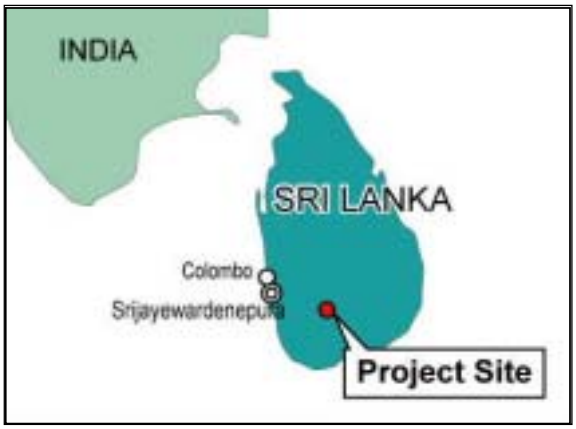
Sri Lanka

Transmission and Grid Substation Development Project

Report Date: September 2002
Field Survey: July/August 2001

1. Project Profile and Japan's ODA Loan



Site Map: Sri Lanka

Site Photo: Matara Substation

1.1 Background

In Sri Lanka, peak demand for electricity reached 570 MW in 1987, and actual sales were 2,248 GWh.

The primary objective of the Ceylon Electricity Board (CEB) was to provide high quality electric power to consumers in Sri Lanka. CEB had been improving its transmission network and adding generating facilities in order to meet the increased demand for electricity. However, there were several inefficient networks, which hindered secure power supply for the country.

When demand for electricity and the actual volume of power consumption increased in 1979, transmission lines could not be developed fast enough, because of the priority placed on developing a distribution system in the country. As a result, the rate of system losses increased from 12% in 1976 to 20% in 1981. Under the circumstances, implementing this project was important.

1.2 Objectives

To reinforce the transmission network of the Ceylon Electricity Board by augmenting the existing transmission system and grid substations to ensure a stable supply of power.

1.3 Project Scope

- Construction of four 132kV transmission lines between:
  - ① Puttlam-Anuradhapura
  - ② K.K.S-Chunnaka
  - ③ Embilipitiya-Matara
  - ④ Ukuwela (In-Out TL: π connected double line, expand the supply capacity)
- Replacement of existing conductors between Kotugoda-Bolawatte
- Construction of two new grid substations at Kankesanthurai and Matara
- Augmentation of capacity at six existing substations: Ukuwela, Kilinichchi, Puttlam, Bolawatte, Kotugoda and Anuradhapura
- Consulting services

This project was conducted under the 10th Power Project of CEB, co-financed by the World Bank.

The 10th Power Project was conducted as a series of Power Projects starting in 1960s, financed mainly by The World Bank, the Asian Development Bank and bilateral aid agencies like JBIC.
The 10th Project aimed to rehabilitate and expand the power distribution system and transmission lines, to give technical assistance to CEB and to digitalize the electricity charge system. The World Bank was in charge of rehabilitating distribution lines, substations and relevant equipment. The total estimated cost of the 10th Power Project was about 12 billion Yen.

1.4 Borrower/Executing Agency

The Government of Democratic Socialist Republic of Sri Lanka (GOSL) / Ceylon Electricity Board (CEB)

1.5 Outline of Loan Agreement

Loan Amount Loan Disbursed Amount	3,855 million yen 2,342 million yen
Exchange of Notes Loan Agreement	January, 1990 March, 1990
Terms and Conditions Interest Rate Repayment Period (Grace Period) Procurement	 2.5% 30 years (10 years) General untied
Final Disbursement Date	June 1999

2. Results and Evaluation

2.1 Relevance

The policy of the government has been to provide a reliable energy supply and to maintain affordable prices. To meet these dual objectives, the Ceylon Electricity Board (CEB) prepares a 10-year National Transmission Development Plan every year.

In the past 30 years, demand for electricity has increased at rates even higher than what was expected at the commencement of the 10th Power Supply Development Project. To meet the growing demand, maintenance of the transmission network has been a substantial theme for Sri Lanka. Most elements of the project, when commissioned, were put to good use immediately, improving the reliability and capacity of the transmission network and of several substations in Sri Lanka. Even now, the project's objectives remain valid. The environment in which the project now operates closely mirrors that envisioned in the original plan. Customer demand has continued to grow, and the overall environment is one of growth and expansion.

