No. 2

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

CEYLON ELECTRICITY BOARD
THE DEMOCRATIC SOCIALIST REPUBLIC OF SRI LANKA

MASTER PLAN STUDY FOR DEVELOPMENT OF THE TRANSMISSION SYSTEM OF THE CEYLON ELECTRICITY BOARD

FINAL REPORT

SUMMARY

JANUARY 1997

NIPPON KOEI CO., LTD.
TOKYO, JAPAN

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PREFACE

In response to a request from the Government of the Democratic Socialist Republic of Sri Lanka, the Government of Japan decided to conduct the Master Plan Study for Development of the Transmission System of the Ceylon Electricity Board and entrusted the study to Japan International Cooperation Agency (JICA).

JICA sent a study team led by Mr. Sumio Tsukahara of Nippon Koei Co., Ltd. to the four times from January 1996 to December 1996.

The team held discussions with the officials concerned of the Government of the Democratic Socialist Republic of Sri Lanka, and conducted related field surveys. After returning to Japan, the team conducted further studies and complied the final results in this report.

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

I wish to express my sincere appreciation to the officials concerned of the Government of the Democratic Socialist Republic of Sri Lanka for their close cooperation throughout the study.

January 1997

Kimio Fujita

Kimio Fujita
President
Japan International Cooperation Agency

EXECUTIVE SUMMARY

1. Background

The electric power demand of the CEB system has been growing rapidly in the recent years after 1990 at a rate of exceeding 8.4% per annum for energy sales and expansion of the power system for generation facilities and transmission network is requested. In the past, CEB has prepared only a long-term generation expansion plan every year using the WASP III program introduced by the World Bank, however a systematic transmission system planning study which requires laborious power system power system analysis has not been performed for long time.

The transmission network of CEB is still in a developing stage, and there are many problems to be improved related to quantity (supply shortage), quality (excessive voltage drop) and reliability (supply interruption) of power supply. However, due to insufficiency in development fund execution of network improvement plans is delaying.

2. Objectives

Objectives of the Study are

(a) To formulate a long-term transmission system development plan of the whole CEB power system for the period of 1996 to 2005 based on the CEB's long-term power demand forecast and a corresponding generation expansion plan, to prepare preliminary design of planned transmission system facilities and to compile a Master Plan Report.

(b) To transfer the technology of transmission system planning works to CEB counterpart engineers so that they can acquire knowledge to carry out similar transmission system planning studies themselves in future.

3. Study Area

The electric energy needs to be delivered impartially to all areas in the country. Therefore, the transmission system shall cover whole the area of the country. Under such situation, the objective area of the Study covered the whole area of Sri Lanka stretching 435 km from north to south and 225 km from east to west.

4. Problems of the Present Transmission System

Sri Lanka has no proven reserves of fossil fuel such as, coal, oil, natural gas, or nuclear energy for thermal generation. Therefore, the past power development effort has been concentrated on the hydro power generation utilizing indigenous and renewable energy resources, and thus the present hydro-dominated generation system has been formulated. In terms of energy generation, about 93% of energy in average has been generated by the hydro stations during the past 10 years according to operation records of CEB. The thermal power stations have been operated only to supplement deficiency in the hydro generation in dry season.

The existing major transmission lines have been constructed with their principal aim to transfer the generated hydro power in the central mountains to the largest load center of the Colombo area which consumes about 60% of the total country demand. 220 kV and 132 kV systems are operated as the main transmission system. The 132 kV system has been extended to other load centers as required, covering up to Jaffna to the northern end of the country to Galle to the southern end. The present transmission system is shown in Fig. 3. However, the transmission system except for that of the Colombo area is mainly of radial formation and does not form a ring, and there is large voltage drop and reliability of supply is not high in local systems. The 132 kV double circuit line to the Jaffna peninsula to the north has been severely damaged due to the disturbance and disconnected at present at the Anuradhapura substation.

The 132 kV power system commenced its operation in the late 1950s, and some facilities are very old exceeding the normal service life. Conductors of old lines are too small to meet increasing power demand, and there are grid substations which are T-branched from major transmission lines without proper relaying protection. These cause frequent interruption of power supply.

Due to shortage of reserve capacities, maintenance of the transmission facilities can not be performed properly. Together with shortage of spare parts, substation equipment seem to have been deteriorated earlier than their normal lives.

Though as a whole the power system in the Colombo area is operated without severe voltage drop and frequent supply interruption compared with those of other developing countries in South-East Asia, the power systems in other areas are much inferior to this Colombo system in supply voltage level and reliability of supply.

5. Long-Term Transmission System Planning Strategy

The transmission system, to connect power stations and demand centers for delivery of generated power to meet the overall demand, has a dependent nature in the power system. Prior to commencing transmission system planning works, power demand, not only nation-wide demand but also demand of each substation, must be identified and corresponding future generation plan, location and output of each power station, have to be determined. The transmission system shall be planned so as to have an enough capacity to deliver the generated power to demand centers in efficient and coordinated manners at least cost among alternatives and to maintain quality and reliability of supply.

6. Available Demand Forecast and Generation Expansion Plan

The power demand forecast for transmission system planning must be prepared for each of grid substation under consideration. The forecast demand of the whole country in the planning year in the CEB's forecast was at first allocated to 40 areas of CEB referring to the past consumption records. Then area demands were allocated to grid substations by distributing them using power supply matrixes determined in consultation with CEB engineers.

The long-term generation expansion plan, 1995 -2015, worked out by the Planning Division of CEB was used as the long-term generation expansion plan for the Study.

7. Formulation of Transmission System Development Projects

This Study was carried out on the assumption that all the transmission system projects now under construction and finance already arranged will be constructed as planned.

At first a preliminary transmission system plan was prepared for each of the 2000, 2005, 2010 and 2015 systems one after next so as to solve current problems, to increase supply capacity as required, not to cause voltage problem and to improve supply reliability. The existing 220 kV and 132 kV transmission system was assumed to be extended as required, but the 220 kV system will be extended extensively for bulk power transmission from distant thermal power stations to the load centers and to form the trunk system for reliable power supply to the Colombo area.

It became clear that the next higher transmission voltage of 400 kV or 330 kV would not be required within the plan period up to the year 2015 as the result of power system analysis, because the maximum power flow on one line will not exceed 1,000 MW.

Locations of additional grid substations were determined taking into account CEB's ideas through discussions with concerned engineers.

Power flow calculation was carried out on the preliminary transmission systems to review flow of power and voltage profile in the above preliminary transmission systems using the PSS/E software owned by CEB. It is noted that actual calculation of this analysis were performed by counterpart engineers of CEB bzsed on data prepared by the JICA team. Supply reliability was assessed using the TPLAN program in the PSS/E group. The preliminary plan was revised when required and calculations were repeated till required criteria have been satisfied.

The overall process of the planning works is presented in Fig. 4.

Particulars of the transmission system reinforcement projects currently under construction and finance arranged are listed in Table 1, and selected transmission system development projects identified through the above process for each year in the periods of 1996 to 2000, 2001 to 2005, 2006 to 2010 and 2011 to 2015 are presented in the project lists in Tables 2, 3, 4 and 5 respectively and in Figs. 5 through 8.

8. Required Fund, and Economic and Financial Evaluation

The project cost for implementation of all the planned projects in this Study is roughly estimated to be US$ 1,184 Million, US$ 942 Million in foreign currency and US$ 242 Million equivalent in local currency, at the end-1995 price level as shown in Table 8.

The estimated overall fund schedule for the power system development plan of CEB for the period of 1996 to 2015 covering generation, transmission and distribution is tabulated in Table 9. Costs include those for construction, O&M and fuel for generation. The EIRR of the overall developments against consumer's willingness to pay is calculated to be 26.3%, and the transmission cost on the LRMC basis is

1.4 cent/kWh and overall energy cost including generation and distribution costs is 10.4 cent/kWh. It is evident that the power tariff has to be increased.

9. Urgent Projects

14 selected transmission system subprojects which are required to be completed in the period of 1998 to 2001 presented in Table 6 are regarded as the projects for urgent implementation through discussion with CEB. The rough construction cost of each subproject in Table 6 is presented in Table 7. The total cost is estimated to be US$ 117.7 Million, consisting of US$ 93.8 Million in foreign currency and US$ 23.9 Million equivalent in local currency.

At the present stage it is not possible to determine funding sources for the projects immediately. Therefore, it is recommended to carry out preparatory studies at an earliest possible time covering site investigation, environmental impact assessment, design and preparation of tender documents so as to ensure smooth execution of projects after contract. Application for an aid loan is to be submitted with such study results.

10. Institutional Arrangement

As Sri Lanka is a fossil fuel importing country suffering from shortage of foreign currency reserve, it is required to try best effort for effective utilization of indigenous energy resources, i.e. hydro resources, biomas, etc., and to reduce dependency on imported fuel. In fuel importation, diversity of fuel sources shall be tried to attain security of acquisition. Promotion for efficiency of energy use and saving of consumption are also important target for Sri Lanka.

In the recent world enough ODA fund to support development of generation plants in developing countries is not available, and many countries are now executing their power developments utilizing private investment.

The cogeneration to generate electric power together with heat can attain very high overall efficiency of 60 to 80%, and preferable to improve efficiency in energy use. Such cogeneration is to be promoted for application by various manufacturing plants using heat for processing. For such a plant, it will be required to connect their power system with the CEB system to sell surplus power and receive power when the self-generation is not enough. For such interconnected operation, studies for institutional arrangements and decision of technical criteria for the interconnected operation will be required.

The daily load curve of the CEB system is of typical evening peak pattern, the duration of peak demand is very short, being around three hours at present. The coal thermal plants which are conceived as the future major power source are not suitable for variable output operation, and extensive construction of gas turbine plants and augmentation of peaking capability of hydro plants are conceived as proper means to meet such short time peak demand. Under such situation, it is also recommended to carry out studies for the peak shift to reduce the peak consumption by shifting some peak load to off-peak time. Review of tariff system and provision of fund to promote off-peak consumption instead of peak time will also be essential.

11. Future Execution of Transmission System Planning

The transmission system planning shall be executed based on a demand forecast divided to grid substations and a generation plan with location and output of each power station. The transmission system plan must be reviewed every time when there is any significant change in these preconditions, either demand or generation. It is a normal practice to prepare around 10 year transmission system development plan every year together with demand forecast and generation expansion plan as a revolving plan.

Transmission lines and substations for actual implementation shall be included in such system development plan and selected for an around three year period based on urgency and priority taking into account future configuration. The next projects for implementation shall be selected according to situation at the time.

Such studies shall be carried out by CEB. However, the number of capable staff in the Planning Department seems not sufficient. It is recommended to train young engineers for operation of the PSS/E and TPLAN software.

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1. Introduction

In response to an official request of the Government of Sri Lanka, the Government of Japan decided to implement technical cooperation for the Mater Plan Study for the Development of Transmission System of the Ceylon Electricity Board (CEB). The Japan International Cooperation Agency (JICA), the official agency responsible for the implementation of technical cooperation programs of the Government of Japan, discussed on implementing methods of the Study with CEB and signed an agreement on terms of reference by the both parties in July 1995.

A team of consultants of Nippon Koei Co., Ltd. was nominated by JICA to implement this technical cooperation. The Study was commenced in January 1996 and some 13 months was required up to completion.

The Study has been carried out based on the agreed terms of reference.

It is noted that this Study has been conducted with close coordination between the JICA team and CEB counterpart engineers of the Planning Division and other divisions.

2. General Description of the Democratic Socialist Republic of Sri Lanka

Sri Lanka is an island country with a land area of 65,600 km^2 floating in the Indian Ocean to the south-east of India, and its 1995 estimated population was 18,112,000 (population density was 276 person/km^2). The land lies in the tropical zone and generally endowed with much rainfall with average annual precipitation of over 1,900 mm. Temperature and humidity are high all the year round. The rainfall is generally intense in the central highland and large rivers flowing therefrom have a considerable hydro potential.

Sri Lanka is a multi ethnic country and ethnically divided into the predominantly Buddhist Sinhalese, which makes up 70% of the population, Hindu Tamils, which makes up 15% of the population, Islamic Moors, which makes up 7% of the population, and others being 8%.

The country is administratively divided into nine provinces. However, CEB divided the West Province, which includes Colombo and consumes about 60% of electric energy in the Country, into three provincial areas, Colombo, Western North and Western South, and is operating with 11 provincial organizations.

Over the past four years, Sri Lanka has recorded a real economic growth of around 5.5% per annum. According to government statistics, economic liberalization and structural reforms have had some economic effects. Nevertheless, these effects have been reduced by the huge annual deficits of the country.

Even with the addition of foreign aid to Sri Lankan revenues in its general account, the country's finances have been unable to escape from the pressure of military expenditures and assistance of refugees. In the recent years Sri Lankan trade deficit has soared, and the country has run constant current account deficits.

In 1994, unpaid foreign obligations totaled 434.9 billion Rupees (or US$ 8.7 billion). This is approximately four times annual government revenues.

3. Current Situation of Electric Power System

(1) Organizations:

The electric power supply activities in Sri Lanka are under control of the Ministry of Irrigation, Power and Energy (MIPE). CEB which is operating under this ministry is responsible for designing, constructing, operating and maintaining the generation, transmission and a substantial portion of distribution facilities in efficient, coordinated and economical manners covering the whole area of Sri Lanka. In addition to CEB's own direct power sales to consumers, CEB is also wholesaling a certain portion of power (17.4% of the whole in 1995) to power distribution utilities, LECO and local authorities, for further retailing to consumers.

(2) Demand and Supply:

In 1995, the generated energy was 4,786 GWh with peak generation of 981 MW and annual load factor of 55.7%. The sold energy was 3,912 GWh and its average annual growth rate was 7.2% for the past 20 years, 6.6% for 10 years and 8.4% after 1990. The recent high growth after 1990 is remarked. The electrified population of the county not including the Northern Province, now being separated from the interconnected system, was about 45% of the whole country in 1995. The present electrification ratio of the whole country if the northern system is included is estimated to be near to 50%. In category wise, out of the CEB's total 1995 sales the largest share was occupied by the Industrial Sector, 39.0%, the second by the Domestic Sector, 25.9%, and followed by Bulk Sales, 17.4%, and Commercial Sector, 16.1%. The recent sector wise growth rate is highest for the domestic sector due to the recent progress in rural electrification activities.

The relation between the installed generating capacity and peak generation for the period of 1972 to 1995 is shown in Fig. 1, and the relation between number of consumers and total sales in Fig. 2.

(3) Power Generation:

The preset generated energy of CEB is predominantly from the hydro power, and the thermal power has been generated only for supplementing deficiencies in the hydro power generation when available river flow is not enough to meet the demand. During the recent 20 year period a predominant portion of energy (more than 90% in average) has been supplied by the hydropower stations.

The available total generation capacity of the CEB system as of the end of 1995 was 1,349 MW consisting of the hydro plants of 1,125 MW and the thermal plants of 224 MW. To ensure power demand is met even in very dry years, considerable amount of contingency thermal capacity is required. In 1996, Sri Lanka experienced severe power shortage due to very dry weather. Due to the depleting of economically exploitable hydro project sites, Sri Lanka is now obliged to consider extensive future development of thermal power. For relatively cheap thermal generation with short annual operation hours, gas turbine, combined cycle and diesel generators are suitable. However, when demand grows further base-load coal thermal stations of larger capacity would become appropriate.

(4) Transmission System:

The CEB's present transmission system involves 220 kV, 132 kV and 66 kV transmission lines, and their total lengths in circuit-km as of the end of 1995 are as given below:

220 kV lines	260 km
132 kV lines	2,580 km
66 kV lines	314 km

Maps of the existing 220 kV and 132 kV transmission lines are shown in Fig. 3. The 66 kV system is planned to cease its operation in near future.

The original aim of the major transmission lines of CEB was to send the generated hydro power in the central mountains to the Colombo area. Thus, a number of 220 kV and 132 kV transmission lines have been constructed between hydro power stations and Colombo. The most serious fault for the present Colombo system is a two-circuit outage of the Kotmale - Biyagama 220 kV line (occurring at a rate of around once a year), which leads to an entire collapse of power supply to the Colombo area.

Most of the 132 kV transmission systems except for the Colombo system are of radial formation, not forming ring. Variation of supply voltage is large and a failure of transmission line causes a total interruption of power supply to its supply area.

