjunction with communication equipment modification - Modification	2 lots	C	NN	-
Protection equipment for Units 1, 2, 3	In conjunction with turbines and generators replacement - Modification	3 lots	C	NN	-
Protection equipment for switchyard and auxiliary circuit	In conjunction with communication equipment modification - Modification	2 lots	C	NN	-

Table 5.2	Items	No.	Level	ODA	Phase
Old Laxapana	(Stage I)				
LV auxiliary circuit		1	E	-	-
Control power source equipment	- Repair for positive-side ground phenomenon	1	C	NN	-
Diesel generator		1	E	-	-
Communication equipment	In conjunction with communication equipment modification in other power station in Laxapana complex - Modification	1	C	NN	-
SCADA System	- Modification and installation of some equipment	1	C	O	DD
Dam distribution equipment		1	D	-	-
Dam (hydro-mech. and civil)	- Installation of flashboard	8	C	O	IN
Penstock valve (hydro-mech.)	- Remote control system	1	C	O	DD
Right abutment of Dam (civil)	- Leakage	-	X	-	-
Surge tank (civil)	- Turbulence and explosive noise	-	X	-	-

Table 5.2	Items	No.	Level	ODA	Phase
Old Laxapana	(Stage II)				
Inspection before the rehabilitation	- Disassembly inspection	1	E	-	-
Turbine		2	D	-	-
Inlet valve	- Seals	2	A	NN	-
Governor		2	E	-	-
Pressure oil supply system		2	E	-	-
Air supply system for governor		2	E	-	-
Air supply system for brake	In conjunction with Stage I generator replacement - Whole	2	A	O	DD
Oil lubrication system	- Modification	2	C	NN	-
Water supply system	In conjunction with the Stage I generator replacement - Whole	2	C	NN	-
Generator		2	D	-	-
Exciter		2	D	-	-
AVR		2	E	-	-
Generator transformer		7	D	-	-
11kV main circuit		2	E	-	-
Plant control equipment	*1	3 lots	E	-	-
Protection equipment	*2	3 lots	E	-	-
LV auxiliary circuit		1	E	-	-

Table 5.2	Items	No.	Level	ODA	Phase
Canyon					
Inspection before the rehabilitation	- Disassembly inspection	1	E	-	-
Turbine	- Repair	2	C	NN	-
Inlet valve	- Seals	2	A	NN	-
Governor		2	D	-	-
Pressure oil supply system		2	D	-	-
Air supply system for governor		2	D	-	-
Air supply system for brake		2	D	-	-
Lubrication system		2	D	-	-
Water supply system		2	D	-	-
Drainage system	- Modification for the controller	2	C	NN	-
Generator	- Repair of the generators	2	C	NN	-
Exciter		2	D	-	-
AVR		2	D	-	-
Generator transformer		2	D	-	-
Spare generator transformer	- Inspection	1	C	NN	-
12.5kV main circuit	- Purchase of spare parts	2	C	NN	-
132kV switchgear		3	D	-	-
Plant control equipment	*1	4 lots	D	-	-
Protection equipment	*2	4 lots	D	-	-
LV auxiliary circuit		1	D	-	-
Control power source equipment	- Inspection for the battery in Unit 1	1	C	NN	-
Diesel generator	- Inspection for control equipment for diesel generator	1	C	NN	-
Communication equipment	- Installation of OPGW and new communication equipment between Canyon and Old Laxapana P/S	1	C	O	DD
Dam distribution equipment		1	D	-	-
Penstock (civil)	- Erosion in foundation of anchor block concrete	-	C	NN	-
Tailrace (civil)	- Displacement in retaining wall concrete	-	X	NN	-
Intake valve (hydro-mech.)	- Modification of air valve of intake valve	1	B	O	DD

Table 5.2	Items	No.	Level	ODA	Phase
New Laxapana					
Investigation (hydro-mech.)	- Investigation for raking machine and access bridge for intake	1	A	O	IN
Inspection before rehabilitation	- Disassembly inspection	1	A	O	SV
Turbine	In conjunction with the governors replacement - Guide vane servomotors	2	A	O	DD
Inlet valve	In conjunction with the governors replacement - Modification for the controllers	2	B	NN	-
	- Seals	2	A	NN	-
Governor	- Whole	2	A	O	DD
Pressure oil supply system	In conjunction with governors replacement - Whole	2	A	O	DD
Air supply system for governor	In conjunction with governors replacement - Whole	2	A	O	DD
Air supply system for brake	In conjunction with generators replacement - Whole	2	A	O	DD
Grease lubrication system	In conjunction with governors replacement - Whole	2	A	O	DD
Water supply system	In conjunction with generators replacement - Whole	2	A	O	DD
Generator	- Whole	2	A	O	DD
Exciter	In conjunction with governors replacement - Whole	2	A	O	DD
AVR	In conjunction with generators replacement - Whole	2	A	O	DD
Generator transformer		7	D	-	-
12.5kV main circuit	- The circuit breaker for auxiliary circuit and auxiliary transformer	2	A	O	DD
132kV switchgear	- Repair for operation mechanism of isolators	9	C	NN	-
Plant control equipment	In conjunction with generators replacement - Whole *1	4 lots	A	O	DD
Protection equipment	In conjunction with generators replacement - Whole *2	4 lots	A	O	DD
LV auxiliary circuit	In conjunction with generators replacement - Whole	1	A	O	DD
Control power source equipment	- Whole - Installation of UPS	1	A	O	DD
Diesel generator		1	D	-	-
Communication equipment		1	D	-	-
Dam distribution equipment		1	D	-	-
Dam (civil)	- Cavity in foundation rock	-	B	NN	-
Surge tank vicinities (civil)	- Leakage	-	X	NN	-
Penstock (civil)	- Erosion in foundation of anchor block concrete	-	C	NN	-
Tailrace (civil)	- Erosion in concrete wall		C	NN	-
Intake (hydro-mech.)	- Raking machine and access bridge	1	C	O	IN