2.2 Efficiency

2.2.1 Project Scope

The following revisions were made to the original plan after reviewing the scope and components of the project during implementation.

The internal conflict in the north of Sri Lanka has continued since appraisal; therefore, the following components of the original plan were canceled:

a) Construction of 132 kV double circuit transmission lines between Kankesanthurai and Chunnakam (Jaffna Area).
b) Construction of a 132 kV/33 kV, 2 x 15 MVA Grid Substation at Kankesanthurai (Jaffna Area).
c) Augmentation of the Grid Substation at Kilinochchi to 2 x 10 MVA and provision of 33 kV bays (Northern Area).

The following revisions were made in the detailed design stage due to duplication or for technical reasons:

a) Augmentation of the grid substations at Kotugoda and Bolawatta with new feeder bays (canceled: built under Second Power Sector Expansion Project = SESEP – Funds from ADB: Asian Development Bank).
b) Provision of an additional 4 bays of 132 kV at Anuradhapura (canceled: new substation to be built under the Transmission Development Plan from 2001 to 2010: Funds to be arranged).
c) Provision of additional bays of 33 kV at Ukuwela Grid Substation (canceled: to be built under the Transmission Development Plan from 2001 to 2010: Funds to be arranged).

2.2.2 Implementation Schedule

Implementation started later and took longer than originally planned. The major reasons for the delays and relevant details are as follows:

a) Transmission Lines

There was 5.5-year delay in the construction of transmission lines for the following reasons:

The start of the construction work was delayed about 4 years (original from March 1991/ actual from July 1995) because there was neither a proper organization nor the resources necessary to perform the civil works. Also, design approval took more time than expected. In addition, the general situation in the country, as stated in 2.2.1 Project scope, caused difficulties. During the early stages of the construction work, contractors showed they were unable to execute turnkey projects of this nature. As a result, construction work was delayed about 14 months. However, in the final stages of the project, after replacement of essential onsite staff and with closer control provided by the contractor's head office, performance improved. CEB also controlled and monitored the work day-to-day, thus limiting delays. Design approval also consumed a substantial amount of time. Due to delays in approving the Lot I contract (transmission lines), the 74 MM allocation for construction supervision was found to be insufficient; it actually took 115 MM.

b) Grid Substation

There was a 4-year delay in the construction/augmentation of grid substations for the following reasons:

The general situation in the country, namely conflict in the Northern area, as stated in 2.2.1 Project scope, caused the executing agency to delay the implementation of the project for four years.

Implementation was also delayed about 2.5 months because of dry weather, which caused shortages of electricity from the hydropower plants and subsequent power cuts throughout 1996. As the construction work required the use of electricity, this had an impact on the implementation of the project.

Due to unexpected soft soil conditions, construction of the Matara Grid Substation embankment was delayed.

Communication difficulties with the contractor's Chinese staff also resulted in delays.

2.2.3 Project Cost

The original budget was 4,605 million yen, while the actual expenditure was 2,342 million yen, nearly

50% less. The reasons for this were as follows:

Revisions in the scope and scale of the project: As for the transmission lines, the contract price was less than the planned price because internal conflict in the north caused the project elements in Jaffna to be cancelled.

For the grid substations, the contract price was lower than the planned price because of the following conditions:

- The construction of the grid substation in the north was canceled because of the internal conflict in the north.
- An additional bay supply at the Anuradhapura Plant was cancelled because construction of a new grid substation of 220kV was approved.

Affected by these changes, the total cost, including the local currency portion (which was not affected by the exchange rate fluctuations), decreased as indicated above.

2.2.4 Performance of the Project Implementation

Implementation of the project was conducted effectively, except for the problems indicated. Some civil engineering work was delayed due to contractors' inappropriate management onsite. This problem was solved by the reassignment of onsite people and with appropriate instructions from headquarters. CEB monitored the work on a daily basis.

Some organizational problems existed in the engineering work for transmission lines in Lot I. In addition, since the number of interpreters on the site was limited when the grid substation in Lot II was being constructed, communication difficulties with Chinese staff resulted in technical problems and delays. By increasing English-speaking staff, this problem was solved. Finally, there were minor problems with the quality of the disconnecting switch; the original one, made by a Korean manufacturer, was exchanged for one from a Spanish firm.