The transmission system facilities in the northern area up to Jaffna have been severely damaged during the recent civil disturbance, and the transmission line to Jaffna is at present disconnected at the outgoing point of the Anuradhapura substation. By 2000, it is expected that their restoration be completed and power supply has been resumed to its normal status.

Many grid substations are T-connected with major transmission lines. The most serious problem of this system is that such grid substations are not provided with proper line protection relays. This causes protection problems to the transmission lines provided with distance relays and hampers system protection and fault restoration.

Installed capacity of static capacitors especially in the Colombo area is not enough to properly regulate the system voltage and this causes large voltage drop in transmission lines.

(5) Transmission Lines:

All the transmission lines of 66 kV and higher voltage are of steel tower construction and there are no pole support lines in the country. All major transmission lines are of double circuit construction, and single circuit lines are constructed for local supply lines and connections to relatively small power stations. As Sri Lanka is located in the tropical region, transmission lines are frequently hit by thunderstorms, major lines are provided with two overhead earthwires.

There has been no salt contamination problems in the country as transmission lines and substations have been constructed with enough separation from the sea coast.

There are three 132 kV underground cable circuits all in the Colombo city area. They are paper insulated OF (oil filled) cables generally directly buried along the central reservation of main roads.

(6) Transmission Line Protection:

The distance protection is applied as the main protection practice to most of the existing overhead 220 kV and 132 kV transmission lines. The major 220 kV lines are provided with two series of the permissive underreach transfer tripping (PUTT) protection scheme with two kinds of distance relays from different manufacturers, associated with 1 plus 3 autoreclosing function. For the 132 kV lines, the PUTT relaying system is being applied only to several major lines, and most of lines are operated with plain 3-stage distance protection without signal exchange through PLC channels.

The pilot-wire relaying protection is applied to the underground cable lines and the four short distance overhead lines of up to a few kilo-meters.

To save the power system from entire collapse even in the case of system disturbances, under-frequency relays for shedding a certain number of 33 kV lines when system frequency drops exceeding certain limits (typically 49, 48.5 and 48 Hz) are provided at the most of grid substations.

The traditional protective relays are mainly of induction disc or cup type. However, the microprocessor-based digital relays are generally provided for recent supplies. The characteristics of these digital relays are flexible and the operation times are adjustable to coordinate with operation of old induction relays.

(7) Substations:

Various types of substation are in operation in the CEB system. Grid substations step down the transmission voltage of 132 kV to the distribution voltage of 33 kV (or 11 kV in Colombo). 220/132 kV substations interconnect two transmission systems with voltages of 220 kV and 132 kV, and at the existing 220/132 kV substations distribution systems are connected to the tertiary 33 kV windings of tie transformers. There are cases that 33 kV distribution facilities are installed in power station premises. The switchyard of some power stations are used for connection of a number of transmission lines.

Most of the existing substations are of open surface type and only two substations, the Fort and Kollupitiya substations in the Colombo city center, are of indoor compact type with gas insulated switchgear (GIS).

Major substations are of double bus design with a number of high voltage circuits, while most of grid substations are of standard design having two incoming lines and a bus section. The initial quantity of main transformers is usually two, which is usually extendible up to four. The present standard transformer capacity is 31.5 MVA, but a number of smaller capacity ones, 16, 10 and 5 MVA, have been used at local substations. Many of these small transformers have been and are planned to be replaced by transformers with standard capacity to meet increasing power demand. A larger capacity of 60 MVA is also used at heavy load centers.

An on-load tap changer is provided on each stepdown transformer and operated automatically to regulate the 33 kV bus voltage. There are many transformers in operation, whose tap changers have already been broken, and the transformers are operated without tap changing. Current transformers for line drop compensator are provided with many transformers as standard accessory, but this equipment has not yet been utilized till now.

Static capacitors to alleviate line voltage drop are installed at several substations only and the total capacity is not sufficient. Deficiency in reactive power supply has been supplemented by the condenser operation of idle gas turbine generators in Colombo.

Various old type equipment have already been deteriorated due to their use exceeding the normal service life and require replacement with new equipment.

(8) Load Dispatching System:

The system control center (SCC) of CEB manages the operation of hydro and thermal power stations, the 220/132 kV transmission system (at present includes 66 kV system) and the 33 kV subtransmission system in the whole country.

The first major system for power stations and 220/132 kV network are provided with dual computers for data processing, display and remote indicating functions. However, Remote Terminal Units (RTU) are installed only at 20 selected major power stations and substations and information on operating conditions from other stations are collected over telephone. The computers have already been fully loaded and addition of functions and stations is not possible. For human interface, VDUs and a mimic diagram board are provided. All 20 RTUs are connected with SCC through the PLC communication network with the 200 bps rate.

The second system for the 33 kV network has a mimic diagram board to indicate system switching status only by manual operation is provided. Switching information from 33 kV stations is collected over PLC, VHF, telephone or other communication means.

Though the system facilities were commissioned in 1984, the equipment design was prepared around 15 years ago. Technologies of this kind of computer-based equipment are progressing rapidly and equipment models are revised in a short time. Therefore, the system has already become old fashioned and has not important functions such as remote control, automatic data logging, off-line power system calculations, etc. Non availability of spare parts for obsolete equipment is an additional problem.

CEB decided to renew the facilities and a tender for purchasing a new system equipment with the full SCADA functions has already been called. However, its contract has not yet been concluded.

(9) Communication System:

The present trunk communication system for power system operation consists of the Power Line Carrier (PLC) system for telephone, telex, teleprotection, data transmission, etc. The VHF radio system is employed as backup of the PLC telephone and for system maintenance.

A new digital micro-wave system has been constructed and is now ready for commissioning test. This system will connect the CEB head office in Colombo, the generation complex offices, major power stations and most of province and area offices in the power supply areas for administrative communication. At the present stage, CEB have no idea to utilize this micro-wave system for transmission line protection and data transmission for power system control.

There are a lot of technical problems on the existing communication system with the main system with PLC in catering for future power system requirements, such as problems in current application of PLC system to T-branched substations, shortage in spare parts, limitation in availability of communication channels, inability to apply recent digital technologies, inability to meet enhanced system control requirements, etc.

Establishment of recent high speed communication system such as digital microwave and optical communication is essential to apply up-to-dated technologies for transmission line protection and system control.

(10) Distribution System:

The standard secondary system voltage of transformers at grid substations is 33 kV, and the main MV distribution voltage is 33 kV. In the CEB distribution system, switching gantries are arranged near large load centers and at important points of the system for connection of a number of feeders. In rural areas including towns, the 33 kV voltage is directly stepped down to LV distribution voltage. While in major cities like Colombo, etc. an intermediate voltage of 11 kV is used as the MV distribution voltage, and in the seacoast areas distribution voltage of 11 kV is employed to avoid salt contamination problems.

Long distance power transfer is possible as the distribution voltage is high, 33 kV. Though the normal maximum line length is 40 km, line lengths are extremely long exceeding 100 km in certain rural areas and this causes very large voltage variation as proper countermeasures for voltage regulation are not taken.

Large drop of distribution voltage in remote areas is a serious problem for the CEB system. To minimize variation of consumer supply voltage, various measures such as raising the setting voltage of transformer on-load tap changer at grid substation high, using line drop compensators to regulate sending end voltage automatically, installing step voltage regulators at mid-points of lines to compensate voltage drop in long MV lines, installing static capacitors at line ends by CEB and by large consumers, and regulating voltage at switching gantries are conceived. CEB is required to carry out systematic studies to find out most efficient and economical methods among these measures.

(11) Operation and Maintenance:

With efforts of CEB maintenance gangs, the Sri Lankan power system as a whole is relatively well maintained. Though the power system is managed by SCC, for more stability of supply voltage and improvement of supply reliability effective utilization of the existing facilities and proper maintenance operations are essential.

The power system of the Colombo area is relatively well maintained with relatively small variation of consumer supply voltage and short annual supply interruption hours. However, the supply situation of local areas is not so good.

According to operation records of CEB, among the existing transmission lines and substations there are certain facilities with extremely high fault rates. On transmission lines, some lines cause frequent faults by lightning strokes and trees touching conductors. Decrepit substation equipment create a lot of problems and T-branched substations cause problems due to lack of proper relaying protection. There is a tendency that faults concentrate on certain transmission lines and substations.

Maintenance teams are relatively well organized. However, the maintenance works are being performed mainly based on past experiences without well-established maintenance procedures or manuals.

Some noted problems of the CEB's maintenance operations are lack of proper procedures for keeping necessary instruction manuals, drawings and data, lack of technologies for recent equipment such as SF6 gas circuit breaker, GIS, digital relays and so on, insufficiency in number of well qualified staff for maintenance operation and so on.

(12) Tariff System:

Similar to other developing countries, the current tariffs are not adequate to generate fund for necessary development to meet growing power demand. The tariff of each category is determined based on pricing policies of the government by distributing expected total expenditures of power utilities and fare return and is not based on real cost of supply.

The cross subsidy system is applied; the domestic category is subsidized by the industrial and commercial categories, and small consumers are subsidized by large consumers. The tariff to the smallest domestic consumption is extremely low, being 21% of that of the large domestic consumption, and this makes rural electrification difficult.

The time-of-day different tariffs are applied only to industrial consumers, but there is no seasonal tariff system.

4. Power Demand Forecast and Long-Term Generation Expansion Plan of CEB

(1) Power Demand Forecast:

In transmission system planning, load of each substation, including those existing and planned by the time, shall be forecast to identify locations and amount of loads. For this purpose, the nation-wide forecast demand of CEB was at first divided to 40 CEB areas then to substations with the help of power supply matrices for allocating demand.

The average growth rate of GDP for the period of 1982 to 1994 was 4.08%, while the energy sales increased at a rate of 6.44% in the same period, which corresponds to an elasticity of 1.58. According to the official statistics and economic development plan, the GDP growth rate was assumed to be 6.0% for 1994 and 1995, 6.5% for 1996 and 7.0% for 1997 and thereafter during the plan period. The demand forecast for the transmission system planning of this Study was based on the CEB's 1994 long-term demand forecast, 1994 - 2014, as summarized below:

Energy and Maximum Demand Forecast (Base Case)

	Required Energy (GWh)			Maximum Demand (MW)		
	Base	High	Low	Base	High	Low
1994	4,364	4,364	4,364	910	910	910
1999	6,805	7,119	6,501	1,365	1,428	1,304
2004	10,194	11,162	9,300	2,010	2,201	1,834
2009	15,684	17,977	13,665	3,087	3,538	2,690
2014	24,132	28,952	20,079	4,757	5,698	4,268

The energy sales is estimated to grow at a rate of 10% annum in the initial years taking into account integration of the northern load and 9% per annum after 2000. This corresponds to nearly 9% growth in terms of generated energy throughout the plan period.

(2) Generation Expansion Plan:

A long-term generation expansion plan of the CEB system is prepared using the WASP III computer program. The most recent preparation is that of 1996, which is based on the above demand forecast. This Study was carried out based on this generation plan

Sri Lanka experienced severe power shortage in 1996 due to shortage in rainfall, as CEB's power generation system is of hydro-dominant. The total capacity of the present generating facilities will not be sufficient to meet the demand of the country in 1997 and thereafter. To meet short-term requirement for increasing generating capability, CEB has a plan to install diesel engine, gas turbine and combined cycle generators with relatively short delivery and construction periods in the Colombo area. The plan by the year 2000 includes 131 MW diesel engine generators at Sapugaskanda, a 115 MW gas turbine generator at Kelanitissa and two 150 MW combined cycle plants, one each at Kelanitissa and Muthuragawella.

In Sri Lanka hydropower projects have been exploited with priority, and the remaining economically promising sites are estimated to be about 400 MW in total. The coal thermal plant is expected to provide the cheapest means of thermal energy when operated at base load and its construction is planned extensively. At present, three coal thermal sites, Puttalam to the northwest (900 MW), Trincomalee to the northeast (1,200 MW) and Mawella to the south (600 MW), and Boossa combined cycle site (600 MW) have been identified. The Trincomalee site is believed to be most appropriate due to availability of deep sea port. However, due to security constraints of this site the Puttalam site has been selected as the first development.

As the CEB power system has a load curve of typical evening peak with peak time of only about three hours, construction of considerable amount of combined cycle and gas turbine plants and future increase in peaking capability of hydro plants must also be planned for peak power supply.

(3) Transmission System Extension Plans:

At present, the 1995 - 97 Transmission System Extension Plan is in progress, and some of them have already been completed by the middle of 1996. For the period succeeding to this plan, financial arrangement has been made for a group of projects. The both projects for completion in 1996 and after are listed in Table 1.

The transmission system development plan of this Study was prepared on the assumption that these project will be completed as scheduled.

5. Transmission System Planning

(1) Planning Criteria:

The power *supply activities shall be executed to attain three criteria of* quantity *to meet demand,* quality represented by supply voltage and frequency, and security expressed by duration of supply interruption in certain period. Among these criteria, the transmission system planning relates to transmission capacity, maintenance of supply voltage and reliability of power supply.

The planning criteria of transmission system in the Study are summarized below:

1. There shall basically be no serious supply problems including loss of load in the system under single contingency fault (loss of one power system facility, either one section of line circuit or one unit of transformer).
2. The voltage variation in transmission system shall be within + 5% to - 5% under normal operation and + 5% to - 10% under single contingencies.
3. The system shall be dynamically stable against 3-phase fault followed by reclosing and its failure at the severest point of the system, i.e. the power source end of a heavily loaded transmission line.

(2) General Work Flow:

An overall transmission plan is prepared so as to connect conceived power stations and substations at load points with transmission lines, thus enabling delivery of increasing forecast power from generation points to demand centers and at the same time current problems of the system must be solved.

Prior to setting to the transmission system planning, locations and outputs of power stations and *locations and amounts of load of grid substations must be clearly defined, and current problems of* the system shall be clarified.

The transmission system planning of this Study was carried out as mentioned below and the *overall work flow is presented in Fig. 4.*

(3) Preparation of Preliminary Transmission System Plans:

A preliminary transmission system plan for 2000 was prepared taking into account various conditions such as the followings:

1. Existing transmission system configuration and its problems related to system operating conditions and reliability. All current problems must be tried to be solved.
2. Power demand forecast for the 2000 and selection of new substations.
3. Generation expansion plans up to 2000.
4. Expected power flow and transfer capacity of lines, transformers, etc.

5. Criteria for system voltage and supply reliability.

The preliminary plans for 2005, 2010 and 2015 were to be prepared based on the selected transmission plan for the previous period. The 2005 system must be planned based on the selected system for 2000 so as to increase supply capability and at the same time rectify the problems of the associated problems for power system voltage and reliability.

In deciding locations of new substations, the JICA team did not have enough knowledge of detailed site situations, while CEB had their own plans especially by the Distribution Development Branch and provincial distribution engineers. Therefore, discussions were made for site selection with concerned staff of CEB.

(4) Least Cost Selection:

The overhead transmission line with ACSR conductors is acknowledged as the least cost mean for large power transmission over a long distance. The size of conductors were determined based on annual cost comparison covering construction, O&M and loss evaluation.

(5) Power System Analysis and Reliability Assessment:

The power flow analysis was at first conducted on the preliminary plan of transmission system to examine system behaviors under normal operation using the PSS/E program of PTI owned by CEB. It is noted that actual calculation was conducted by CEB engineers according to basic data prepared by the JICA team.

After normal supply criteria are satisfied by the power flow analysis, reliability of power supply was examined with the TPLAN program of the PSS/E group applying the "N-1" criteria (conditions of single contingencies which take into account one facility fault at various locations). Serious voltage problems, supply interruptions or excessive equipment loading shall not take place under normal operation and single contingency fault.

The preliminary plans have been modified until all the required criteria are satisfied. Thus the transmission system plans were determined.

After that the 3-phase fault current of the selected system was calculated to check adequacy of circuit breaker breaking capacity, and the dynamic stability of the system was examined for the severest fault of the system, 3-phase fault at the power source end of a heavily loaded line and followed by reclosing and its failure. The PSS/E program was used for the both analyses.

(6) Selected plans:

The transmission system development plans selected by the above procedures are presented as Figs. 5, 6, 7 and 8 for the years 2000, 2005, 2010 and 2015 respectively. The corresponding project lists are presented in Tables 2, 3, 4 and 5.