Table 5.2	Items	No.	Level	ODA	Phase
Polpitiya					
Investigation	- Disassembly inspection for electro-mechanical equipment	1	A	O	IN
Investigation (hydro-mech.)	- Investigation for raking machine and access bridge for intake	1	A	O	IN
Turbine	- Whole the turbines except embedded parts	2	B	O	IN
Inlet valve	In conjunction with governors modification - Modification for controllers	2	B	NN	-
	- Seals	2	A	NN	
Governor	In conjunction with turbines replacement - Modification	2	B	NN	-
Pressure oil supply system	In conjunction with turbines replacement - Modification	2	B	NN	-
Air supply system for governor	In conjunction with turbines replacement - Modification	2	B	NN	-
Air supply system for brake	In conjunction with generators repair - Modification	2	C	NN	-
Grease lubrication system	In conjunction with turbines replacement - Whole	2	B	O	IN
Water supply system	- Whole	2	B	O	IN
Drainage system	- Whole	2	B	O	IN
Generator	In conjunction with turbines replacement - Thrust bearing	2	B	O	IN
Exciter		2	D	-	-
AVR		2	E	-	-
Generator transformer	- Whole	7	A	O	SV
12.5kV main circuit	- Auxiliary transformer	2	A	O	SV
132kV switchgear		12	E	-	-
Control equipment for the Unit 1, 2	In conjunction with turbines replacement - Modification	2 lots	C	NN	-
Control equipment for the switchyard and the auxiliary circuit	In conjunction with communication equipment modification - Modification	2 lots	C	NN	-
Protection equipment for Units 1, 2	In conjunction with turbines replacement - Modification	2 lots	C	NN	-
Protection equipment for switchyard and auxiliary circuit	In conjunction with communication equipment modification - Modification	2 lots	C	NN	-
LV auxiliary circuit		1	E	-	-
Control power source equipment	- Repair for the ground phenomenon at positive side	1	C	NN	-
Diesel generator		1	E	-	-
Communication equipment	- Installation of OPGW and new communication equipment between Polpitiya and Old Laxapana P/S	1	C	O	DD
Dam distribution equipment		1	D	-	-
Dam (civil)	Installation of rain gauge station	-	B	O	DD
Spillway (civil)	Reinforcement of spillway	-	X	-	-
Intake (hydro-mech.)	Plan for raking machine and access bridge	1	C	O	IN
Intake (civil)	Vortex	-	X	NN	-
Penstock (civil)	Erosion in foundation of anchor block concrete	-	C	NN	-
Powerhouse (civil)	Landslide	-	X	NN	-
Powerhouse (civil)	Leakage in wall concrete	-	C	NN	-
Tailrace (civil)	Erosion in concrete wall	-	C	NN	-

Table 5.3 Cost of the Rehabilitation Plan
(Including civil and hydromechanical equipment)

Notice: The recommended rehabilitation plan is shown in the green area.

Common rehabilitation Matrix

Table 5.3		Deterioration Level		
		A	B	C
Phase of Implementation	SV		- Small blasting and painting machine for general use Total cost: US$200,000	- Removal of sedimentation from Canyon and Laxapana ponds Dredging grab Mobile crane - Dam control system for Canyon and Laxapana pound - Robot for repainting the inside of penstock Total cost: US$2,500,000
	DD			
	IN			

Estimated cost of the recommended rehabilitation plan in this sheet

Item	Cost
Total cost of the green area	US$2,700,000
Engineering fee (10%)	US$300,000
Contingency (10%)	US$300,000
Total cost	US$3,300,000