2.3 Effectiveness

The achievements of the Transmission and Substation Development Project cannot be examined comprehensively in terms of technical and financial indices. The transmission network was planned and built to ensure improvements in system reliability and a reduction of losses.

2.3.1 Increase of Power Supply

Table 1: The entire transition of CEB Sales, Electricity Supply, and Supply/ Demand Gap in Sri Lanka

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
CEB sales (GWh)	2,608	2,742	2,916	3,269	3,565	3,829	3,610	4,029	4,521	4,809	5,258
Rate of increase %	10.8	5.1	6.3	12.1	9.1	7.4	- 5.7	11.6	12.2	6.4	9.3
Electricity supply (GWh)	3,149	3,376	3,540	3,979	4,386	4,800	4,527	5,146	5,683	6,173	6,086
Rate of increase %	10.2	7.2	4.8	12.4	10.2	9.4	- 5.6	13.6	10.4	8.6	- 1.4
Supply / Demand gap (Supply –Demand)	541	634	624	710	821	971	917	1,117	1,162	1,364	828

Source: CEB (Ceylon Electricity Board)

As shown in the figures in Table 1, both demand and supply were increasing rapidly throughout the 1990s (with exceptions in 1996 and 2000, both years of severe drought). The average growth rate for demand was about 8 % per year, and for supply, about 7%. Though the average rate of growth in demand outweighed that of supply, overall, the supply of electricity was steadily improving so that it equaled demand. According to the CEB's Long Term Generation Expansion Plan (2000-2014), it was estimated that the reserve margin of total capacity in 2010 would be 14.8%, enough to avoid a shortage in electricity supply. Since detailed data for the project could not be collected, it is impossible to evaluate the direct effect of the project quantitatively. However, it can be assumed that the project contributed to a better power supply network in Sri Lanka.

2.3.2 Expansion of Supply Area

Table 2: The entire transition in No. of Consumers and Household Electrification Rate in Sri Lanka

(Unit: thousand persons)

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
No. of CEB consumers	740	882	1,076	1,266	1,414	1,527	1,691	1,851	2,039	2,259	2,490
Rate of increase (%)	26.7%	19.2%	21.9%	17.7%	11.6%	8.0%	10.7%	9.5%	10.1%	10.8%	10.2%
Households Electrification rate (%)	29.0%	33.0%	35.0%	37.0%	44.5%	45.1%	46.8%	48.3%	52.4%	56.6%	61.2%

Source: CEB (Ceylon Electricity Board)

As shown in Table 2, both the number of CEB consumers and the area supplied with electricity have increased steadily since 1990. According to the CEB, with the expanded capability of the existing grid substation in Ukuwela, 9,000 consumers were newly connected to the grid. Also in Puttlam, about 15,000 consumers were newly connected to the grid and supplied electricity by the project. Moreover, most components of the project were located in areas outside the western load centers, where household electrification rates are high. The project will indirectly support electrification of more households in the future.

2.3.3 Transmission Line / Grid Substation

① Loss Rate

Table3: Loss Rate of entire networks in Sri Lanka

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Loss rate (planned) %	13	12	12	12	12	12	12	12	12	12	12
Loss rate (actual) %	17.2	18.8	19.0	17.8	18.3	18.1	14.5	17.8	18.8	20.9	21.4
Transmission Loss %	3.6	3.9	4.0	3.5	3.8	3.8	3.1	3.7	4.7	4.3	3.9
Distribution Loss %	13.6	14.9	15.0	13.5	14.5	14.3	11.4	14.1	13.2	15.8	16.5

Source: CEB (Ceylon Electricity Board)

As described in 1.1 Background, the loss rate for the entire Sri Lankan power network worsened through the 1990s, and the present loss rate is still higher than it was in 1990. Under these circumstances, however, the project contributed to the improvement of the entire power transmission and delivery network of CEB because the project distributed electricity to several regions of Sri Lanka outside of the north and east. The chart above indicates that total loss rates have become worse recently because distribution losses rose. However, transmission losses show a steady decrease from 1998 to 2000 (when the project components began operation), despite the fact that the total loss rate was increasing. This means that without implementation of the project, the total loss rate would have worsened further, causing an insufficient supply of electricity. Some representative indicators for the project prove that it contributed to a more effective supply of electricity.