6. Economic and Financial Evaluation

(1) Implementation Schedule and Necessary Fund:

The name and required time of implementation of each planned subproject are shown in the project lists mentioned above. The stream of necessary fund is allocated to each year for the period of 1996 to 2015 as shown in Table 8 and summary of each 5 year fund requirements for the planned transmission system is shown below:

Summary of Project Costs

(Unit: Million US$)

Period	FC Portion	LC Portion	Total
1995 - 2000	105.9	27.4	133.3
2001 - 2005	186.8	50.9	237.7
2006 - 2010	369.0	96.5	465.5
2011 - 2015	279.8	67.2	347.0
Total	941.5	242.0	1,183.6

Thus the total required fund amounts to about 1,184 Million US Dollars equivalent at the end-1995 price level.

(2) Economic and Financial Evaluation:

The expected overall cost stream of CEB's development programs from 1996 to 2015 covering not only the transmission system but also generation expansion and distribution system is presented in Table 9.

EIRR (economic internal rate of return) of the overall development program of CEB including generation and distribution up to 2015 based on benefit calculated from the willingness to pay was 26.3%.

The transmission cost based on long-run marginal cost was calculated to be 1.4 cent/kWh and the overall cost including generation and distribution to be 10.4 cent/kWh. It is anticipated that considerable tariff increase is required.

7. Energy Conservation and Loss Reduction Plan

(1) Energy Conservation Activities:

Sri Lanka is a fossil fuel importing country. Therefore, country-wide energy saving is important to curtail expenditure for fuel import. CEB has the Demand Side Management Branch to promote the demand side management (DSM) movement within CEB and to consumers. Activities of this branch include promotion of energy efficient fixtures like compact fluorescent lamps in stead of incandescent lamps, consumer education and assistance to energy audit, fund arrangement for capacitor installation by consumers, promotion of self generation by users, etc. The reduction of transmission and distribution (T&D) loss is also very important to energy conservation.

(2) Actual Situation of T&D Loss:

In the Sri Lankan power system which include CEB, LECO and local authorities, the overall loss in the transmission and distribution systems in 1995 was about 20% of the generated energy. This loss value is fairly high compared with that of Japan, 5.5%, and other developed countries. The loss rate can be decreased by taking improvement measures which require considerable investment and the Sri Lanka's figure is not unreasonably high compared with countries with similar economic situation.

Meter accuracy is not well managed in the CEB system, and actual allocation of loss to the transmission, MV distribution and LV distribution systems is not clear. The actual loss in the transmission and MV distribution systems can be estimated by computer calculation and would be not more than 7.5% in total, and the loss in the LV system including non-technical loss is estimated to exceed 12%. The sum of non-technical loss, illegal use, and metering and tariff collecting loss is estimated to amount to at least 6%.

(3) Loss Reduction Measures:

The loss in the transmission and MV distribution systems of CEB can be reduced only by using larger conductors and power factor improvement. However, these loss reduction measures will cost high to obtain relatively small output. In deciding conductor size, not only transfer capacity and construction cost but also loss evaluation shall be taken into account in planning.

Remarkable loss reduction can be achieved only by improvement of the LV distribution system and measures to reduce non-technical loss. To reduce technical LV system loss, the most appropriate measure will be to shorten the LV line length by increasing the number of distribution transformers. The use of insulated conductor results in selection of larger size conductors and reduce the ohmic loss. This measure is effective to reduction of pilferage and to avoid accident due to trees touching to conductors. There are several measures to reduce non-technical loss; improvement of consumer service facilities to prevent trials for pilferage, public campaign to avoid illegal use, promotion of moral sense including CEB technicians, introduction of severe penalty to illegal use, proper management of consumer service meters, etc.

(4) Actions to be Taken:

A thorough studies to seek for effective measures for loss reduction shall be carried out including identification of causes of loss and cost - benefit analysis of various loss reduction measures.

For any loss reduction measures, certain investment is required. From the results of loss reduction studies, cost effective measures shall be identified; to obtain large benefit from small investment. Usually, reduction of illegal use including improvement of consumer service facilities is recognized as the most cost effective measure and a normal loss reduction studies concentrate efforts on this point. The selected measures shall be realized one by one based on economic priority.

8. Environmental Protection Plan

(1) Environmental Problems of Transmission System:

It is a world-wide tendency to pay more attention to environmental protection. It is observed that concerns on environmental protection are becoming serious also in Sri Lanka.

(2) Institutional Arrangement:

In Sri Lanka, an environmental impact assessment (EIA) studies is required for overhead transmission lines of more than 10 km in length or over 50 kV in voltage. Therefore, a EIA report must be prepared for the projects under study for review by the Project Approving Agencies.

(3) Environmental Studies for Transmission System:

In Japan the seven items of air pollution, water pollution, soil contamination, noise, vibration, land subsidence and bad smell are regarded as environmental pollution items. In addition, any influence to national park, natural scenery, historical and cultural assets, public lives, and fauna and flora must be investigated.

However, there are also problems peculiar to transmission lines such as the route selection, tower site finishing, electromagnetic induction on communication line, electrostatic induction, radio interference, etc. and to substations such as rise of ground voltage, oil fire and contamination, etc.

In the EIA studies, environmental situation before construction, during construction and after completion shall be clearly evaluated.

9. Future Funding Plan

(1) Utilization of Own Fund:

For a power supply utility it is normal practice to arrange development fund out of its income from power sales and CEB shall utilize its own fund as far as possible. However, the CEB's own fund will not be sufficient to cater for all the planned projects.

(2) Bilateral and International Assistance Fund:

Preferential low interest rates of certain international institutions, either from bilateral sources or international organizations, are very beneficial to the government of Sri Lanka and CEB.

(3) Supplier's Credit:

In case that lending as mentioned above is not available, there may be an idea to call tender based on supplier's financing, supplier's credit.

10. Supporting Program for Urgent Plan

(1) Identification of Projects for Urgent Implementation:

At present the 1995 - 97 Transmission System Extension Plan is in progress and financial sources for the next plans for completion in 1998 and 99 have already been arranged. In addition 14 transmission system development projects which are identified to be required by 2001 in the Study and according to CEB's request are taken up as urgent projects, list of which is included in Table 6 and their cost estimates in Table 7.

The estimated total cost of the above 14 projects is US$ 93,246,000 in foreign currency and US$ 23,557,000 equivalent in local currency at the end-1995 price level as seen in Table 7..

(2) Necessity of Prior Studies:

In the past, transmission system development projects have been executed without prior studies including selection of line routes and compensation for substation sites, site investigation and identification of locations where land problems are expected. Various troubles have been discovered after commencing site activities and caused delay in construction.

It is recommended to perform such kind of studies especially related to the land problems are carried out during the preparatory study stage so that the projects can be executed with less troubles during construction.

(3) Preparatory Studies for the Selected Projects:

Under such situation, it is recommended to carry out a study covering the basic design which includes survey of the existing facilities, selection of line routes and substation sites, assistance in investigation of substation sites, and basic design of transmission line and substation facilities, and EIA studies for transmission system facilities, before application of project loan.

TABLES

Table 1 List of Ongoing Transmission System Development Project

Augmentation and Extension of Transmission System	Re-marks	Fund Source	Project Name	Commiss. Year
(1) Construction of Chilaw Substation				
a) T-connection line for Chilaw (2cct, 6.8km, Lynx)		IDA	PDTP	Completed
b) Chilaw (2x31.5MVA)		IDA	PDTP	Completed
(2) Construction of Badulla - Laxapana 132kV Transmission Line	a			
a) Laxapana - Badulla 132kV line (2cct, 74.2km, Lynx)		OECF	TSADP	Jul. 96
b) Badulla (two T/L bays for Laxapana line)		OECF	TSADP	Jul. 96
c) Badulla (1x31.5MVA addition)		OECF	TSADP	Jul. 96
(3) Construction of Nuwara Eliya Substation				
a) Nuwala Eliya (2x31.5MVA)		OECF	TSADP	Jun. 96
b) T-connection line for Nuwala Eliya (2cct, _km, Lynx)		OECF	TSADP	Jun. 96
(4) Construction of Avissawella Substation				
a) Avissawella (2x31.5MVA)		OECF	TSADP	Dec.96
b) T-connection line for Avissawela (2cct, 0.5km, Lynx)		OECF	TSADP	Dec.96
(5) 2nd Pi-connection for Kiribatkumbura Substation				
a) 2nd pi-connection line for Kiribatkumbra (2cct, 3.9km, Lynx)		CEB		Completed
b) Kiribatkumbra (two T/L bays for pi-connection arrangement)		Korean		1999
(6) Construction of Matara Substation				
a) Matara (2x31.5MVA)		OECF	TGDP	Nov.97
b) Embilipitiya - Matara 132kV line (2cct, 52km, Lynx)		OECF	TGDP	Nov.97
c) Embilipitiya (two T/L bays for Matara line)		OECF	TGDP	Nov.97
(7) 2nd Pi-connection for Ukuwela Substation				
a) 2nd pi-connection for Ukuwela (2cct, 11km, Lynx)		OECF	TGDP	Nov.97
b) Ukuwela (two T/L bays for pi-connection arrangement)		OECF	TGDP	Nov.97
(8) Constuction of 132kV Puttalam - Anuradhapura Line				
a) Puttalam - Anuradhapura (2cct, 75km, Lynx)		OECF	TGDP	Nov.97
b) Puttalam (two T/L bays for Anuradhapura line))		OECF	TGDP	Nov.97
c) Anuradhapura (two T/L bays for Puttalam line)	b	OECF	TGDP	Nov.97
(9) Reconductoring of 132kV Kotugoda - Bolawatta Line and Double Pi-Connection Arrangement for Bolawatta				
a) Kotugoda - Bolawatta 132kV line (2cct, 22km, Coyote to Zebra)		OECF	TGDP	Nov.97
b) Bolawatta (two T/L bays for pi-connection arrangement)	c	OECF	TGDP	Nov.97
(10) 2nd Pi-connection of Kotmale Power station				
a) T-off of Kotamale (2cct, 6.8km, Lynx)		IDA	SPDTP	Completed
b) Kotmale (two T/L bays for pi-connection arrangement)		IDA	SPDTP	Dec.96

Table 1 List of Ongoing Transmission System Development Project

Augmentation and Extension of Transmission System	Re-marks	Fund Source	Project Name	Commiss. Year
(11) 2nd Circuit of Rantembe - Badulla Line				
a) Rantembe - Badulla 132kV 2nd cct line (1cct(2cct const.), 33km, Lynx)		IDA	SPDTP	Jan.98
b) Rantembe (a T/L bay for Badulla line)		IDA	SPDTP	Dec.96
c) Badulla (a T/L bay for Rantembe line)		IDA	SPDTP	Dec.96
(12) Construction of Veyangoda Substation				
a) Veyangoda (2x31.5MVA)		ADB	SPSEP	Dec.98
b) Kotugoda - Veyangoda 132kV line (220kV design, 2cct, 20km, 2xZebra)	d	ADB	SPSEP	Dec.98
c) Kotugoda (two T/L bays for Veyangoda line)		ADB	SPSEP	Dec.98
(13) Reconductoring of 132kV Sapgaskanda - Biyagama Line				
a) Sapgaskanda - Biyagama 132kV line (2cct, 2.1km, Lynx to Zebra)		ADB	SPSEP	Dec.96
(14) Construction of 220kV New Anuradhapura Substation				
a) Kotmale - New Anuradhapura 220kV line (2cct,163km, Zebra)		IDA	SPDTP	Jan.99
b) New Anuradhapura (2x150MVA transformers)		NORAD	SPDTP	Jan.99
c) Kotmale (two T/L bays for New Anuradhapura line)		NORAD	SPDTP	Jan.99
d) Double pi-connection of Anuradhapura - Trinkomalee line	e	CEB	SPDTP	Jan.99
(15) Upgrading of 132kV Switchgear to 220kV of Kelanitissa Power Station				
a) Biyagama - Kelanitissa 220kV line (2cct, 2xGoat, 12.5km)	f	IDA	K-B220	Jun.98
b) Kelanitissa (GIS with 2x150MVA trans.)	g	IDA	K-B220	Jun.98
c) Biyagama (two 220kV T/L bays for Kelanitissa line)		IDA	K-B220	Jun.98
(16) Construction of Ampara Substation				
a) Inginiyagala - Ampara 132kV line (1cct, 25km, Lynx)	i	NORAD	SPDTP	Jan.98
b) Ampara (2x31.5MVA)		NORAD	SPDTP	Jan.98
c) Inginiyagala (a T/L bay for Ampara line)		NORAD	SPDTP	Jan.98
(17) Upgrading of 132kV Kolonnawa - Sapgaskanda - Kotugoda Line				
a) Kolonnawa - Kotugoda 132kV line (2cct, 28km, Coyote to Zebra)		ADB	SPSEP	Dec.98
b) Junction - Sapgaskanda line (2cct, 4.6km, Lynx to Zebra,)		ADB	SPSEP	Dec.98
(18) Construction of Sithawaka Substation				
a) Sithawaka (2x31.5MVA)		OECF		Mar.98
b) Single pi-connection for Sithawaka (deadend towers)		OECF		Mar.98
(19) Addition of Transformers				
19-1) Panipitiya (1x31.5MVA,Total 91.5MVA)		IDA	PDTP	Completed
19-2) Ratmalana (1x31.5MVA, Total 91.5MVA)		IDA	PDTP	Completed
19-3) ODSS Kolonnawa (2x31.5MVA, Total 123MVA)		OECF	TSADP	Sep.96
19-4) Sapgaskanda (1x31.5MVA, Total 121.5MVA)		ADB	SPSEP	Dec.98
19-5) Kiribatkumbura (1x31.5MVA, Total 3x31.5MVA)		ADB	SPSEP	Dec.98
19-6) Matugama (1x31.5MVA, Total 3x31.5MVA)		ADB	SPSEP	Dec.98
19-7) Bolawatta (1x31.5MVA, Total 3x31.5MVA)		ADB	SPSEP	Dec.98

Table 1 List of Ongoing Transmission System Development Project

Augmentation and Extension of Transmission System	Re-marks	Fund Source	Project Name	Commiss. Year
19-8) Fort (1x30MVA, Total 3x30MVA)		CEB		
19-9) Kollipitiya (1x30MVA, Total 3x30MVA)		KfW		Dec.97
19-10) Thulhiliya (1x31.5MVA, Total 3x31.5MVA)		KfW		Dec.97
(20) Replacement of Transformers				
20-1) Puttalam (2x10MVA to 2x31.5MVA)		OECF	TSADP	Completed
20-2) Anuradhapura (2x10MVA to 2x31.5MVA)		CEB		Dec.96
20-3) Habarana (2x10MVA to 2x31.5MVA)		Korean	PSDP	Dec.98
20-4) Balangoda (2x10MVA to 2x31.5MVA)		Korean	PSDP	1999
20-5) Trincomalee (2x10MVA to 2x31.5MVA)		Korean	PSDP	1999
20-6) Embilipitiya (2x10MVA to 2x31.5MVA)		ADB	SPSEP	Dec.98
20-7) Kurunegara (2x16MVA to 2x31.5MVA)		ADB	SPSEP	Dec.98
20-8) Valaichchenai (2x10MVA to 2x31.5MVA)		ADB	SPSEP	Dec.98
(21) Var Compensator				
21-1) Kotugoda (20MVA)		NORAD	Norad	Dec.98
(22) Static Capacitor				
22-1) Kiribatkumbura (10MVA)		ADB	SPSEP	Dec.98
22-2) Kurunegala (10MVA)		ADB	SPSEP	Dec.98
22-3) Habarana (10MVA)		ADB	SPSEP	Dec.98
22-4) Kelanitissa(45MVA)	h	ADB	SPSEP	Dec.98

Remarks:

1) Project Name
   TSADP : Transmission System Augmentation and Development Project (OECF)
   TGDP : Transmission and Grid Substation Development Project (OECF)
   PDTP : Power Distribution and Transmission Project (IDA)
   SPDTP : Second Power Distribution and Transmission Project (IDA)
   SPSEP : (ADB)
   K-B220 : (IDA)

2) (a) Two T/L bays of Laxapana power station for Badulla line had been constructed under other project prior to the TSADP.
   (b) For Puttalam-Anuradhapura line, the existing Chunnakam line bays were scheduled to be used. However,two new T/L bays for the line are decided to be additionally constructed under the TGSDP.
   (c) A new line is planned to be constructed along the existing 132 kV line and the existing one is moved after the completion.
   (d) Kotugoda-Veyangoda line is proposed to be 220kV design, 2-cct with 2xZebra for future reinforcement and extension of the system, instead of original 132kV line with Lynx.
   (e) New Anuradhapura-Anuradhapura line is proposed to be newly constructed instead of originally planned double pi-connection of the existing Anuradhapura-Trincomalee line for transmitting bulk power to the 132kV system.
   (f) The existing towers are designed as 220kV ones, but number of discs of suspension insulators only will be increased.
   (g) Two T/L bays for extension 220kV system to Kolonnawa shall be provided for future easy arrangement.
   (h) Static capacitor of 60MVA is needed instead of presently planned 45MVA under ADB finance.
   (i) Site of Ampara GSS should be slightly shifed towards Kalmunai.