Wimalasurendra Rehabilitation Matrix

Table 5.3		Deterioration Level		
		A	B	C
Phase of Implementation	SV	- Disassembly inspection Total Cost: US$1,200,000 - Generator transformer - 11kV main circuit Total cost: US$1,800,000	- 132kV switchgear Total cost: US$3,200,000	
	DD	- Turbine (replacement of some parts) - Governor - Pressure oil supply system - Air supply system for governor - Air supply system for brake - Grease lubrication system - Water supply system - Drainage system - Generator: Case 1: Repair Case 2: Replacement - Exciter and AVR - Plant control equipment - Protection equipment - LV auxiliary circuit - Control power source Total cost of case1: US$8,900,000 Total cost of case 2:		- Communication equipment Total cost: US$400,000
	IN	- Investigation for modification of spillway Total Cost: US$300,000	- Modification of spillway [Reference] Cost: US$5,600,000	

Estimated cost of the recommended rehabilitation plan in this table

Item	Cost of Case 1	Cost of Case 2
Total cost of items in green, above (excluding the cost of investigation and disassembly inspection)	US$14,300,000	US$18,200,000
Engineering fee (10%)	US$1,500,000	US$1,900,000
Cost of investigation	US$300,000	US$300,000
Cost of disassembly inspection	US$1,200,000	US$1,200,000
Contingency (10%)	US$1,600,000	US$2,000,000
Total cost	US$18,900,000	US$23,600,000

Old Laxapana (Stage I) Rehabilitation Matrix

Table 5.3		Deterioration Level A	B	C
Phase of Implementation	SV	- Disassembly inspection Total cost: US$1,200,000		
	DD	- Turbine - Inlet valve - Governor - Pressure oil supply system - Air supply system for governor - Air supply system for brake - Oil lubrication system - Water supply system - Generator - Exciter - AVR - 11kV main circuit Total cost: US$12,400,000		- Communication equipment Total cost: US$200,000 - Repair for remote control system of the penstock valve Total cost: US$200,000
	IN	- Investigation for Installation of flashboard Total cost: US$300,000	- Flashboard [Reference] Cost: US$3,200,000	

Old Laxapana (Stage II) Rehabilitation Matrix

Table 5.3		Deterioration Level A	B	C
Phase of Implementation	SV			
	DD	- Air supply system for brake Total cost: US$100,000		
	IN			

Estimated cost of the recommended rehabilitation plan in this table

Item	Cost
Total cost of items in green, above, in Old Laxapana P/S Stage I (excluding the cost of investigation and disassembly inspection)	US$12,600,000
Total cost of items in green, above, in Old Laxapana P/S Stage II	US$100,000
Engineering fee (10%)	US$1,300,000
Cost of investigation	US$300,000
Cost of disassembly inspection	US$1,200,000
Contingency (10%)	US$1,500,000
Total cost (The cost includes the cost of rehabilitation plan of Old Laxapana Stage II.)	US$17,000,000

Canyon Rehabilitation Matrix

Table 5.3		Deterioration Level		
		A	B	C
Phase of Implementation	SV			
	DD		- Modification of air valve of intake valve Total cost: US$300,000	- Communication equipment Total cost: US$400,000
	IN			

Estimated cost of the recommended rehabilitation plan on this sheet

Item	Cost
Total cost of the green area	US$700,000
Engineering fee (10%)	US$100,000
Contingency (10%)	US$100,000
Total cost	US$900,000

New Laxapana Rehabilitation Matrix

Table 5.3		Deterioration Level		
		A	B	C
Phase of Implementation	SV	- Disassemble inspection Total cost: US$1.400.000		
	DD	- Turbine (Replacement of some parts) - Governor - Pressure oil supply system - Air supply system for governor - Grease lubrication system - Air supply system for brake - Water supply system - Generator - Exciter - AVR - 2.5kV main circuit - Plant control equipment - Protection equipment - LV auxiliary circuit - Control power source		
	IN	- Investigation for raking machine and access bridge Total cost: US$500,000		- Raking machine and access bridge [Reference] Cost: Unknown

Estimated cost of the recommended rehabilitation plan on this sheet

Item	Cost
Total cost of items in green, above (excluding the cost of investigation)	US$15,800,000
Engineering fee (10%)	US$1,600,000
Cost of investigation	US$500,000
Cost of disassembly inspection	US$1,400,000
Contingency (10%)	US$1,800,000
Total cost	US$21,100,000

Polpitiya Rehabilitation Matrix

Table 5.3		Deterioration Level A	B	C
Phase of Implementation	SV	- Generator transformer - 12.5kV main circuit Total cost: US$2,100,000		
	DD		- Installation of rain gauge station Total cost: US$600,000	- Communication equipment Total cost: US$400,000
	IN	- Investigation for the turbine Total cost: US$1,400,000 - Investigation for raking machine and access bridge Total cost: US$500,000	- Turbine - Grease lubrication system - Water supply system - Drainage system - Generator (Parts replacement) [Reference] Cost: US$10,00,000	- Raking machine and access bridge [Reference] Cost: Unknown