② Grid Substation

The availability of an alternative 132kV supply to Anuradhapura has improved the reliability of the supply to that area.

Table 4: Voltage Fluctuations

(Unit: kW)

Grid Substation	Normal Voltage	Previous Voltage Fluctuations (1997-1998)	Present Voltage Fluctuations
Bolawatta	132	128-130	132-135 (1999-2000)
Puttlam	132	126-130	130-134 (1999-2000)

Source: CEB (Ceylon Electricity Board)

Present (2000) loading of Matara grid substation is 37.4MW, Deniyaya grid substation (near station from Matara substation) is 25.9MW and Galle substation is 54.1MW during system peak. Without the Matara grid, overloading at the Galle substation would be 143% and at Deniyaya substation it would be 122%. These figures prove that the project stabilizes electricity supply in these areas.

Expanding the capability of the existing substation reduced the risk of overload in Ukuwela. The table below compares the capacity of substation with / without the project. As clarified in this table, without this project, there would be a serious risk of frequent supply interruptions due to overload, and consumers would experience low voltage.

Table 5: Comparison of station capability with / without the project

Grid substation	Previous capacity (MVA)	New capacity (MVA)	Peak load in year 2000 (MW)	% Overloading if not augmented
Ukuwela	2×15	2×31.5	40.9	151%

Source: Ceylon Electricity Board (CEB)

Based on the above assessment, it is clear that the project helps electricity supply both in the target area and in all of Sri Lanka but the North and East. Although the change in the scope of the project reduced the benefit of the project overall, the transmission network clearly improved, as shown by the indices for loss rate and electrification rate. In addition, this project is a part of a long-term plan for developing Sri Lanka's power networks that is supported by The World Bank and the Asian Development Bank. The combined effects of the separate elements indicate even greater benefits.

It can be concluded that this project contributed to the expansion of CEB's transmission/transformation network and to the effective supply of electricity.

2.3.4 Calculation of Economic Internal Rate of Return (EIRR)

Because of the nature of the project, which does not generate its own revenue, EIRR was not calculated.

2.4 Impact

2.4.1 Improvement in Social Welfare / Economy

The macro objective of the project was to improve social welfare and the development of the economy of Sri Lanka. Although the change in the scope of the project affected the degree of the benefit, the overall objectives, like the improvement of social welfare, were achieved satisfactorily.

The analysis below indicates that the project contributed to the achievement of these objectives by contributing to job creation. Although quantitative data were not available, increased electrification in rural areas was achieved, and this created an opportunity for industries to expand, facilitating greater employment opportunities.

2.4.2 Technical Transfer

One of the project objectives was to train CEB staff in effective management. The project promoted the technological transfer to all CEB staff engaged in planning, execution, and maintenance.

Since CEB has many similar projects ongoing and planned for the future (i.e., the Long Term Transmission Development Plan, 2001-2010), this Project will not only contribute significantly to CEB, but also to the personnel responsible for design, purchasing of equipment and materials, construction, operation, and maintenance of similar projects.

2.4.3 Impact on local residents

Actually, with the construction and commissioning of the Matara Grid Substation in 1999, electricity demand grew at a rate of 11%, and present loading has become 70% of the transformer capacity. Approximately 150,000 consumers benefited from this grid substation, thereby stimulating the economy of that area. This point alone may be sufficient to prove that jobs were created as a result of commissioning this grid substation.

2.4.4 Impact on environment

No negative impact on the environment resulting from the construction work can be seen. JBIC suggested CEB to conduct an environmental impact assessment, and CEB conducted the environmental impact assessment in 1989. Negative impact was minimized when constructing new transmission lines and grid substations. (Sites like paddy fields, manmade forests, and marshy lands were selected instead of natural forests.) As a result, no negative impact on the natural environment was seen in subsequent environmental monitoring (according to the CEB).