Table 2 Proposed New Subprojects for Transmission System up to The Year 2000

Subprojects for Augmentation and Extension	Re-marks	Proposed Commiss. Year
(1) Upgrading of 132kV Biyagama - Pannipitiya Line to 220kV		
a) Upgrading of Biyagama - Panipitiya 132kV line to 220kV (2cct, 15.5km, 2xZebra)	a	2000
b) Biyagama (two 220kV T/L bays for Pannipitiya line)		
c) Pannipitiya (2x250MVA, two 220kV T/L bays for Biyagama line)		
(2) Reconductoring of Kolonnawa - Pannipitiya 132kV Line		2000
a) Kolonnawa - Panipitiya 132kV line (2cct, 13km, Lynx to Zebra)		
(3) Construction of Sapugaskanda GSS - KHD 132kV Line		1998
a) Sapugaskanda GSS - KHD 132kV line (2cct, 1.0km, Lynx)		
b) Sapugaskanda GSS (two 132kV T/L bays for KHD line)		
(4) Upgrading of Sapugaskanda P/S - Sapugaskanda GSS 132kV Line		1998
a) Removal of the existing 132kV line (1cct, 1.5km, Lynx)		
b) Construction of 132kV line (2cct, 1.5km, Zebra)		
c) Sapugaskanda P/S (one 132kV T/L bay for Sapugaskanda GSS line)		
d) Sapugaskanda GSS (one 132kV T/L bay for Sapugaskanda P/S line)		
(5) Construction of Ratnapura 132 kV Substation	g	1998
a) Ratnapura (2x31.5MVA)		
b) Balangoda - Ratnapura 132kV line (2cct, 40km, Zebra)		
c) Balangoda (two 132kV T/L bays for Ratnapura line)		
(6) Construction of Aniyakanda 132 kV Substation		1998
a) Aniyakanda (2x31.5MVA)		
b) Double pi-connection for Aniyakanda (2x2cct, 0.2km, Zebra)		
(7) Construction of Athurugiriya 132 kV Substation		1998
a) Athurugiriya (2x31.5MVA)		
b) Triple pi-connection for Athurugiriya (3x2cct, 0.1km, Lynx)		
(8) Construction of Sri Jaya'pura 132 kV Substation		1998
a) Sri Jaya'pura (2x31.5MVA)		
b) Double pi-connection for Sri Jaya'pura (2x2cct, 0.1km, Zebra)		
(9) Construction of New Galle 132 kV Substation	b	2000
a) New Galle (2x31.5MVA)	c	
b) Double pi-connection of New Galle (2x2cct, 0.1km, Lynx)		
(10) Construction of Matugama - New Galle 132kV Line	b	2000
a) Matugama - New Galle 132kV line (2cct, 64km, Zebra)		
b) Matugama (two 132kV T/L bays for New Galle line)		
c) New Galle (two 132kV T/L bays for Matugama line)		
(11) Construction of Kelaniya 132kV GIS	d	2000
a) Kelaniya (2x63MVA)		
b) Triple pi-connection for Kelaniya (3x2cct, 0.1km, Zebra)		
(12) Construction of 132kV Dehiwala Substation		2000
a) Pannipitiya - Dehiwala 132kV line (220kV construction,2cct, 8km, 2xZebra)		
b) Dehiwala (132/33kV:2x63MVA)	e	
c) Pannipitiya (two 132kV T/L bays for Dehiwala line)		

Table 2 Proposed New Subprojects for Transmission System up to The Year 2000

Subprojects for Augmentation and Extension	Re-marks	Proposed Commiss. Year
(13) Power Transmission Facilities Related to Muthuragawella Combined Cycle Power Plants		
13-1) Construction of Muthuragawella - Kotugoda 220kV Line		2000
a) Muthuragawella - Kotugoda 220kV line (2cct, 18.0km, 2xZebra)		
b) Kotugoda (two 220kV T/L bays for Muthuragawella line)		
13-2) Rearrangement of Kotugoda 220kV Switchgear	f	2000
(14) Rehabilitation of Kolonnawa Substation		1998
a) Replacement of transformers (3x30MVA to 1x31.5MVA)		
b) Renovation of 132kV switchgears (except for CB)		
c) Renovation of 33kV switchgears		
d) Renovation of control and relay panels for 132kV and 33kV systems		
e) Removal of 66kV and 11kV equipment		
(15) Construction of Valaichchenai - Ampara 132kV Line		1998
a) Valaichchenai - Ampara 132kV line (1cct, 75km, Lynx)		
b) Valaichchenai (one 132kV T/L bay for Ampara line)		
c) Ampara (one 132kV T/L bay for Valaichchenai line)		
(16) Replacement of Transformers		
16-1) Ukuwela (2x15MVA to 2x31.5MVA)		1998
New Subprojects Proposed by Power System Analysis		
(17) Static Capacitor		
17-1) Pannipitiya (100MVA)		2000
17-2) Kelanittissa (total 60MVA)		1998
(18) Replacement of 132kV Circuit Breakers		
18-1) Kolonnawa (20kA to 40kA, 2 sets)		1998
18-2) Sapgaskanda GSS (15.3kA and 11kA to 40kA, 6 sets)		1998

Remarks:

(a) The existing 132kV line has been designed for 220kV.

(b) The existing Galle GSS has no space for the further extension of the 132kV switchyard (but addition of transformers is possible).

(c) Two units of gas turbine of 35MW is planned to be constructed in future for supplying peak power in Southern Area.

(d) The site is proposed to be near the junction point of Kolonnawa - Kotugoda - Sapgaskanda lines in order to dissolve the existing T-connection.

(e) In future 132kV system extension from this substation is needed to supply bulk power to Colombo city area. Therefore, convensional type of substation is preferable for easy arrangement in future.

(f) Kotugoda - Veyangoda 132kV line is planned to be upgraded to 220kV in future.

(g) Bus arrangement is proposed to be reconsidered after detail tophographic survey.

Table 3 Proposed New Subprojects for Transmission System up to The Year 2005

Augmentation and Extension of T/L and GSS	Re-marks	Proposed Commiss. Year
(1) Power Transmission Facilities Related to Puttalam Coal-Fired Thermal Plant		
(1-1) Upgrading Kotugoda - Veyangoda Line & Veyangoda Substation to 220 kV	a	2002
a) Upgrading of Veyangoda substation to 220kV (2 x 150MVA (220/132kV))		
b) Kotugoda (two 220kV T/L bays for Veyangoda line)		
(1-2) Construction of Puttalam P/S - Veyangoda 220 kV Line		2002
a) Puttalam P/S - New Chilaw 220kV line (2cct, 43km, 3 x Zebra)		
b) New Chilaw - Veyangoda 220kV line (2cct, 42km, 3 x Zebra)		
c) Veyangoda (two T/L bays for Puttalam line)		
(1-3) Construction of Puttalam P/S 220/132 kV Substation		2002
a) Puttalam P/S (2 x 150MVA (220/132kV))		
(1-4) Construction of Puttalam P/S - Puttalam 132 kV Line		2002
a) Puttalam P/S - Puttalam 132kV line (2cct, 22km, 2 x Zebra)		
b) Puttalam (two T/L bays for Puttalam P/S line)		
(2) Construction of New Chilaw 220/132 kV Substation		2002
a) New Chilaw (2 x 150MVA (220/132))		
b) Connection of Puttalam - Veyangoda 220kV line (2x2cct, 0.1km, 3xZebra)		
c) Double pi-connection of Bolawatta - Puttalam 132kV line (2x2cct, 0.5km, Lynx)		
d) Connection of Chilaw 132kV line (2cct,0.5km, Lynx)		
e) Connection of Kuliyapitiya 132kV line (2cct, 0.5km, Zebra)		
(3) Construction of Kuliyapitiya 132 kV Substation		2001
a) Double T-connection for Kuliyapitiya (2cct, 18km, Zebra)		
b) Kuliyapitiya (2 x 31.5MVA)		
(4) Construction of Katana 132 kV Substation		2005
a) Katana (2 x 31.5MVA)		
b) Double pi-connection for Katana (2 x 2cct, 0.5km, Lynx)		
(5) Construction of Gonawala Substation		2004
a) Gonawala (2 x 31.5MVA)		
b) Double pi-connection for Gonawala (2 x 2cct, 0.2km, Zebra)		
(6) Construction of Veyangoda - Thulhiliya 132 kV Line		2003
a) Veyangoda - Thulhiliya 132kV line (2cct, 25km, Zebra)		
b) Veyangoda (two 132kV T/L bays for Thulhiliya line)		
c) Thulhiliya (two 132kV T/L bays for Veyangoda line)		
(7) Construction of Kegalle 132 kV Substation		2004
a) Thulhiliya - Kegalle 132kV line (2cct, 19km, Zebra)		
b) Kegalle (2 x 31.5MVA)		
c) Thulhiliya (two T/L bays for Kegalle Line)		
(8) Construction of Palekelle 132 kV Substation		2005
a) Ukuwela - Palekelle 132kV line (2cct, 17km, Zebra)		
b) Ukuwela (two T/L bays for Palekelle line)		
c) Palekelle (2 x 31.5MVA)		

Table 3 Proposed New Subprojects for Transmission System up to The Year 2005

Augmentation and Extension of T/L and GSS	Re-marks	Proposed Commiss. Year
(9) Construction of Polonnaruwa 132 kV Substation		2001
a) Polonnaruwa (2 x 16MVA)	b	
b) Single pi-connection for Polonnaruwa (2cct, 0.5km, Lynx)		
(10) Construction of Vavunia 132 kV Substation		2001
a) Vavunia (1 x 10MVA)	c	
b) Double pi-connection for Vavunia (2cct, 0.5km, Lynx)	d	
(11) Construction of Horana 132 kV Substation	e	2003
a) Horana (2 x 31.5MVA)		
b) Single pi-connection for Horana (2cct, 11.0km, Bear)		
(12) Power Transmission Facilities Related to Kukule Hydropower Plant	f	
(12-1) Construction of Kukule - Matugama 132 kV Line		2002
a) Kukule - Matugama 132kV line (2cct, 27km, Zebra)		
b) Matugama (two 132kV T/L bays for Kukule line)		
(12-1) Construction of Kukule - Ratnapura 132 kV Line		2002
a) Kukule - Ratnapura 132kV line (2cct, 25km, Zebra)		
b) Ratnapura (two 132kV T/L bays for Kukule line)		
(13) Double pi-connection for Panadura 132 kV Substation		2003
a) Panadura - Junction Point line (2cct, 5km, Lynx)		
b) Panadura (two 132kV bays for pi-connection)		
(14) Construction of Ambalangoda 132 kV Substation		2001
a) Ambalangoda (2 x 31.5MVA)		
b) Single pi-connection for Ambalangoda (2cct, 0.1km, Zebra)		
(15) Construction of Hambantota 132 kV Substation		2001
a) Embilipitiya - Hambantota 132kV line (1st cct of 2cct construction, 24km, Bear)	g	
b) Hambantota (2 x 10MVA)		
c) Embilipitiya (one 132kV T/L bays for Hambantota line)		
(16) Construction of New Galle - Matara 132 kV Line		2003
a) New Galle - Matara 132kV line (2cct, 34.0km, Bear)		
b) New Galle (two 132kV T/L bays for Matara line)		
c) Matara (two 132kV T/L bays for New Galle line)		
(17) Construction of Medagama 132 kV Substation		2002
a) Medagama (1 x 10MVA)	c,h	
b) Single pi-connection for Medagama (2cct, 0.5km, Oriole)		
(18) Construction of Paddiruppu 132 kV Substation		2003
a) Paddiruppu (1 x 10MVA)	c,h	
b) Single pi-connection for Paddiruppu (2cct, 5.0km, Lynx)		

Table 3 Proposed New Subprojects for Transmission System up to The Year 2005

Augmentation and Extension of T/L and GSS	Re-marks	Proposed Commiss. Year
(19) Construction of Town Hall 132 kV Substation (GIS)		
a) Kolonnawa - Town Hall 132kV underground cable line (1cct, 4.2km, Cu 800sq.mm, CV cable)		2005
b) Single pi-connection of Kolonnawa - Kollupitiya UGC (2x1cct, 0.2km, Cu 500sq.mm, OF cable)		
c) Kolonnawa (one 132kV T/L bay for Town Hall line)		
d) Town Hall (2 x 63MVA (Final : 3 x 63MVA))		
(20) Upgrading 132kV Kelanittissa - Kolonnawa Line to 220 kV		2003
a) Kelanittissa - Kolonnawa 220kV line (2cct, 2.2km, 2 x Goat)	i	
b) Construction of 220kV GIS at Kolonnawa (2 x 250MVA Transformers)		
c) Kelanittissa (two 220kV T/L bays for Kolonnawa line)	j	
(21) Addition of Transformers		
(21-1) Kilinochchi (132/33kV, 1 x 10MVA, total 2 x 10MVA)		2003
(21-2) Galle (132/33kV, 1 x 31.5MVA, total 91.5MVA)		2005
(21-3) New Galle (132/33kV, 1 x 31.5MVA, total 3 x 31.5MVA)		2005
(21-4) Sri Jaya'pura		
a) 132/33kV, 1x31.5MVA, total 3x31.5MVA)		2002
b) 132/33kV, 1x31.5MVA, total 4x31.5MVA)		2005
(21-5) Kolonnawa		
a) 132/33kV, 1x31.5MVA, total 4x31.5MVA)		2004
b) 132/33kV, 1x31.5MVA, total 5x31.5MVA)		2005
(21-6) Gonawala (132/33kV, 1x31.5MVA, total 3x31.5MVA)		2005
(21-7) Ratmalana (132/33kV, 1x31.5MVA, total 123MVA)		2005
(21-8) Pannipitiya (132/33kV, 1x31.5MVA, total 123MVA)		2005
(21-9) Muthurgawella (220/33kV, 2x63MVA, total 2x63MVA)	k	2002
(21-10) Bowatenna (132/33kV, 1x15MVA, total 1x15MVA)	k,l	2002
New Subprojects Proposed by Power System Analysis		
(22) Static Capacitor		
(22-1) Chunnakam (20MVA)		2004

Remarks :

(a) Kotugoda - Veyangoda line is planned to be designed as 220 kV construction.
(b) Transformers of 16MVA presently used in Kurunegara substation are available for Polonnaruwa.
(c) Transformers of 10MVA presently used are available.
(d) Double pi-connection is needed for reliable and stable operation of the 132kV system in northern area.
(e) In order to meet energy requirement such as planned water supply project, additional reinforcement like double pi-connection may be needed.
(f) Necessary 132kV switching equipment is proposed to be provided under the Kukule project.
(g) One circuit line is proposed to be initially constructed from the economical point of view.
(h) One unit only will be initially provided for cost saving, since no high demand is expected.
(i) Right of way and tower sites of the existing 132kV line is usable.
(j) Two 220kV T/L bays for upgrading Kolonnawa substation to 220 kV are proposed to be provided under the project for upgrading of Kelanittissa substation to 220kV.
(k) Transformers are newly installed for area supply.
(l) Transformers of 15MVA presently used in Ukuwela substation are available for Bowatenna.