Estimated cost of the recommended rehabilitation plan on this sheet

Item	Cost
Total cost of items in green, above (excluding the cost of investigation)	US$3,100,000
Engineering fee (10%)	US$400,000
Cost of investigation items in green, above	US$1,900,000
Contingency (10%)	US$600,000
Total cost	US$6,000,000

Total cost of recommended rehabilitation plan

Common		US$3,300,000
Wimalasurendra	US$18,900,000	US$23,600,000
Old Laxapana Stage I (including the cost for Stage II)		US$17,000,000
Canyon		US$900,000
New Laxapana		US$21,100,000
Polpitiya		US$6,000,000
Total cost	US$67,200,000	US$71,900,000

Table 5.4 Schedule of the Rehabilitation Plan (Case 1)

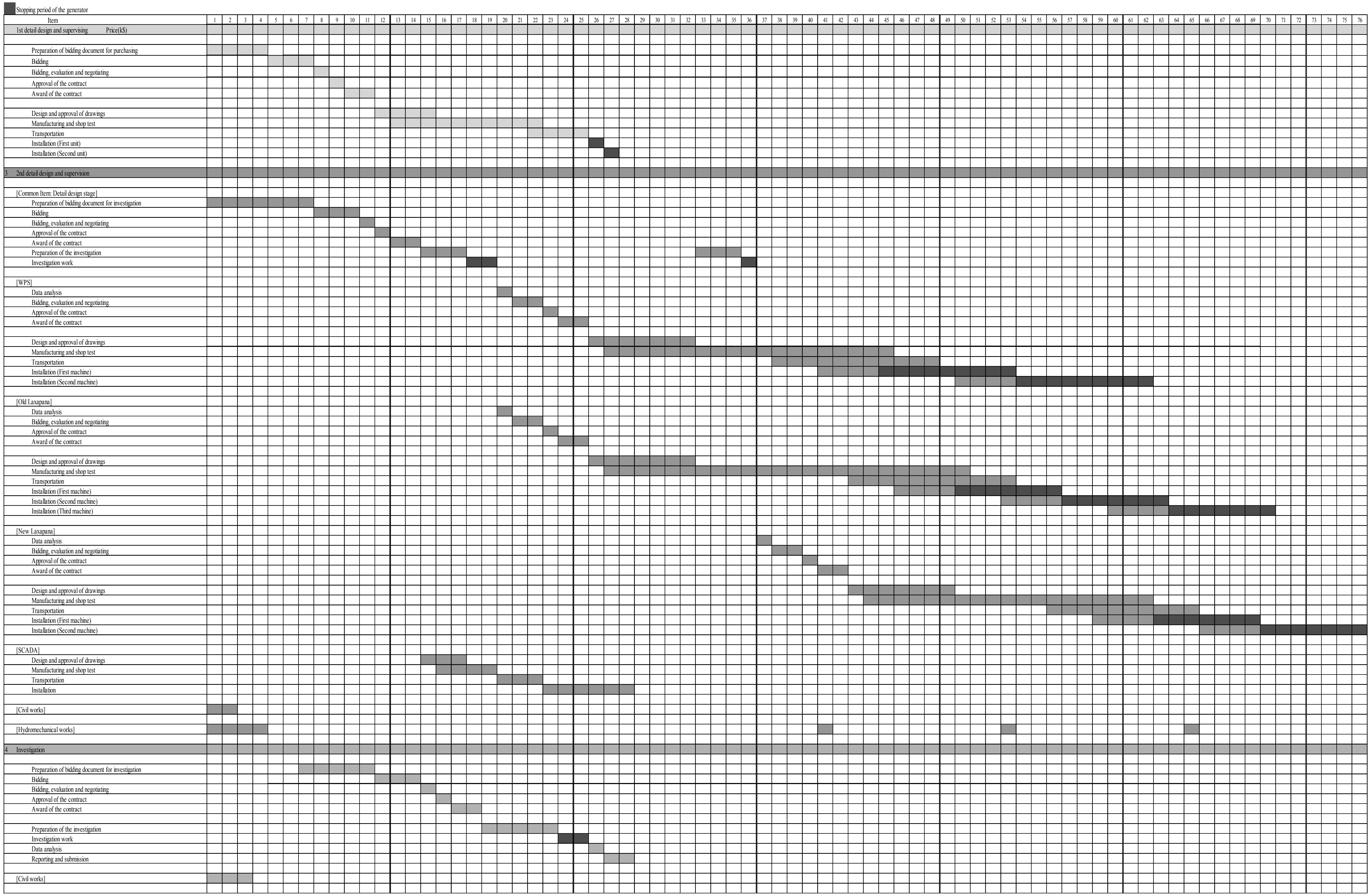


Table 5.5 Schedule of the Rehabilitation Plan (Case 2)