2.5 Sustainability

2.5.1 Operation and Maintenance

The CEB organization was reformed in preparation for its maintenance role and also established a Transmission Planning and O&M Division. The Transmission Planning and O&M Division is responsible for maintenance of all facilities, but not telecommunication equipment. A deputy general manager of O&M services, who works in to the Transmission Planning and O&M Division, was hired in each of four areas (Colombo, Kandy, Anuradhapura and Galle), and a chief engineer was appointed as head of each office.

CEB branch offices are responsible for the maintenance of communications equipment, battery banks, and battery chargers. O&M service branches are responsible for the switchyard communications equipment, wave traps and constant voltage transmitter.

Maintenance personnel at offices around Colombo are responsible for day-to-day operations. Each staff employee is responsible for completing daily tasks and for planning for future needs.

① Frequency of maintenance and inspection

For major equipment, yearly-maintenance and inspection are conducted.

② Each component

Grid substations: daily and weekly
Transmission lines: once every three years, replace if necessary.

③ Inspection manual obtained from this project

Inspection is implemented according to the day-to-day operation plan, although the timing and frequency

is sometimes modified. Inspections, including inventory of spare parts, will be implemented based on the plan. In an interview with staff in the Matara Grid Substation, CEB had been providing capable staff for technical maintenance.

For the reasons mentioned above, we conclude that CEB is capable of maintaining the results and effects of the project and operating the facilities on a long-term basis.

2.5.2 Technical Capacity

All necessary machinery, including spare parts and tools, etc., was available. Inventory of spare parts was implemented in accordance with advice from power equipment manufacturers and by empirical means.

Technical capacity was adequate in the Colombo region; however, it will take at least two years to complete technology transfer to other regions. Until such time, the Colombo Region will oversee maintenance work in the other regions. As CEB has transmission lines and grid substations that it is managing as part of other projects, the contribution of technological transfer in this project is significant. In addition, the O&M Agency of CEB conducts on-the-job training and other local training sessions; foreign (manufacturers') support may be helpful for improving the technical capacity and skill level of O&M personnel.

2.5.3 Financial Status

In general, CEB's financial status was adequate to maintain sufficient equipment and personnel. However, in the year 2000/2001, CEB entered a difficult period. Affected by the serious drought, CEB was compelled to operate expensive thermal power plants to meet the growing demand for electricity. The higher cost of operating these diesel engines was not passed on to the customers because of government restrictions on price increases, which resulted in a financial crisis at CEB.

To date, CEB has met its obligations toward the lenders. However, under the circumstances, CEB finally decided, in March 2001, to increase energy costs by 25%. This is the fuel adjustment charge adjusted for the increase in the fuel price rate. At present, however, it is still unclear whether CEB's financial status will improve sufficiently to maintain adequate management of power networks.

3. Lessons Learned

None.

3. Recommendations

None.

Comparison of Original and Actual Scope

Items		Original	Actual
① Project Scope	1. Construction		
	A. Transmission lines		
	1) Constructing new lines	132kV	As planned
	-Puttlam - Anuradhapura	80km	As planned
	-K.K.S. – Chunnakam	9km	Cancelled
	-Embilipitiya – Matara	62km	As planned
	-Ukuwela	10km	As planned
	2) Replacing existing conductors	132kV	
	-Kotugoda - Bolawatte	21km	As planned
	B. Grid substations		
	1) Constructing new grid substations		
	-Kankesanthurai	132/33kV, 2x15MVA	Cancelled
	-Matara	132/33 kV, 2x30MVA	As planned
	2) Extending existing grid substations		
	-Ukuwela	2 x 15MVA→2 x 31.5MVA	As planned
		Additional four 33kV bays	Cancelled
	-Kilinochchi	Additional 132/33 kV 10MVA	Cancelled
		Additional two 33kV bays	Cancelled
	-Puttlam	Additional 132 kV switching station	As planned
	-Bolawatte	Additional 33kV bay	Cancelled
	-Kotugoda	2 x 132 kV circuit breaker	Cancelled
		3 x 33 kV circuit breaker	Cancelled
		14 x 33 kV disconnector	Cancelled
	-Anuradhapura	Additional four 33kV bay	Cancelled
	2. Consulting services		
	- Detailed designing	17 M/M	As planned
	- Supervising the construction work	115 M/M	As planned
	- Total	132 M/M	As planned
② Implementation Schedule	Selection of consultant	March 1990	May 1991
	D/D, T/D	March 1990 to August 1990	April 1992 to September 1992
	Bidding & Contract	September 1990 to February 1991	(Bidding) June 1993 to December 1993 (Contract) February 1994 to June 1995
	Construction work for transmission Lines (LOT Ⅰ)	March 1991 to December 1993	July 1995 to June 1999
	Replacement of Existing T/L Conductors	January 1993 to December 1993	July 1995 to April 1999
	Augmentation of Grid Substation(LOT Ⅱ)	March 1991 to December 1993	July 1995 to April 1998
③ Project Cost	Foreign currency	2,960 million yen	2,009 million yen
	Local currency	1,645 million yen (422 million rupee)	333million yen (171 million rupee)
	Total	4,605 million yen	2,342 million yen
	ODA Loan Portion	3,855 million yen	2,342 million yen