Table 4 Proposed New Subprojects for Transmission System up to the Year 2010

Augmentation and Extension of GSS	Re-marks	Proposed Commiss. Year
(1) Power Transmission Facilities Related to Trincomalee Coal-Fired Thermal Plant		
(1-1) Construction of Trincomalee - Veyangoda 220kV Line		2007
a) Trincomalee P/S - Habarana 220kV line (2cct, 95km, 4xZebra)		
b) Habarana - Wariyapola 220kV line (2cct, 80km, 4xZebra)		
c) Wariyapola - Veyangoda 220kV line (2cct, 65km, 4xZebra)		
d) Veyangoda (two 220kV T/L bays for Wariyapola line)		
(1-2) Construction of 220kV Habarana Switching Substation	a	2007
a) Habarana 220kV Switching Station		
b) Double pi-connection of Kotmale - New Anuradhapura 220kV line (2x2cct, 0.5km, Zebra)		
(1-3) Construction of 220kV Wariyapola Switching Station	a	2007
a) Wariyapola 220kV Switching Station		
(1-4) Construction of 220kV Matale Substation		2009
a) Matale (2x150MVA (220/132kV))	b	
b) Double pi-connection of Kotmale - Habarana 220kV line (2x2cct, 0.5km, Zebra)		
c) Double pi-connection of Ukuwela - Habarana 132kV line (2x2cct, 2.0km, Lynx)		
(1-5) Construction of Trincomalee P/S Substation		2007
a) Trincomalee P/S (2x150MVA (220/132kV))		
b) Trincomalee P/S - Trincomalee 132kV line (2cct, 10km, 2xZebra)		
c) Trincomalee (two 132kV T/L bays for Trincomalee P/S line)		
(1-6) Construction of Victoria - Padukka 220kV Line	c	2009
a) Victoria - New Polipitiya 220kV line (2cct, 40km, 2xZebra)		
b) New Polipitiya - Padukka 220kV line (2cct, 60km, 2xZebra)		
c) Victoria power station (two T/L bays for Padukka line)		
(1-7) Construction of 220kV Padukka Switching Substation	a	2007
a) Padukka switching station		
(1-8) Construction of 220kV New Polpitiya Substation		2009
a) New Polpitiya (2x150MVA (220/132kV))		
b) Double pi-connection of Polpitiya - Avissawella 132kV line (2x2cct, 2.0km, Lynx&2xZebra)		
c) Reconductoring of Polpitiya - New Polpitiya section (2cct, 4.0km, 2xZebra)		
(1-9) Construction of Veyangoda - Padukka 220kV Line		2007
a) Veyangoda - Padukka line (2cct, 37km, 4xZebra)		
b) Veyangoda (two 220kV T/L bays for Padukka line)		
(1-10) Construction of Padukka - Pannipitiya 220kV Line		2007
a) Padukka - Pannipitiya line (2cct, 18km, 4xZebra)		
b) Pannipitiya (two T/L bays for 220kV Padukka line)		
(2) Construction of Pannala Substation		2010
a) Veyangoda - Pannala 132kV line (2cct, 20km, Zebra)		
b) Pannala (2 x 31.5MVA)		

Table 4 Proposed New Subprojects for Transmission System up to the Year 2010

Augmentation and Extension of GSS	Re-marks	Proposed Commiss. Year
(3) Construction of Eheliyagoda 132kV Substation		2010
a) Avissawella - Eheliyagoda 132kV line (2cct, 17km, Bear)		
b) Eheliyagoda - Ratnapura 132kV line (2cct, 25km, Bear)		
c) Eheliyagoda (2 x 31.5MVA)		
d) Avissawella (four 132kV T/L bays for Eheliyagoda line & double pi arrangement)		
e) Ratnapura (two 132kV T/L bays for Eheliyagoda line)		
f) Double pi-connection for Avisawella (2cct, 0.3km, Lynx)		
(4) Construction of Imbulgoda 132kV Substation		2008
a) Biyagama - Imbulgoda 132kV line (2cct, 12km, Zebra)		
b) Imbulgoda (3x31.5MVA)		
c) Biyagama (two 132kV T/L bays for Imbulgoda line)		
(5) Construction of Angoda 132kV Substation		2009
a) Angoda (3 x 31.5MVA)		
b) Double pi-connection for Angoda (2x2cct, 0.1km, Lynx)		
(6) Construction of Aguruwella 132kV Substation		2007
a) Aguruwella (2 x 31.5MVA)		
b) Connection of Polpitiya 132kV line (1x2cct, 0.2km, Lynx)		
c) Connection of Thulhiriya 132kV line (1x2cct, 0.2km, Lynx)		
d) Connection of Kolonnawa 132kV line (1x2cct, 0.2km, Lynx)		
(7) Construction of Kesbewa 132kV Substation		2006
a) Kesbewa (2 x 31.5MVA)		
b) Double pi-connection for Kesbewa (2x2cct, 1.0km, Lynx)		
(8) Construction of Sub-B 132kV Substation (GIS)		2007
a) Kelanittissa - Sub-B underground cables (1cct, 3.5km, Cu800sq.mm,CV Cables)		
b) Sub-B (2 x 63MVA (Final : 3 x 63MVA))		
c) Single pi-connection of Kelanittissa - Fort UGC (2x1cct, 0.2km, Cu500, OF Cables)		
d) Kelanittissa (one 132kV T/L bay for Sub-B line)		
(9) Power Transmission Facilities Related to Boossa Thermal Plant		
(9-1) Construction of Boossa - Pannipitiya 220kV Line		2008
a) Boossa - Matugama 220kV line (2cct, 54km, 2xZebra)		
b) Matugama - Pannipitiya 220kV line (2cct, 45km, 2xZebra)		
c) Pannipitiya (two 220kV T/L bays for Boossa line)		
(9-2) Construction of Boossa Substation		2008
a) Boossa (2x150MVA (220/132kV), 2x31.5MVA (132/33kV))		
(9-3) Construction of Boossa - New Galle 132kV Line		2008
a) Boossa - New Galle 132kV line (2cct, 12km, 2xZebra)		
b) New Galle (two 132kV T/L bays for Boossa line)		
(9-4) Construction of Matugama 220kV Substation	d	2008
a) Matugama (2x150MVA (220/132kV))		
b) Connection to existing 132kV Matugama substayion		

Table 4 Proposed New Subprojects for Transmission System up to the Year 2010

Augmentation and Extension of GSS	Re-marks	Proposed Commiss. Year
(10) Construction of Trincomalee - Kilinochchi 132kV Line		2007
a) Trincomalee - Kilinochchi Line (2cct, 140km, Lynx)		
b) Trincomalee (two 132kV T/L bays for Kilinochchi line)		
c) Kilinochchi (two 132kV T/L bays for Trincomalee line)		
(11) Construction of Pulmoddai 132kV Substation		2007
a) Pulmoddai (1 x 10MVA)	e	
b) Single pi-connection line for Pulmoddai (2cct, 8km, Lynx)		
(12) Construction of Mannar 132kV Substation		2006
a) Vavuniya - Mannar 132kV line (1st cct of 2cct construction, 80km, Lynx)		
b) Mannar (1 x 10MVA)	e,f	
c) Vavunia (one 132kV T/L bays for Mannar line)		
(13) Construction of Galenbindunuwewa 132kV Substation		2006
a) Galenbidunuwewa (1x10MVA)	e	
b) Single pi-connection line for Galenbidunuwewa (2cct, 1.0km, Lynx)		
(14) Construction of Daladagama 132kV Substation		2006
a) Kuliyapitiya - Daladagama 132kV line (1st cct of 2cct construction, 50km, Bear)		
b) Daladagama (1 x 10MVA)	e,f	
c) Kuliyapitiya (one 132kV T/L bays for Daladagama line)		
(15) Construction of Batticaloa 132kV Substation		2008
a) Batticalloa (1 x 10MVA)	e	
b) Single pi-connection line for Batticaloa (2cct, 5km, Lynx)		
(16) Construction of Girandurukotre 132kV Substation		2008
a) Rantembe - Girandurukotre 132kV line (1st cct of 2cct construction, 40km, Lynx)		
b) Girandurukotre (1 x 10MVA)	e,f	
c) Rantembe (one 132kV T/L bays for Girandurukotre line)		
(17) Construction of Wellawaya 132kV Substation		2008
a) Badulla - Wellawaya 132kV line (1st cct of 2cct construction,40km, Lynx)		
b) Wellawaya (1 x 10MVA)	e,f	
c) Badulla (one T/L bays for 132kV Wellawaya line)		
(18) Construction of Tissamaharama 132kV Substation		2006
a) Hambantota - Tissamaharama 132kV line (1st cct of 2cct construction, 30km, Lynx)		
b) Embilipitiya - Hambantota 132kV line (2nd cct of 2cct construction, 24.0km, Bear)		
c) Tissamaharama (1 x 10MVA)	e,f	
d) Embilipitiya (one 132kV T/L bay for Hambantota line)		
e) Hambantota (two 132kV T/L bays for Embilipitiya & Tissamaharama line)		
(19) Addition of Transformers		
(19-1) Chilaw (132/33kV, 1x31.5MVA, total 3x31.5MVA)		2007
(19-2) Kuliyapitiya (132/33kV, 1x31.5MVA, total 3x31.5MVA)		2007
(19-3) Aniyakanda (132/33kV, 1x31.5MVA, total 3x31.5MVA)		2010
(19-4) Kelaniya (132/33kV, 1x63MVA, total 3x63MVA)		2009

Table 4 Proposed New Subprojects for Transmission System up to the Year 2010

Augmentation and Extension of GSS	Re-marks	Proposed Commiss. Year
(19-5) Gonawala (132/33kV, 1x31.5MVA, total 4x31.5MVA)		2010
(19-6) Katana (132/33kV, 1x31.5MVA, total 3x31.5MVA)		2009
(19-7) Panadura (1x31.5MVA, total 3x31.5MVA)		2007
(19-8) Dehiwala (132/33kV, 1x63MVA, total 3x63MVA)		2009
(19-9) Matara (132/33kV, 1x31.5MVA, total 3x31.5MVA)		2008
(19-10) Ratnapura (132/33kV, 1x31.5MVA, total 3x31.5MVA)		2009
(19-11) Kegalle (132/33kV, 1x31.5MVA, total 3x31.5MVA)		2009
(19-12) Athurugiriya (132/33kV, 1x31.5MVA, total 3x31.5MVA)		2007
(19-13) Vavunia (132/33kV, 1x10MVA, total 2x10MVA)		2007
(19-14) Kesbewa (132/33kV, 1x31.5MVA, total 3x31.5MVA)		2009
(19-15) Imbulgoda (132/33kV, 1x31.5MVA, total 4x31.5MVA)		2009
(20) Replace of Transformers		
(21-1) Chunnakam (only 1x10MVA to 1x31.5MVA, total 91.5MVA)		2007
(21-2) Deniyaya (only 1x15MVA to 1x31.5MVA, total 46.5MVA)		2010
New Subprojects Proposed by Power System Analysis		
(21) Addition of 220/132kV Tie Transformers		
(21-1) Pannipitiya (1x250MVA, total 3x250MVA)		2007
(21-2) Veyangoda (1x150MVA, total 3x150MVA)		2007
(21-3) Kotugoda (1x250MVA, total 3x250MVA)		2008
(21-4) New Chilaw (1x150MVA, total 3x150MVA)		2008
(21-5) Biyagama (1x250MVA, total 3x250MVA)		2008
(22) Static Capacitor		
(22-1) Ampara (10MVA)		2009
(22-2) Biyagama (60MVA)		2008
(22-3) Chunnakam (20MVA, total 40MVA)		2007
(22-4) Dehiwala (60MVA)		2009
(22-5) Inginiyagara (10MVA)		2008
(22-6) Kegalle (20MVA)		2009
(22-7) Kelaniya (60MVA)		2009
(22-8) Kolonnawa (120MVA)		2007
(22-9) Kotugoda (30MVA, total 60MVA)		2008
(22-10) Matugama (80MVA)		2008
(22-11) Thulhiriya (40MVA)		2008
(22-12) Valaichchenai (10MVA)		2009
(23) Replacement of 132kV Circuit Breakers		
(23-1) Anuradhapura (11kA to 31.5kA, 6sets)		2007
(23-2) Kollupitiya (25kA to 40kA, 6sets)		2007
(23-3) Trincomalee (12.5kA to 31.5kA, 2sets)		2007

Remarks :

(a) Land space for future extension of 132kV switchgear shall be considered.

(b) Space for installation of distribution transformer(s) in future shall be considered.

(c) Righht of way of the abolished 66kV line may be used for the proposed 220kV line.

(d) *Land space adjoinning to the existing 132kV Matugama substation is available for the 220kV substation.*

(e) One unit only is proposed to be provided for cost saving, since no high demand is expected.

(f) A circuit breaker is proposed not to be provided for cost saving.

Table 5 Proposed New Subprojects for Transmission System up to The Year 2015

Sub-projects for Augmentation and Extension	Re-marks	Proposed Commiss. Year
(1) Power Transmission Facilities Related to Mawella Coal-fired Thermal Plant		
(1-1) Construction of Mawella - Padukka 220kV Line		2013
a) Mawella - Kahawatta Line (2cct, 100km, 4xZebra)		
b) Kahawatta - Padukka Line (2cct, 90km, 4xZebra)		
c) Padukka (two T/L bays for Kahawatta line)		
(1-2) Construction of Khawatta Switching Station		2013
(1-3) Construction of Mawella - Boossa Line		2013
a) Mawella - Boossa line (2cct, 70km, 2xZebra)		
b) Boossa (two T/L bays for Kahawatta line)		
(2) Construction of Mullaittivu 132kV Substation		2012
a) Single pi-connection of Trincomalee - Kilinochchi line (2cct, 3km, Lynx)		
b) Mullativu (1x10MVA)		
(3) Construction of Palattadichchenai 132kV Substation		2011
a) Trincomalee P/S - Palattadichchenai line (1st cct on 2cct, 35km, Lynx)		
b) Palattadichchenai (1x10MVA)		
c) Trincomalee (one T/L bay for Palattadichchenai line)		
(4) Construction of Maha Oya 132kV Substation		2012
a) Rantembe - Maha Oya line (1st cct on 2cct, 70km, Lynx)		
b) Maha Oya (1x10MVA)		
c) Rantembe (one T/L bay for Maha Oya line)		
(5) Construction of Pottuvil 132 kV Substation		2011
a) Single T-branch line for Pottuvil (1st cct on 2cct, 40km, Lynx)		
b) Pottuvil (1x10MVA)		
(6) Construction of Substations		
(6-1) North - A (2x31.5MVA, TL 1x2cct, 10km, Bear)		
(6-2) North Western - A (2x31.5MVA, TL 1x2cct, 10km, Bear)		
(6-3) North Western - B (2x31.5MVA, TL 1x2cct, 10km, Bear)		
(6-4) Western North - A (3x31.5MVA, TL 1x2cct, 10km, Zebra)		
(6-5) Western North - B (3x31.5MVA, TL 1x2cct, 10km, Zebra)		
(6-6) Western North - C (3x31.5MVA, TL 1x2cct, 10km, Zebra)		
(6-7) Western North - D (3x31.5MVA, TL 1x2cct, 10km, Zebra)		
(6-8) Western North - E (3x31.5MVA, TL 1x2cct, 10km, Zebra)		
(6-9) Western North - F (3x31.5MVA, TL 1x2cct, 10km, Zebra)		
(6-10) Western South - A (3x31.5MVA, TL 1x2cct, 10km, Zebra)		
(6-11) Western South - B (3x31.5MVA, TL 1x2cct, 10km, Zebra)		
(6-12) Western South - C (3x31.5MVA, TL 1x2cct, 10km, Zebra)		
(6-13) Western South - D (3x31.5MVA, TL 1x2cct, 10km, Zebra)		
(6-14) Sabaragamuwa - A (2x31.5MVA, TL 1x2cct, 10km, Bear)		
(6-15) Sabaragamuwa - B (2x31.5MVA, TL 1x2cct, 10km, Bear)		
(6-16) South - A (2x31.5MVA, TL 1x2cct, 10km, Bear)		
(7) Addition of Transformers		
(7-1) Anuradhapura (132/33kV, 2x31.5MVA, total 4x31.5MVA)		
(7-2) Kilinochchi (132/33kV, 1x10MVA, total 3x10MVA)		
(7-3) Ukuwela (132/33kV, 1x31.5MVA, total 3x31.5MVA)		