Generator down period

Item	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76
1st detail design and supervising Price(k$)
Preparation of bidding document for purchasing
Bidding
Bidding, evaluation and negotiating
Approval of the contract
Award of the contract
Design and approval of drawings
Manufacturing and shop test
Transportation
Installation (First unit)
Installation (Second unit)
3 2nd detail design and supervision
[Common Item: Detail design stage]
Preparation of bidding document for investigation
Bidding
Bidding, evaluation and negotiating
Approval of the contract
Award of the contract
Preparation of the investigation
Investigation work
[WPS]
Data analysis
Bidding, evaluation and negotiating
Approval of the contract
Award of the contract
Design and approval of drawings
Manufacturing and shop test
Transportation
Installation (First machine)
Installation (Second machine)
[Old Laxapana]
Data analysis
Bidding, evaluation and negotiating
Approval of the contract
Award of the contract
Design and approval of drawings
Manufacturing and shop test
Transportation
Installation (First machine)
Installation (Second machine)
Installation (Third machine)
[New Laxapana]
Preparation of bidding document for investigation
Bidding
Bidding, evaluation and negotiating
Approval of the contract
Award of the contract
Preparation of the investigation
Investigation work
Data analysis
Bidding, evaluation and negotiating
Approval of the contract
Award of the contract
Design and approval of drawings
Manufacturing and shop test
Transportation
Installation (First machine)
Installation (Second machine)
[SCADA]
Design and approval of drawings
Manufacturing and shop test
Transportation
Installation
[Civil works]
[Hydromechanical works]
4 Investigation
Preparation of bidding document for investigation
Bidding
Bidding, evaluation and negotiating
Approval of the contract
Award of the contract
Preparation of the investigation
Investigation work
Data analysis
Reporting and submission
[Civil works]

6. ECONOMIC AND FINANCIAL ANALYSIS

6. ECONOMIC AND FINANCIAL ANALYSIS

6.1 Economic Analysis

The economic and financial analysis is focused on Wimalasurendra P/S (40 years old), Old Laxapana P/S (54 years old) and New Laxapana P/S (30 years old), for which replacement of the main electrical equipment is being planned. The rehabilitation plan is thoroughly considered from the technical standpoint, and when two or more rehabilitation plans can be considered, they should be analyzed for every case in regard to differences in improved generating efficiency, outage time, future operation and maintenance cost and so on.

6.1.1 Estimate of Economic Benefits

The consultant chose a gas turbine type power plant as the alternative thermal power plant for this analysis, and its construction cost and operation and maintenance cost including fuel cost will be considered as a benefit.

6.1.2 Estimate of Economic Costs

The local currency portion of the estimated pure construction cost is calculated as an economic cost by a conversion factor which, based on discussions with CEB, was determined to be 0.9. The economic construction cost is shown in the table below. And the cost of common items is divided among five power stations with the following percentage; 5% for Wimalasurendra P/S, 30% for Old Laxapana (Stage I) P/S, 30% for Canyon P/S, 30% for New Laxapana P/S and 5% for Polpitiya P/S.

(Unit: US$1,000)

Economic Cost			
Power Station	Total Amount	Foreign Currency Portion	Local Currency Portion
Wimalasurendra (Case1)	18,875 repair cost of US$1 million every 5 years	17,159	1,716
(Case2)	23,528	21,389	2,139
Old Laxapana (Stage I)	17,810	16,191	1,619
New Laxapana	21,869	19,881	1,988

The operation and maintenance cost (O&M cost) consists of personnel costs and equipment procurement costs in consideration of the actual cost. A 10% reduction of the O&M cost can be assumed when the main equipment is replaced by the rehabilitation project.

6.1.3 Result of Economic Evaluation

Three indices, surplus benefit (B-C), benefit cost ratio (B/C) and economic internal rate of return (EIRR), are calculated, and the consultant judges the feasibility from the economic standpoint. The discount rate was set as 10% upon discussion with CEB for this evaluation.

Power Station	B-C	B/C	EIRR
Wimalasurendra (Case1) (Case2)	 US$45,087,000 US$44,008,000	 3.95 3.52	 21.91 % 20.49 %
Old Laxapana (Stage I)	US$87,018,000	7.26	45.60 %
New Laxapana	US$50,083,000	4.39	15.65 %

These calculation results prove that each of the rehabilitation plans is feasible from the economic point of view. Regarding Wimalasurendra P/S, the Case1 rehabilitation plan, in which repairs are made as required, shows better economic outcome than Case2 based on calculations because the initial investment is smaller. But the consultant tried some cases in which a US$5 million per year as special repair cost, and used the result for comparison with Case2. As the results of this trial indicate, Case2 (scheduled replacement) is more economical when the special repairs are needed before the unit is 62 years old. On the other hand, Case1 (repair as required) is more economical if the special repairs are needed after it is 63 years old.