	Exchange rate	1 rupee = 3.9 yen (March , 1989)	1 rupee = 1.95 yen (Average for 1991 – 1999)

Independent Evaluator's Opinion on Transmission and Grid Substation Development Project

Buddhadasa Hewavitharana,
Emeritus Professor of Economics,University of Peradeniya

The objectives of the Project as they were stated in 1990, viz., to reinforce the transmission network of the CEB and grid sub-stations to ensure a secure supply of high quality electric power, remain valid today and will continue to be so with even greater force against a background of ever increasing demand for electricity, the worrisome increase in the entire networks' loss rate, the policy of expanding the generating capacity and the declared policy of increasing the provision of grid electricity from its present 53% (1998) to at least 80% of the population by 2004. Thus, the very same objectives as above are reiterated in the Power Sector Policy Directions and the Six Year Development Programme, 1999-2004. In fact, there are no less than seven transmission and grid sub-station development/rehabilitation projects taking off in 1999-2001, including two with OECF(present JBIC) assistance.

Delays on the implementation of electricity projects which can be traced to delays that are avoidable and resulting in a high level of underutilisation of funds as repeatedly reported by the Central Bank needs serious attention in view of the resource constraints experienced in the power sector. However, it is gratifying to note that limits were able to be placed on the delays arising from weaknesses in the contractors' management, a commonly reported cause of delay in project implementation, by ensuring corrective action and with the CEB controlling and monitoring the work with close attention. It is also noted that where revisions had to be made for some Project components, care has been taken to include them under a succeeding project with funds to be arranged.

Convincing are the data presented on the new connections and the stabilisation of electricity supply directly facilitated by the Project. The point that the Project contributed to the declining trend in the rate of transmission losses in the entire network after 1998, supported by specific facts and figures (Table 3), is well taken, yet, cognizance should be taken of contribution that could possibly have been made by at least two other transmission and grid sub-station projects that are reported to have been implemented in 1997.

Rural electrification is considered under current national policy to be a major means of revitalising rural development as access to electricity would enable rural areas to host industries and other off-farm income generating activities. Besides, electric lighting by itself can make a very important contribution to the quality and effectiveness of rural education. In this context it is gratifying to note that the North Central Province which at 20% records the lowest household electricity access among the nine provinces, stands to benefit immensely from the improvements to transmission at Anuradhapura. Embilipitiya, in the rural heartland of the South where electricity connections are also at a low level stands to benefit from the improvements there and so will the North Western Province, recording a 40% access benefit from an improvement at Puttalama. The Central Province recording a 45% access, will benefit from the investments at Ukuwela. In the government's policy of effecting structural socio-economic changes and pro-poor economic growth, the target set for raising the level of rural household access to electricity is from the present 44% to 80% by 2005. This stands to benefit from the contribution made by the Project.

The institution of a Division for Transmission Planning and Operation and Maintenance, the technology transferred by the Project to the CEB together with its spread effects and the steps taken to ensure that spare parts will be available and inventorised will go a long way to ensure the technological sustainability of the Project.

Sources Consulted

- Annual Report, Central Bank of Sri Lanka, 1995, 1996, 1997 and 1999.
- Public Investment Programme, National Planning Department, 1992-'96, 1995-'99, 1999-2001.
- Six Year Development Programme, 1999-2004, National Planning Department, Colombo.
- A Framework for Poverty Reduction, Government of Sri Lanka, 2000.