Table 5 Proposed New Subprojects for Transmission System up to The Year 2015

Sub-projects for Augmentation and Extension	Re-marks	Proposed Commiss. Year
(7-4) Kurunegara (132/33kV, 1x31.5MVA, total 3x31.5MVA)		
(7-5) Putallam (132/33kV, 1x31.5MVA, total 3x31.5MVA)		
(7-6) Bolawatta (132/33kV, 1x31.5MVA, total 123MVA)		
(7-7) Chilaw (132/33kV, 1x31.5MVA, total 4x31.5MVA)		
(7-8) Kuliyapitiya (132/33kV, 1x31.5MVA, total 4x31.5MVA)		
(7-9) Pannala (132/33kV, 2x31.5MVA, total 4x31.5MVA)		
(7-10) Veyangoda (132/33kV, 1x31.5MVA, total 3x31.5MVA)		
(7-11) Aniyakanda (132/33kV, 1x31.5MVA, total 4x31.5MVA)		
(7-12) Muthuragawella (220/33kV, 1x63MVA, total 3x63MVA)		
(7-13) Katana (132/33kV, 1x31.5MVA, total 4x31.5MVA)		
(7-14) Avissawella (132/33kV, 1x31.5MVA, total 3x31.5MVA)		
(7-15) Panadura (132/33kV, 1x31.5MVA, total 4x31.5MVA)		
(7-16) Athurugiriya (132/33kV, 1x31.5MVA, total 4x31.5MVA)		
(7-17) Kesbewa (132/33kV, 1x31.5MVA, total 4x31.5MVA)		
(7-18) Angoda (132/33kV, 1x31.5MVA, total 4x31.5MVA)		
(7-19) Hambantota (132/33kV, 1x10MVA, total 3x10MVA)		
(7-20) Boossa (132/33kV, 1x31.5MVA, total 3x31.5MVA)		
(7-21) Thulhiriya (132/33kV, 1x31.5MVA, total 4x31.5MVA)		
(7-22) Ratnapura (132/33kV, 1x31.5MVA, total 4x31.5MVA)		
(7-23) Kegalle (132/33kV, 1x31.5MVA, total 4x31.5MVA)		
(7-24) Aguruwella (132/33kV, 1x31.5MVA, total 3x31.5MVA)		
(7-25) Eheliyagoda (132/33kV, 1x31.5MVA, total 3x31.5MVA)		
(8) Replacement of Transformers		
(8-1) Polonnaruwa (132/33kV, 2x16MVA to 2x31.5MVA)		
New Subprojects Proposed by Power System Analysis		
(9) Addition of 220/132kV Tie Transformers		
(9-1) Boossa (1x150MVA, total 3x150MVA)		2011
(9-2) Kolonnawa (1x250MVA, total 3x250MVA)		2013
(9-3) Matale (1x150MVA, total 3x150MVA)		2013
(9-4) Trincomalee (1x150MVA, total 3x150MVA)		2013
(9-5) Biyagama (1x250MVA, total 4x250MVA)		2013
(9-6) Pannipitiya (1x250MVA,total 4x250MVA)		2013
(9-7) New Chilaw (1x150MVA, total 4x150MVA)		2014
(9-8) Veyangoda (1x150MVA, total 4x150MVA)		2014
(10) Static Capacitor		
Addition 700MVA in total in the system		

Table 6 Urgent Implementation

Augmentation and Extension of Substations	Proposed Commiss. Year
(1) Upgrading of 132kV Biyagama - Panipitiya Line to 220kV	2000
a) Upgrading of Biyagama - Panipitiya 132kV line to 220kV (220kV construction)	
b) Biyagama (two 220kV T/L bays for Panipitiya line)	
c) Panipitiya (2x250MVA, two 220kV T/L bays for Biyagama line)	
(2) Reconductoring of Kolonnawa - Panipitiya 132kV Line	2000
a) Kolonnawa - Panipitiya 132kV line (2cct, 13km, Lynx to Zebra)	
(3) Construction of Ratnapura 132 kV Substation	1998
a) Ratnapura (2x31.5MVA)	
b) Balangoda - Ratnapura 132kV line (2cct, 40km, Zebra)	
c) Balangoda (two 132kV T/L bays for Ratnapura line)	
(4) Construction of Aniyakanda 132 kV Grid Substation	1998
a) Aniyakanda (2x31.5MVA)	
b) Double pi-connection for Aniyakanda (2x2cct, 0.2km, Zebra)	
(5) Construction of Athurugiriya 132 kV Grid Substation	1998
a) Athurugiriya (2x31.5MVA)	
b) Triple pi-connection for Athurugiriya (3x2cct, 0.1km, Lynx)	
(6) Construction of Sri Jayawardenapura 132 kV Grid Substation	1998
a) Sri Jaya'pura (2x63MVA)	
b) Double pi-connection for Sri Jaya'pura (2x2cct, 0.1km, Zebra)	
(7) Construction of New Galle 132 kV Grid Substation	2000
a) New Galle (2x31.5MVA)	
b) Double pi-connection of New Galle (2x2cct, 0.1km, Tiger)	
(8) Construction of Matugama - New Galle 132kV Line	2000
a) Matugama - New Galle 132kV line (2cct, 64km, Zebra)	
b) Matugama (two 132kV T/L bays for New Galle line)	
c) New Galle (two 132kV T/L bays for Matugama line)	
(9) Construction of Kelaniya 132kV GIS Grid Substation	2000
a) Kelaniya (2x63MVA)	
b) Triple pi-connection for Kelaniya (3x2cct, 0.1km, Zebra)	
(10) Construction of 132kV Dehiwala Grid Substation	2000
a) Panipitiya - Dehiwala 132kV line (220kV construction, 2cct, 8km, 2xZebra)	
b) Dehiwala (132/33kV:2x63MVA)	
c) Panipitiya (two 132kV T/L bays : existing bus for Biyagama line are available)	
(11) Construction of Kuliyapitiya 132 kV Grid Substation	2001
a) Double T-connection for Kuliyapitiya (2cct, 18km, Zebra)	
b) Kuliyapitiya (2 x 31.5MVA)	
(12) Construction of Polonnaruwa 132 kV Grid Substation	2001
a) Polonnaruwa (2 x 16MVA) : (replaced transformer)	
b) Single pi-connection for Polonnaruwa (2cct, 0.5km, Lynx)	
(13) Construction of Ambalangoda 132 kV Grid Substation	2001
a) Ambalangoda (2 x 31.5MVA)	
b) Single pi-connection for Ambalangoda (2x2cct, 0.1km, Zebra)	
(14) Construction of Hambantota 132 kV Grid Substation	2001
a) Embilipitiya - Hambantota 132kV line (1cct on 2cct towers, 28km, Bear)	
b) Hambantota (2 x 10MVA) : (replaced transformer)	
c) Embilipitiya (one 132kV T/L bays for Hambantota line)	

Table 7 Cost of Proposed Subprojects

Augmentation and Extension of Substations	Cost (1,000 US$)		Proposed Commiss. Year
	FC	LC	
(1) Upgrading of 132kV Biyagama - Pannipitiya Line to 220kV	11,597	2,370	2000
(2) Reconductoring of Kolonnawa - Pannipitiya 132kV Line	1,338	471	2000
(3) Construction of Ratnapura 132 kV Substation	8,907	2,316	1998
(4) Construction of Aniyakanda 132 kV Grid Substation	5,748	1,453	1998
(5) Construction of Athurugiriya 132 kV Grid Substation	6,549	1,629	1998
(6) Construction of Sri Jayawardenapura 132 kV Grid Substation	5,727	1,448	1998
(7) Construction of New Galle 132 kV Grid Substation	5,858	1,482	2000
(8) Construction of Matugama - New Galle 132kV Line	6,886	1,783	2000
(9) Construction of Kelaniya 132kV GIS Grid Substation	11,528	2,336	2000
(10) Construction of 132kV Dehiwala Grid Substation	8,551	2,053	2000
(11) Construction of Kuliyapitiya 132 kV Grid Substation	6,368	1,687	2001
(12) Construction of Polonnaruwa 132 kV Grid Substation	3,352	1,143	2001
(13) Construction of Ambalangoda 132 kV Grid Substation	4,882	1,275	2001
(14) Construction of Hambantota 132 kV Grid Substation	6,458	2,475	2001
Total	93,749	23,921	

Table 8 Scedule of Required Fund

(Unit : Mil. $)

Year	Foreign Component			Local Component			Total
	Ongoing	Planned	Total	Ongoing	Planned	Total	FC + LC
1995	7.9		7.9	2.4		2.4	10.3
1996	19.6		19.6	5.0		5	24.6
1997	30.3	16.6	46.9	8.5	5.6	14.1	61
1998	36.9	24.8	61.7	8.7	5.6	14.3	76
1999	13.6	21.3	34.9	2.7	6.0	8.7	43.6
2000		43.2	43.2		10.2	10.2	53.4
Subtotal	108.3	105.9	214.2	27.3	27.4	54.7	268.9
2001		44.7	44.7		13.2	13.2	57.9
2002		55.9	55.9		12.7	12.7	68.6
2003		22.4	22.4		5.3	5.3	27.7
2004		26.6	26.6		8.8	8.8	35.4
2005		37.2	37.2		10.9	10.9	48.1
Subtotal	0	186.8	186.8	0	50.9	50.9	237.7
2006		103.8	103.8		33.7	33.7	137.5
2007		146.3	146.3		34.1	34.1	180.4
2008		47.4	47.4		12.2	12.2	59.6
2009		50.4	50.4		11.4	11.4	61.8
2010		21.1	21.1		5.1	5.1	26.2
Subtotal	0	369	369	0	96.5	96.5	465.5
2011		43.2	43.2		10.7	10.7	53.9
2012		76.1	76.1		20.9	20.9	97.0
2013		91.6	91.6		19.9	19.9	111.5
2014		36.1	36.1		8.1	8.1	44.2
2015		32.8	32.8		7.6	7.6	40.4
Subtotal	0	279.8	279.8	0	67.2	67.2	347.0
Total	**108.3**	**941.5**	**1049.8**	**27.3**	**242**	**269.3**	**1319.1**

Table 9 Economic Evaluation of CEB's Power System Expansion Program (for JICA Study)

No	Item / Year	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
1	Load Forecast																						
	Generation Required (GWh)	4,806	5,242	5,718	6,238	6,805	7,407	8,017	8,659	9,373	10,194	11,111	12,111	13,201	14,389	15,684	17,096	18,635	20,312	22,140	24,132	26,304	
	Sales (GWh)	3,946	4,341	4,775	5,252	5,777	6,355	6,927	7,550	8,230	8,971	9,778	10,658	11,617	12,663	13,802	15,044	16,398	17,874	19,483	21,236	23,148	
	Peak Load (MW)	996	1,071	1,161	1,256	1,365	1,481	1,597	1,719	1,854	2,010	2,187	2,384	2,598	2,832	3,087	3,365	3,668	3,998	4,358	4,750	5,177	
2	Expansion Program																						
	Net Capacity Commissioned (MW)	0	-36	40	266	150	150	26	166	156	324	300	0	300	264	300	300	300	600	300	335	475	4,716
	Total CEB Generation Capacity (MW)	1,339	1,303	1,343	1,609	1,759	1,909	1,935	2,105	2,257	2,581	2,881	2,881	3,181	3,445	3,745	4,045	4,345	4,945	5,245	5,580	6,055	
	Reserve Margin (% of Peak Load)	25.6%	17.8%	13.6%	21.9%	22.4%	22.4%	17.5%	15.4%	15.2%	20.0%	22.2%	15.2%	16.5%	16.1%	16.0%	15.3%	14.2%	18.0%	15.8%	13.8%	13.5%	
3	Capital Costs (Million $)	144.7	183.5	343.0	270.0	247.3	324.7	351.7	388.7	324.5	256.2	312.7	486.9	549.9	410.4	470.2	566.9	542.4	491.3	512.5	386.7	284.8	7,849.0
	CEB Power Plant	85.4	109.8	231.5	139.0	139.5	201.2	225.1	245.5	211.2	128.1	164.5	248.5	261.6	220.6	266.2	381.9	317.7	211.8	202.3	119.0	0.0	4,110.4
	Transmission	9.3	22.4	55.2	69.1	39.7	48.5	52.3	62.4	25.1	31.9	43.5	124.2	163.9	54.1	56.2	23.8	49.0	87.9	101.4	40.2	36.7	1,196.8
	Distribution	50.0	51.3	56.3	61.9	68.1	75.0	74.3	80.8	88.2	96.2	104.7	114.2	124.4	135.7	147.8	161.2	175.7	191.6	208.8	227.5	248.1	2,541.8
4	Fuel and O&M Costs (Million $)	29.0	56.0	68.8	98.5	114.1	131.5	160.5	157.0	172.3	180.5	194.2	227.0	248.3	286.7	313.4	345.8	394.7	435.1	479.8	529.9	603.0	5,226.2
	Fuel Costs	17.8	44.4	52.9	70.3	81.0	93.7	118.3	109.5	117.9	119.3	125.6	151.8	163.3	193.5	209.8	231.6	270.9	298.1	329.2	364.2	424.3	3,587.4
	O&M Costs (Thermal)	4.1	3.4	6.3	16.6	19.3	22.0	24.1	26.9	31.3	35.9	40.9	44.8	50.4	53.7	60.6	67.4	73.4	82.3	90.8	100.2	108.0	962.4
	O&M Costs (Hydro)	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	94.5
	O&M Costs (Transmission)	0.8	0.9	1.3	2.1	3.1	3.7	4.5	5.2	6.2	6.6	7.0	7.7	9.6	12.0	12.8	13.7	14.0	14.8	16.1	17.6	18.2	177.9
	O&M Costs (Distribution)	2.0	3.0	4.0	5.2	6.4	7.8	9.3	10.7	12.4	14.1	16.0	18.1	20.4	22.9	25.6	28.6	31.8	35.3	39.1	43.3	47.9	404.0
5	Incremental Fuel and O&M Costs (1995 base) (M$)	0.0	27.0	39.8	69.5	85.1	102.5	131.5	128.0	143.3	151.5	165.2	198.0	219.3	257.7	284.4	316.8	365.7	406.1	450.8	500.9	574.6	4,617.2
	Generation	0.0	25.9	37.3	65.0	78.4	93.8	120.5	114.8	127.6	133.6	144.9	175.0	192.1	225.6	248.8	277.4	322.7	358.8	398.4	442.8	510.7	4,094.1
	Transmission	0.0	0.1	0.5	1.3	2.3	2.9	3.7	4.4	5.4	5.8	6.2	6.9	8.8	11.2	12.0	12.9	13.2	14.0	15.3	16.8	17.4	161.1
	Distribution	0.0	1.0	2.0	3.2	4.4	5.8	7.3	8.7	10.4	12.1	14.0	16.1	18.4	20.9	23.6	26.6	29.8	33.3	37.1	41.3	45.9	362.0
6	Total of 3 and 5 (Million $)	0.0	210.5	382.8	339.5	332.4	427.2	483.2	516.7	467.8	407.7	477.9	684.9	769.2	668.1	754.6	883.7	908.1	897.4	963.3	887.6	858.8	12,321.5
	Generation	85.4	135.7	268.8	204.0	217.9	295.0	345.6	360.3	338.8	261.7	309.4	423.5	453.7	446.2	515.0	659.3	640.4	570.6	600.7	561.8	510.7	8,204.5
	Transmission	9.3	22.5	55.7	70.4	42.0	51.4	56.0	66.8	30.5	37.7	49.7	131.1	172.7	65.3	68.2	36.7	62.2	101.9	116.7	57.0	54.1	1,357.9
	Distribution	50.0	52.3	58.3	65.1	72.5	80.8	81.6	89.5	98.6	108.3	118.7	130.3	142.8	156.6	171.4	187.8	205.5	224.9	245.9	268.8	294.0	2,903.8
7	Total Incremental Energy Sales (1995 base) (GWh)	0	395	829	1,306	1,831	2,409	2,981	3,604	4,284	5,025	5,832	6,712	7,671	8,717	9,856	11,098	12,452	13,928	15,537	17,290	19,202	150,959.0
8	Economic Benefit due to Incremental Energy Sales (M$)	0.0	61.6	129.3	203.7	285.6	375.8	465.0	562.2	668.3	783.9	909.8	1,047.1	1,196.7	1,359.9	1,537.5	1,731.3	1,942.5	2,172.8	2,423.8	2,697.2	2,995.5	23,549.6
9	Net Incremental Benefits - Costs (Million $)	0.0	-148.9	-253.5	-135.7	-46.8	-51.4	-18.1	45.5	200.5	376.2	431.9	362.1	427.5	691.7	782.9	847.5	1,034.4	1,275.4	1,460.4	1,809.6	2,136.7	11,228.1

Note: Costs are economic costs expressed in constant January 1995 US$. Exchange rate is 1US$=Rs.50.