6.2 Sensitivity Analysis of EIRR

6.2.1 Sensitivity of Project Costs and Fuel Price

Sensitivity analysis has been done for the cases in which the cost of the rehabilitation project and the fuel price of the alternative thermal plant change, and they have been verified that every project maintains economical feasibility against some rate of change because of the original stable economic feasibility.

6.2.2 The Limiting Time of Without Project

The consultant analyzed the sensitivity of the timing and economic efficiency on the assumption that no rehabilitation will be done until power plant completely breaks down and functionally stops in consideration of the economic cost of not supplying energy (Cost of Energy Not Served).

To continue operating without rehabilitation and await a crash with outage brings an enhanced the risk of blackouts. The calculation result is as follows. As for Wimalasurendra P/S, if a crash occurs and replacement of the unit becomes necessary before it is 50 years old, implementing scheduled replacement is preferable. As for Old Laxapana (Stage I) P/S, if a crash occurs and replacement of the unit becomes necessary before it is 65 years old, implementing scheduled replacement is preferable. As for New Laxapana P/S, if a crash occurs and replacement of the unit becomes necessary before it is 46 years old, implementing scheduled replacement is preferable.

6.3 Financial Analysis

The financial internal rate of return (FIRR) is calculated by comparing the financial cost and financial benefit of the rehabilitation plan.

6.3.1 Estimate of Financial Benefit

Assumed income from electricity sales based on the electricity unit price is used as a financial benefit.

6.3.2 Estimate of Financial Cost

The financial cost is estimated for the construction cost and O&M cost at a financial price.

(Unit: US$1,000)

Financial Cost			
Power Station	Total Amount	Foreign Currency Portion	Local Currency Portion
Wimalasurendra (Case1)	24,550 repair cost of US$1 million every 5 years	22,358	2,193
(Case2)	30,602	27,869	2,733
Old Laxapana (Stage I)	23,165	21,096	2,069
New Laxapana	28,444	25,904	2,540

6.4 Result of Financial Evaluation

The financial internal rate of return (FIRR) has been calculated and the consultant has judged feasibility from the financial standpoint. These calculation results indicate that all of the rehabilitation plans are sufficiently feasible based on financial evaluation.

Power Station	FIRR
Wimalasurendra	
Case1	14.15 %
Case2	12.82 %
Old Laxapana (Stage I)	28.86 %
New Laxapana	14.23 %

6.5 Sensitivity Analysis of FIRR

6.5.1 Sensitivity of Project Costs and Electricity Price

For the case in which the project cost of the rehabilitation project and electricity price is changed, sensitivity analysis was carried out. The calculation results indicate that each project is sufficiently feasible when the project cost and electricity price change regarding FIRR, as expected.

6.6 ODA Finance

6.6.1 Analysis of ODA Finance

As a measure of ODA finance analysis, three have been calculated. These are DSCR (Debt Service Coverage Ratio), ROI (Return on Investment), and LLCR (Loan Life Coverage Ratio). The calculation results are shown below. Both DSCR and LLCR exceed the standard rate of around 1.5%, which indicates high repayment capability.

Power Station	DSCR	ROI	LLCR
Wimalasurendra			
Case1	3.365	8.3%	2.996
Case2	2.772	8.3%	2.473
Old Laxapana (Stage I)	6.227	8.4%	5.328
New Laxapana	7.515	8.6%	5.577

6.7 Sensitivity Analysis of ODA Finance

6.7.1 Sensitivity Analysis of Electricity Price and Foreign Loan Condition

The cases in which the electricity price and foreign loan condition change have been calculated. The calculation results indicated that each project is sufficiently feasible in regarding to changing electricity price and foreign loan condition as expected.

7. ENVIRONMENTAL IMPACT ASSESSMENT

7. ENVIRONMENTAL IMPACT ASSESSMENT

7.1 Awareness of Environmental and Social Issues in Sri Lanka

There are some development projects that have not been promoted smoothly because of citizens' objections. Probable environmental and/or social issues have been raised as reasons to object. Those projects include not only electric power generation projects, which are vulnerable to criticism, such as the Upper Kotmale Hydropower Project and Coal Fired Thermal Development Project, West Coast, but also other various kinds of projects such as road construction, mine development, shrimp cultivation, etc.

Views raised by the projects opponents can be summarized after studying some cases.

- The project has problems regarding the natural environment.
- The project has problems regarding the social environment (especially resettlement plan, compensation, etc.).
- An alternative plan has not been studied though it seems a better option.
- Communication with the residents has not been sufficient.

The lessons that have been learned from the above are: An EIA report should have clear description based on scientific grounds regarding the natural environment. Regarding the social environment, it should include an appropriate resettlement plan (if necessary) and concrete plans for compensation for the loss of residents' livelihood. The procedure through by the priority option has been selected because of its advantages in view of the natural and social environment should be explained. In addition, it is necessary to carry out consultations with the stakeholders from an early stage to obtain their trust and understanding.