Basic Results

1. Average economic benefit of electricity sales: 0.156 $/kWh (refer to the right)
2. Average incremental cost of electricity sales: 0.104 $/kWh
   (Economic cost at Jan. 1995 price, 10% discount rate)
3. Long term average incremental generation cost: 0.069 $/kWh
   (Economic cost at Jan. 1995 price, 10% discount rate)
4. Long term average incremental transmission cost: 0.012 $/kWh
   (Economic cost at Jan. 1995 price, 10% discount rate)
5. Long term average incremental distribution cost: 0.022 $/kWh
   (Economic cost at Jan. 1995 price, 10% discount rate)
6. Economic internal rate of return system as a whole: 26.3%
7. Benefit/cost ratio for expansion program, 1996-2015: 1.502
   (at 10% discount rate)

Consumer Category	Share of Sales	Average Economic Benefit (Rs/kWh)
Residential	26%	12.60
Commercial	17%	8.90
Industrial	40%	5.20
LECO Bulk Supply	17%	5.52
Weighted Average		7.81 Rs/kWh
	or	0.156 $/kWh

FIGURES

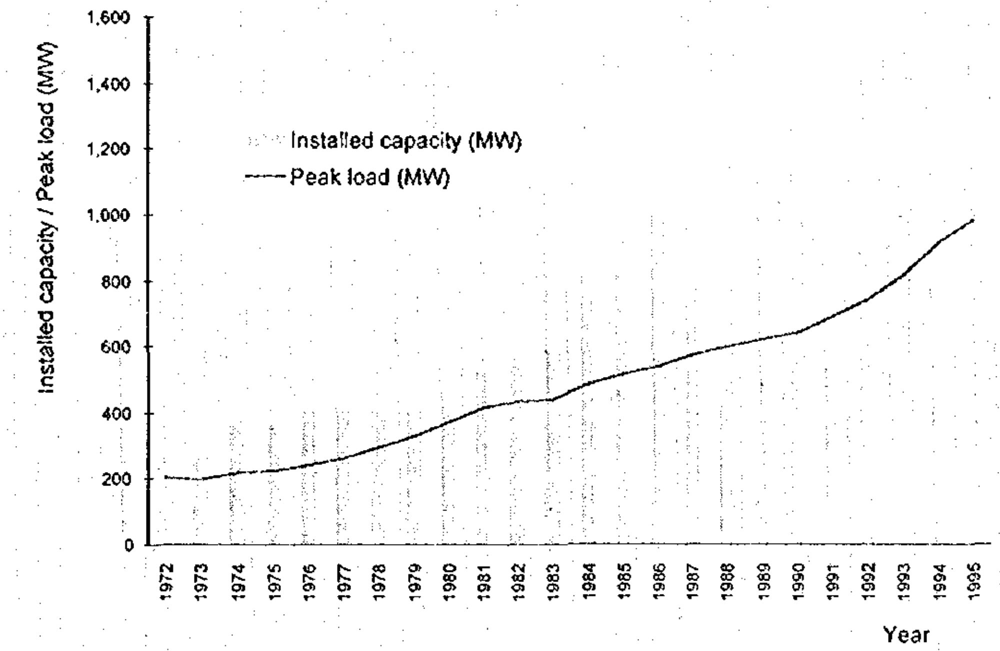


Fig. 1 Installed Capacity and Peak Demand Growth

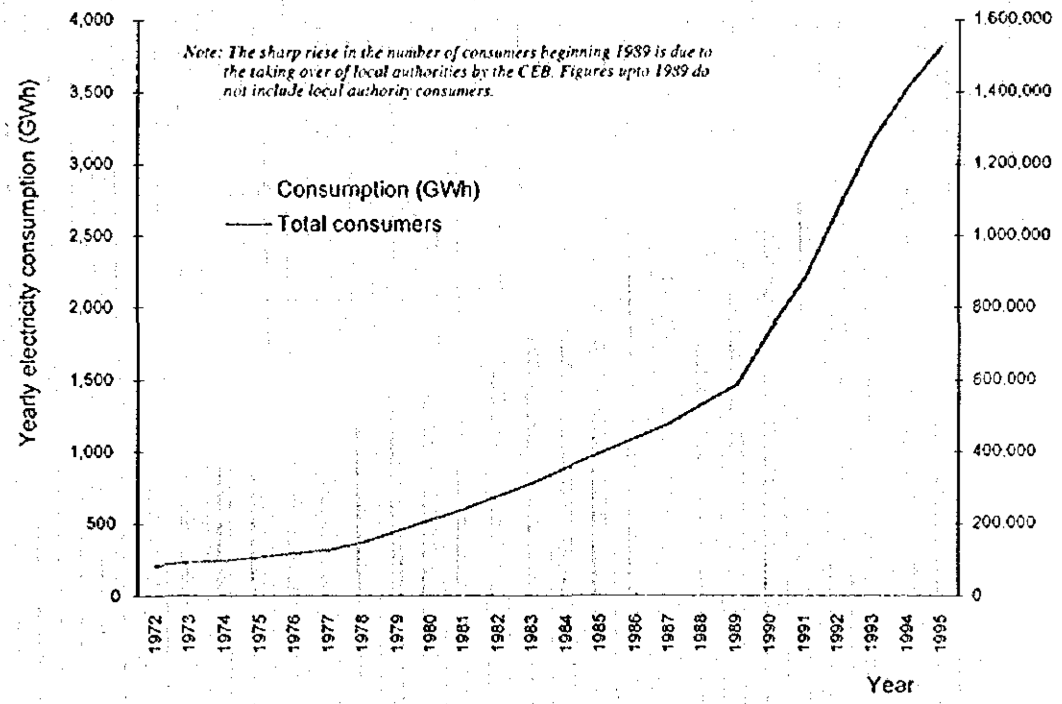
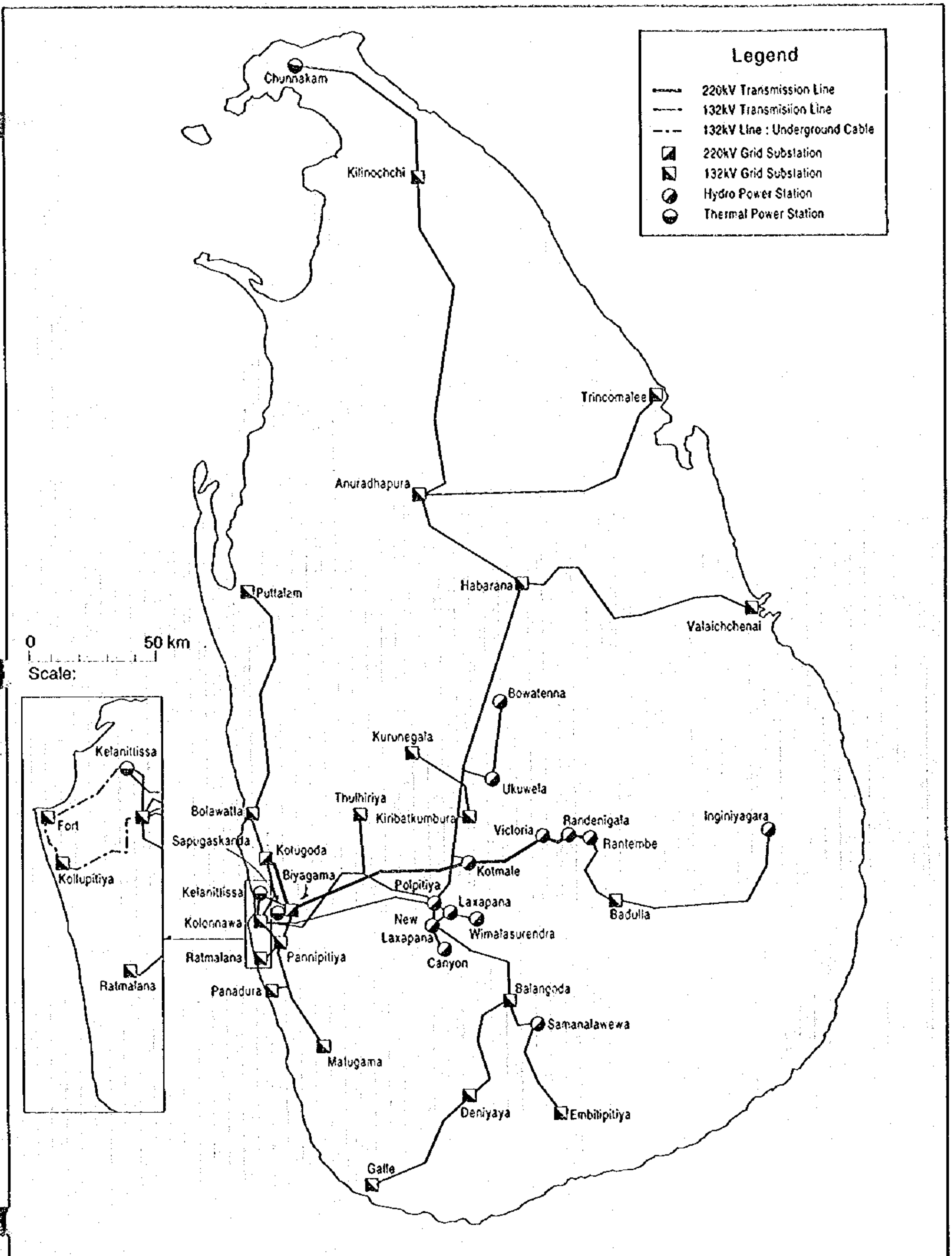
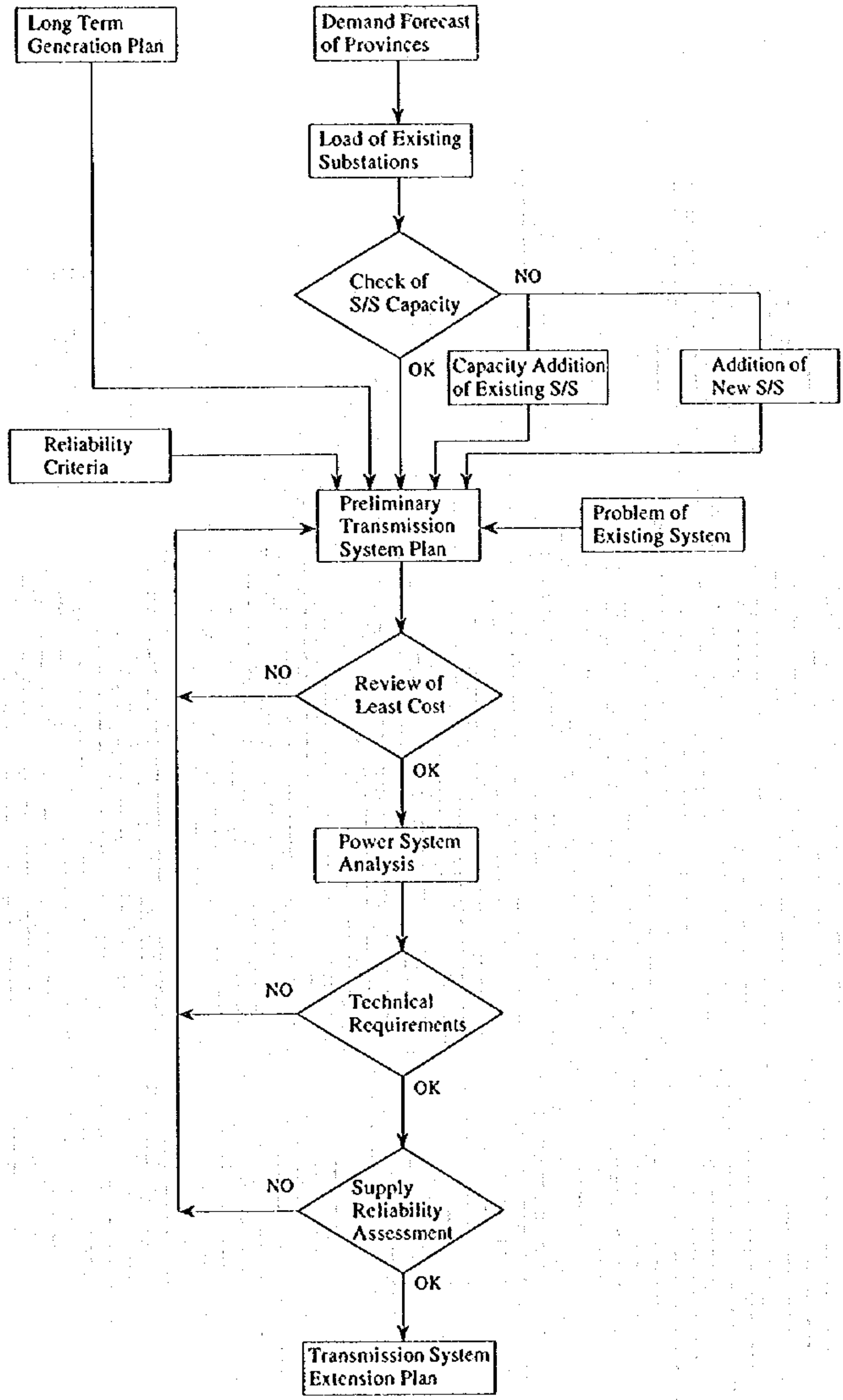


Fig. 2 Total Power Consumption and Number of Consumers

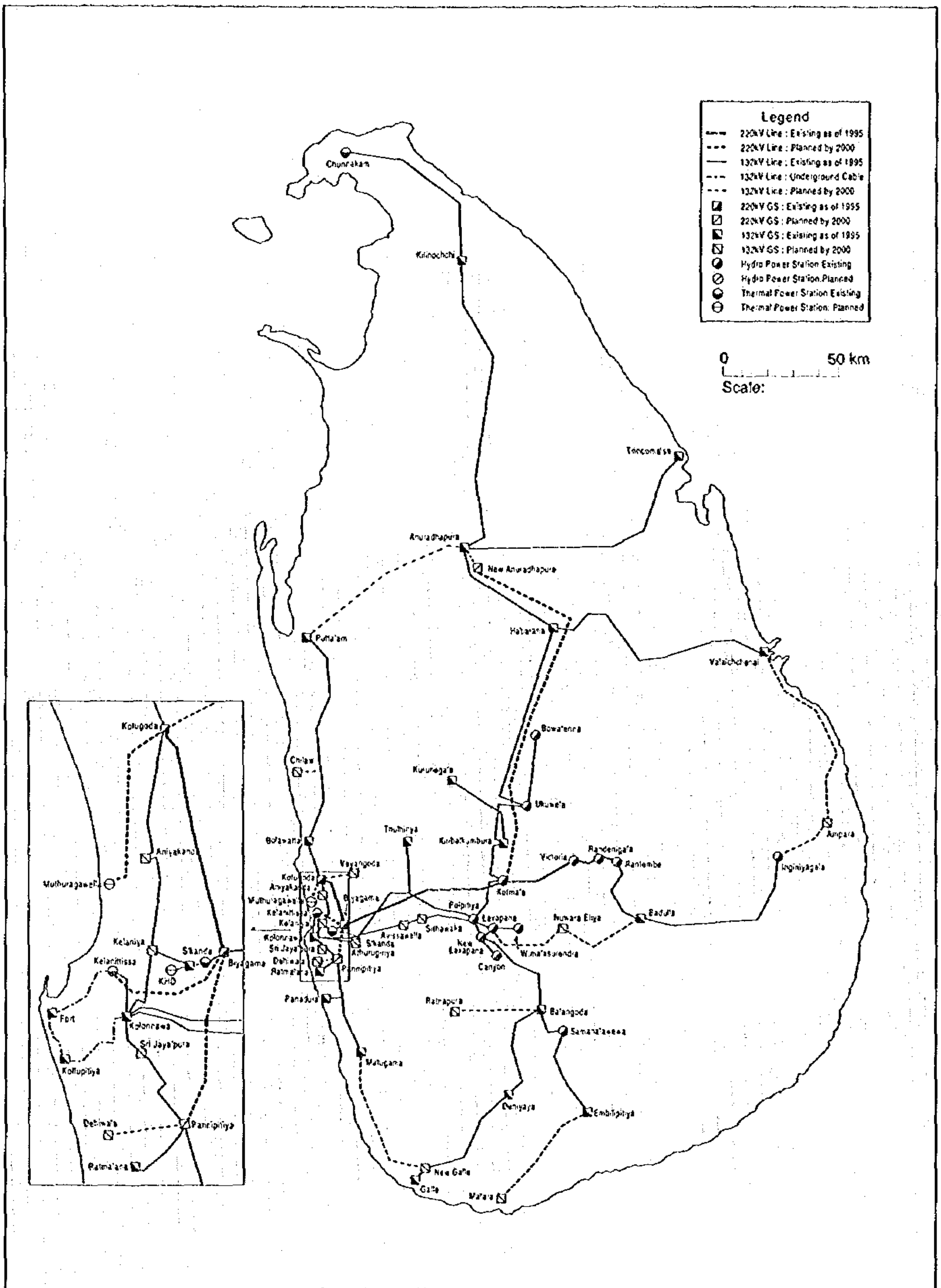
CEYLON ELECTRICITY BOARD	JAPAN INTERNATIONAL COOPERATION AGENCY NIPPON KOEI CO., LTD. Consulting Engineer	MASTER PLAN STUDY FOR DEVELOPMENT OF THE TRANSMISSION SYSTEM OF THE CEYLON ELECTRICITY BOARD IN THE DEMOCRATIC SOCIALIST REPUBRIC OF SRI LANKA	TITLE



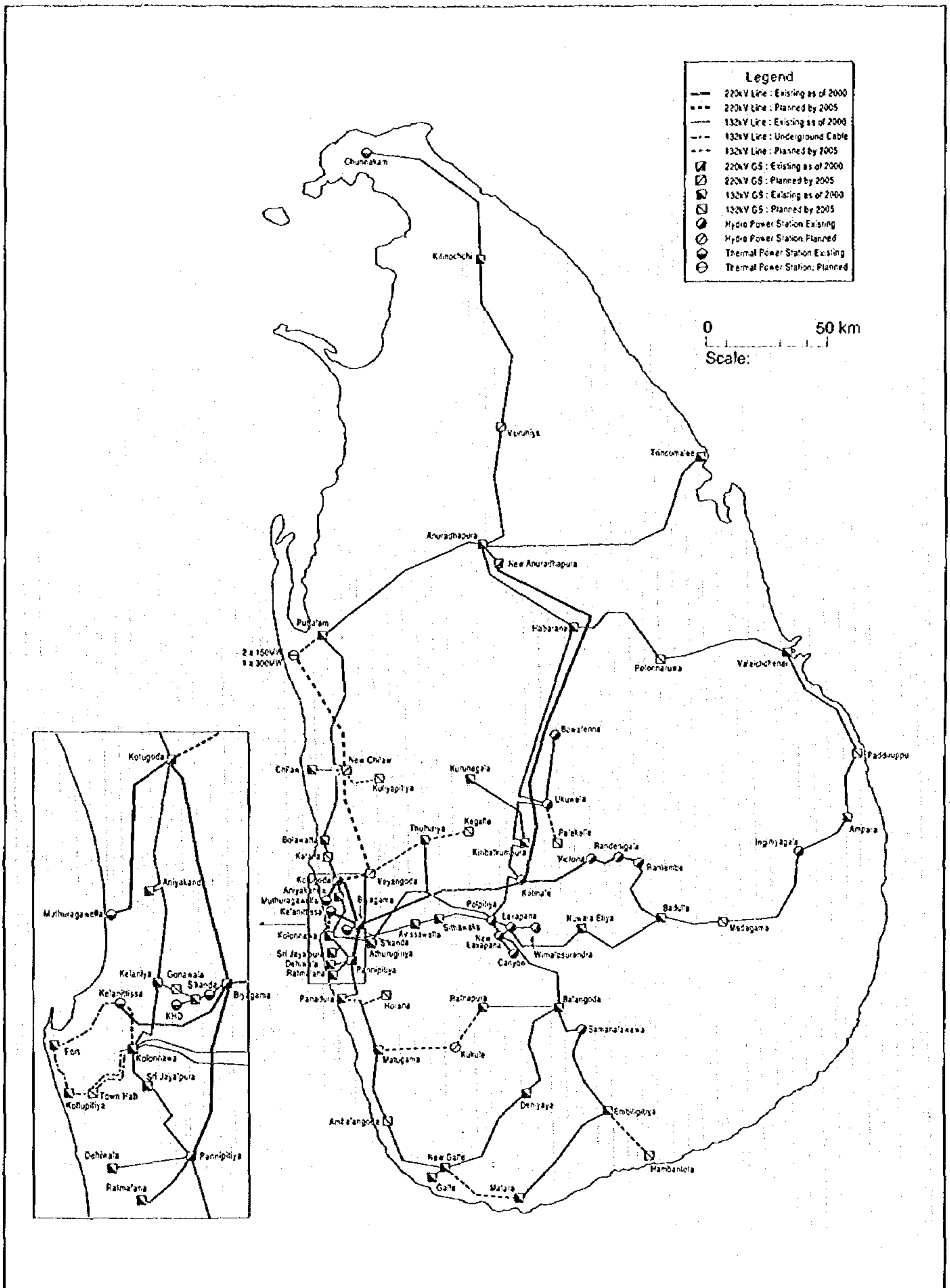
CEYLON ELECTRICITY BOARD	JAPAN INTERNATIONAL COOPERATION AGENCY NIPPON KOEI CO., LTD. Consulting Engineer	MASTER PLAN STUDY FOR DEVELOPMENT OF THE TRANSMISSION SYSTEM OF THE CEYLON ELECTRICITY BOARD IN THE DEMOCRATIC SOCIALIST REPUBLIC OF SRI LANKA	TITLE Fig. 3 End - 1995 Power System Map



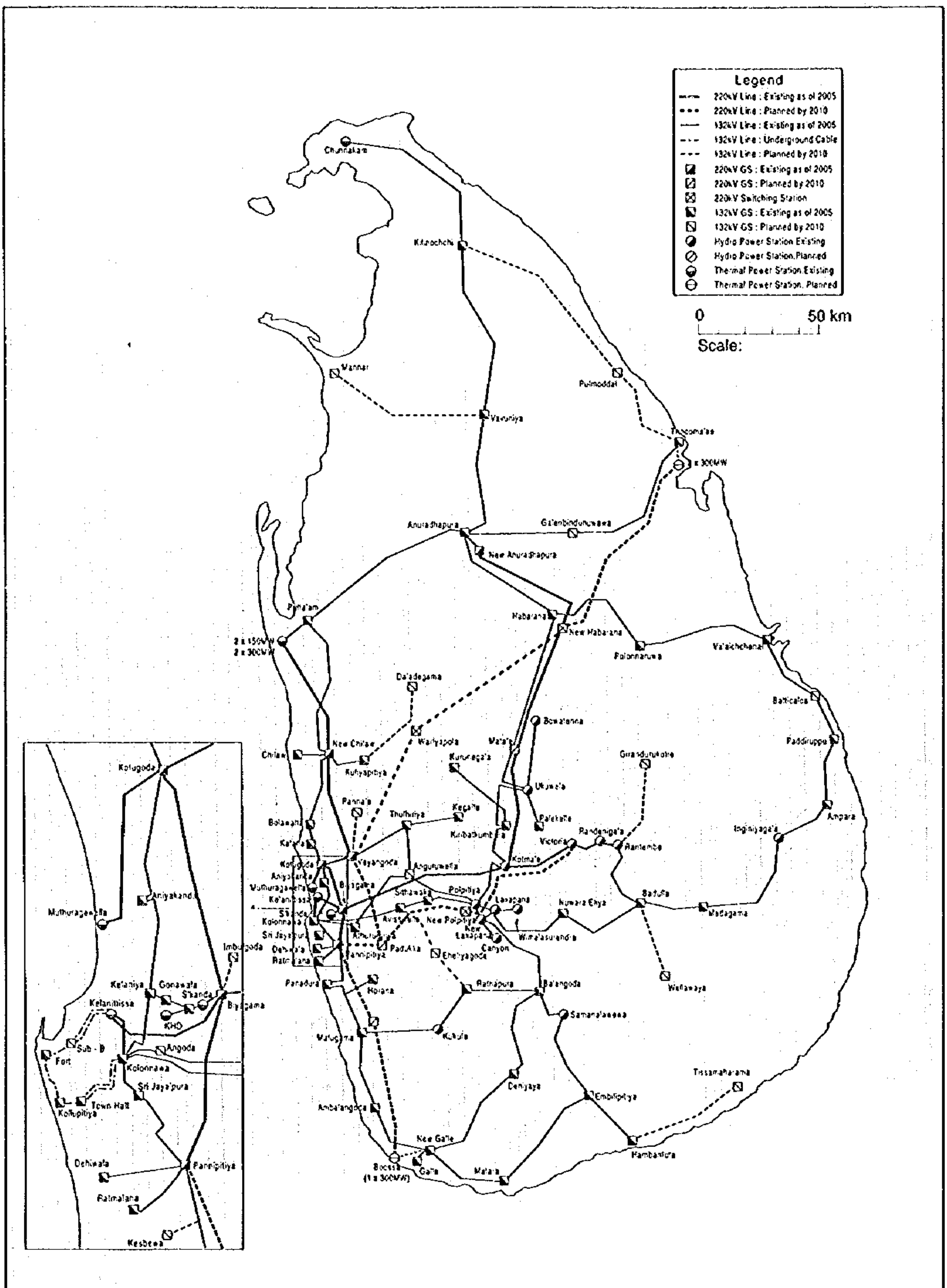
CEYLON ELECTRICITY BOARD	JAPAN INTERNATIONAL COOPERATION AGENCY NIPPON KOEI CO., LTD. Consulting Engineer	MASTER PLAN STUDY FOR DEVELOPMENT OF THE TRANSMISSION SYSTEM OF THE CEYLON ELECTRICITY BOARD IN THE DEMOCRATIC SOCIALIST REPUBRIC OF SRI LANKA	TITLE Fig. 4 Procedure of Transmission System Planning



CEYLON *ELECTRICITY BOARD*	JAPAN INTERNATIONAL COOPERATION AGENCY NIPPON KOEI CO., LTD. Consulting Engineers	MASTER PLAN STUDY FOR DEVELOPMENT OF THE TRANSMISSION SYSTEM OF THE CEYLON ELECTRICITY BOARD IN THE DEMOCRATIC SOCIALIST REPUBLIC OF SRI LANKA	TITLE Fig. 5 CEB Tranmission Line System in 2000

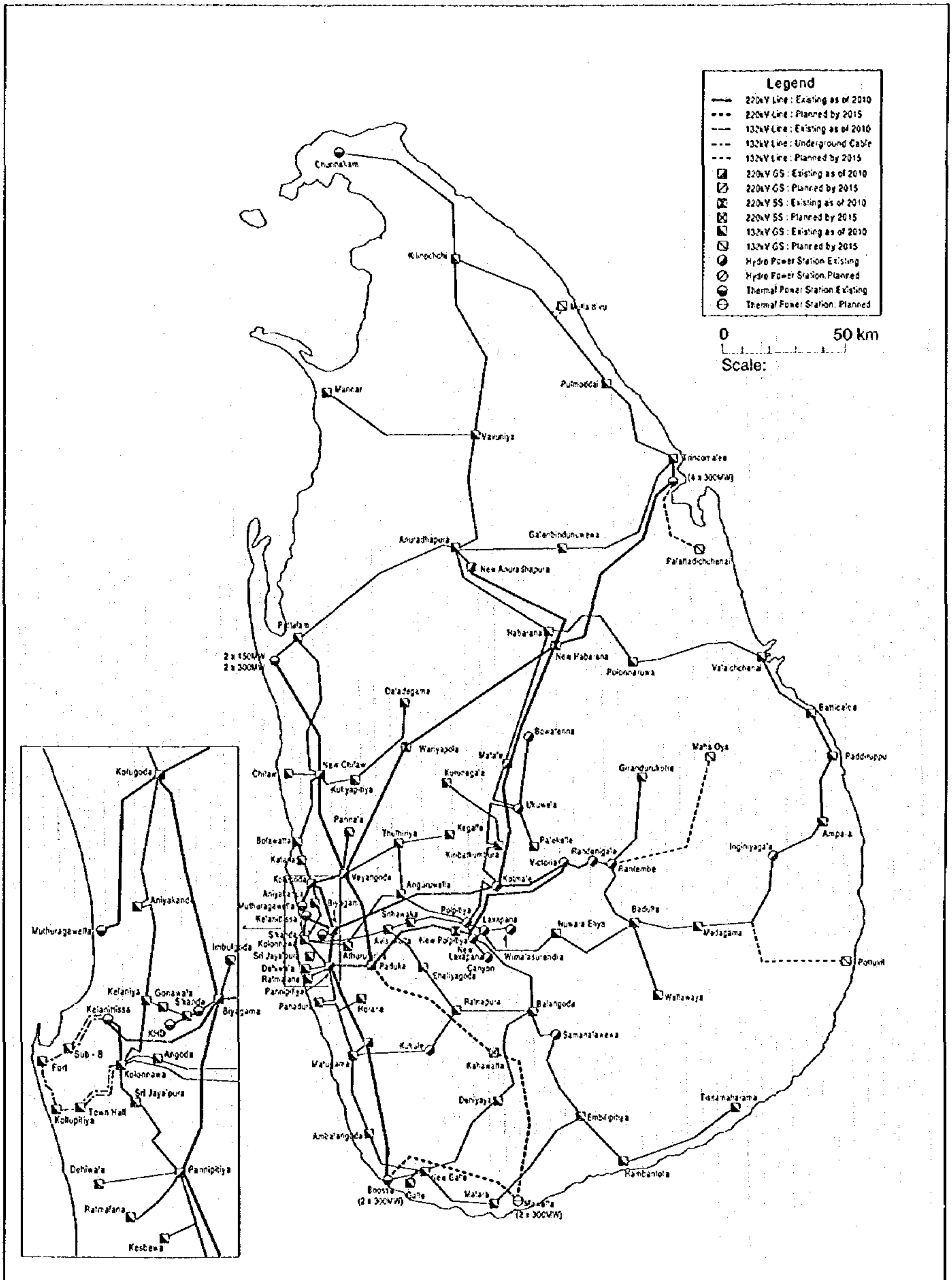


CEYLON ELECTRICITY BOARD	JAPAN INTERNATIONAL COOPERATION AGENCY NIPPON KOEI CO., LTD. Consulting Engineers	MASTER PLAN STUDY FOR DEVELOPMENT OF THE TRANSMISSION SYSTEM OF THE CEYLON ELECTRICITY BOARD IN THE DEMOCRATIC SOCIALIST REPUBLIC OF SRI LANKA	TITLE Fig. 6 CEB Transmission Line System In 2005



CEYLON ELECTRICITY BOARD	JAPAN INTERNATIONAL COOPERATION AGENCY NIPPON KOEI CO., LTD. Consulting Engineers	MASTER PLAN STUDY FOR DEVELOPMENT OF THE TRANSMISSION SYSTEM OF THE CEYLON ELECTRICITY BOARD IN THE DEMOCRATIC SOCIALIST REPUBLIC OF SRI LANKA	TITLE Fig. 7 CEB Transmission Line System In 2010

Fig. 7 CEB Transmission Line System In 2010



CEYLON ELECTRICITY BOARD	JAPAN INTERNATIONAL COOPERATION AGENCY NIPPON KOEI CO., LTD. Consulting Engineer	MASTER PLAN STUDY FOR DEVELOPMENT OF THE TRANSMISSION SYSTEM OF THE CEYLON ELECTRICITY BOARD IN THE DEMOCRATIC SOCIALIST REPUBLIC OF SRI LANKA	TITLE Fig. 8 CEB Transmission Line System in 2015

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