However, the rehabilitation of hydropower stations in the Kelani River basin does not aim to install additional structures or facilities but rather to maintain or replace the existing facilities. Additionally, an alternative study may not be required because of the characteristics of the rehabilitation work.

It is tenuous that the Environmental Impact Assessment (EIA) is necessary for the implementation of this rehabilitation project according to the institutional framework in Sri Lanka.

7.2 Institutional and Legal Framework in Sri Lanka

7.2.1 Governmental Institutions

The Ministry of Environment and Natural Resources handles environmental issues in Sri Lanka, and there are six agencies under the Ministry:

- Central Environmental Authority (CEA)
- State Timber Corporation
- Geological Survey & Mines Bureau
- Forest Department
- Department of Wildlife Conservation
- Department of National Zoological Gardens

7.2.2 Environmental Laws and Regulations

National Environmental Act No. 47 of 1980 (NEA) is Sri Lanka's basic national charter for protection and management of the environment. Regulation on tolerance limits for effluents, regulation on noise control and other regulations are issued under the Act. The framework of the Environmental Impact Assessment (EIA) procedure is also stipulated in the Act.

Other main acts related to the environment are these:

- Agrarian Development Act
- Fauna and Flora Protection Ordinance
- Forest Ordinance
- Mines and Minerals Act
- National Heritage Wildness Areas Act
- Coast Conservation Act
- Marine Pollution Prevention Act
- Fisheries and Aquatic Resources Act

7.3 Procedure of Environmental Impact Assessment

The NEA was amended by Act No. 56 of 1988 to include a provision relating to environmental impact assessment (EIA) contained in Part IV C of the statute entitled 'Approval of Projects'. The details are stipulated in the National Environmental Regulations (Procedure for Approval of Projects). The EIA procedure is specified by an Act and the Regulations as follows:

- The Minister may specify the state agency which shall be the Project Approving Agency (PAA).
- A project proponent of any proposed project shall submit to the PAA preliminary information on the project requested by the appropriate PAA.
- The PAA shall convey in writing to the project proponent the Terms of Reference within 30 days in the case of an Environmental Impact Assessment Report from the date of acknowledging receipt of the preliminary information.
- Upon receipt of an Environmental Impact Assessment Report, the PAA shall, within 14 days, determine whether the matters referred to by the Terms of Reference are addressed and, if the Report is determined to be inadequate, the PAA shall require the project proponent to make necessary amendments and re-submit the report, together with the required number of copies.
- Upon receipt of the Report, the PAA shall submit a copy thereof to the Authority and by prompt notice published in the Gazette and in one national newspaper published daily in the Shinhala, Tamil and English languages invite the public to make written comments, if any, thereon to the PAA within 30 days from the date of the first appearance of the notice, either in the Gazette or in the newspaper.
- It shall be the duty of the PAA, upon completion of the period of public inspection or public hearing, if held, to forward to the project proponent comments received for review and response, within six days. The project proponent shall respond to such comments in writing to the PAA.

- Upon receipt of such responses, the PAA shall with the concurrence of the Authority within 30 days either

  (i) grant approval for the implementation of the proposed project to specified conditions; or

  (ii) refuse approval for the implementation of the proposed project, with reasons for doing so.

The following guidelines are issued by the CEA for the good practice of the EIA:

- Guidance for Implementing the Environmental Impact Assessment (EIA) Process

  No.1: A General Guide for Project Approving Agency (PAA)
  No.2: A General Guide for Conducting Environmental Scoping

The statement on public hearings in the guideline is as follows:

A public hearing may be held at the discretion of the PAA when it thinks that it would be in the public interest to do so. A variety of situations may fall within the meaning of "public interest," and these cannot be exhaustively defined. Factors for the PAA to consider are:

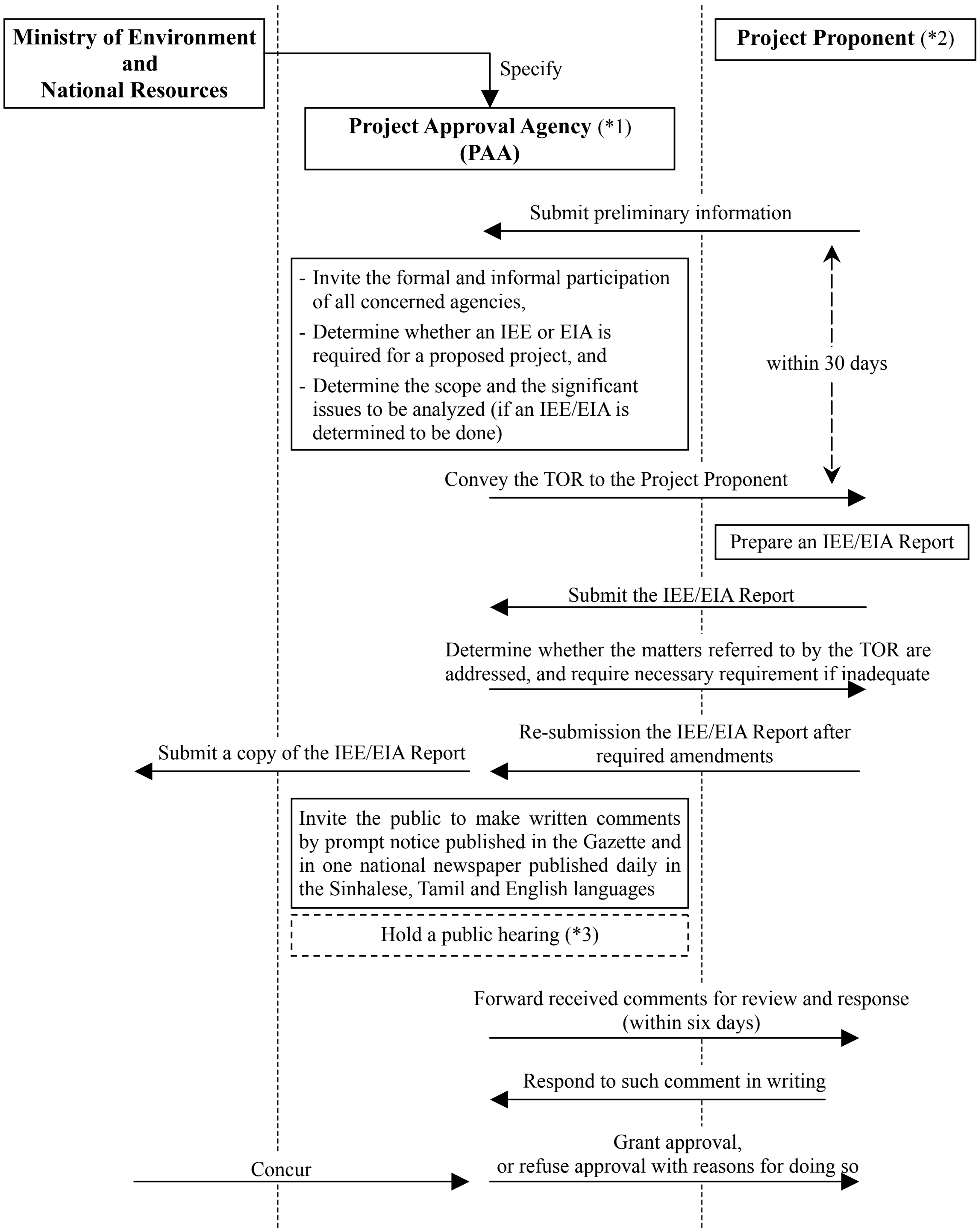
- whether a proposed prescribed project is highly controversial, whether more expressions of public views are essential to make decision;

- whether the proposed prescribed project might cause unusual national regional impacts;

- whether it might threaten a nationally important environmentally sensitive area;

- whether a formal request for a public hearing has been requested by an interested party.

EIA Flow



*1: It is Central Environmental Authority (CEA) in this study
*2: It is CEB in this study
*3: In case of being judged by the PAA to be necessary

7.4 Environmental Impact Assessment for the Rehabilitation of Hydropower Stations in the Kelani River Basin

At this time, it is difficult to judge whether an Initial Environmental Examination (IEE) or EIA is required for the rehabilitation of hydropower stations in the Kelani River basin to obtain approval for the project implementation. The Study Team unofficially consulted with a CEA officer who is in charge of the Upper Kotmale Hydropower Project about the necessity of an IEE or EIA for the rehabilitation during the first study period in Sri Lanka of this study. Then the Study Team obtained an unofficial comment that an IEE or EIA might not be required. Anyway, the necessity of an IEE or EIA should be reconfirmed according to "10.3 Procedure of Environmental Impact Assessment" prior to implementing the rehabilitation.

According to the government notifications in June 24 1993, development work in an area within 100m of an existing reservoir is classified as a project that is required to be approved by the Project Approving Agency (PAA), based on the National Environmental Act. That is to say, the rehabilitation of hydropower stations in the Kelani River basin corresponds to a project which is required to receive approval by the PAA. Part of the government notification is as follows.

- Gazette Extraordinary of the Democratic Socialist Republic of Sri Lanka - 1993.06.24
  --- omission ---

- Part II, All projects and undertakings listed in Part I irrespective of their magnitudes and irrespective of whether they are located in the coastal zone or not, if located wholly or partly with in the areas specified in Part III of the Schedule.

- Part III, --- omission ---, 2. Within the following areas whether or not the areas are wholly or partly within the Coastal Zone: --- omission ---

- any reservation beyond the full supply level of a reservoir. --- omission ---

- "reservoir" means an expanse of water resulting from man made constructions across a river or a stream to store or regulate water. Its environs will include that area extending up to a distance of 100 meters from full supply level of the reservoir inclusive of all islands falling within the reservoir.