Democratic Socialist Republic of Sri Lanka
Ceylon Electricity Board (CEB)

Preparatory Study on National Transmission and Distribution Network Development and Efficiency Improvement Project (II) in Democratic Socialist Republic of Sri Lanka

Final Report

November 2015

Japan International Cooperation Agency (JICA)

Tokyo Electric Power Services Co., Ltd.

Nippon Koei Co., Ltd.

Executive Summary

1. Objectives

This preparatory study (hereinafter referred to as "the Study") was conducted to evaluate the application of a Japanese ODA loan to the "National Transmission and Distribution Network Development and Efficiency Improvement Project (II) in Democratic Socialist Republic of Sri Lanka" (hereinafter referred to as "the Project"). The main objectives of the Study are as follows:

- ✓ The confirmation of the Project scope.
- ✓ The preparation of the Project summary including the conceptual design, approximate cost estimate, implementation schedule, and economic evaluation of the Project.
- ✓ The confirmation of the Project implementation organization and operation and maintenance organization
- ✓ The confirmation of the environmental and social considerations for the Project.
- ✓ The confirmation of the situation regarding the Sampoor coal-fired power plant.

2. Project Summary

1) Demand Forecast

The demand forecast described in Table 3.1-1 is under review, and there is a possibility that the revised demand forecast is lower than at present. However, it has been determined to apply this demand forecast for the Study based on the discussion with CEB in consideration of some safety margin for power system analysis.

2) Generation Expansion Plan

The generation expansion plan, as described in the "Long Term Generation Expansion Plan 2013 – 2032 (October 2013)" has not been modified based on the recent situation. Therefore, it is revised and shown in Table 3.2-1; however, this may be revised based on the revised demand forecast.

3) Timing of the Step-up of Transmission Line (T/L) from 220 kV to 400 kV and the Study for the 400 kV Substation

At first, Sampoor – New Habarana T/L will be operated at 220 kV. In order to avoid increasing the number of 16.5/220 kV step-up transformers and increase the stability of generator and also to reduce the initial cost of 400/220 kV transformer for Sampoor substation, CEB would like the voltage of this T/L to be step-upped to 400 kV one year before the construction of the Trincomalee-2 Phase-I power plant.

The 400 kV substation shall be constructed at the same time as the stepping-up of the T/L. However, it will take around one year to complete the design study for the 400 kV substation; this should be started as soon as possible.

4) Facility Design of the Transmission Lines

During the first survey, the scope of the transmission lines was confirmed. Following the specifications of the 400 kV facilities ware discussed and determined with CEB engineers based on the IEC standards, the Japanese standards, and the site condition (including temperature and wind velocity). In addition, it was determined that low loss conductor should be used for the 400 kV transmission line based on the cost comparison study.

5) Facility Design of the Substations

During the first survey the scope of the substations was confirmed and the preliminary design of the 220 kV facilities was discussed and determined with CEB engineers.

In addition, the changing-over method from the 220 kV system to the 400 kV system was also proposed in consideration of reducing power outages and adverse influences on the system.

6) Estimate of the Project Costs

In light of the above, the scopes of transmission and substation facilities were determined as follows;

✓ Transmission Line

- 400 kV Sampoor – New Habarana T/L (4 x Low Loss Conductor (Zebra equivalent capacity), 95 km, 2 cct, initially operates at 220 kV)
- 220 kV Sampoor – Kappalturai T/L (2 x Zebra, 45 km, 2 cct)

✓ Switching Station at Sampoor

- 220 kV indoor GIS, one-and-half circuit breaker scheme

The base cost of the Project was calculated as follows;

Item	Foreign	Local	Total
	Mil. JPY	Mil. LKR	Mil. JPY
Package 01: Construction of transmission lines	7,747	3,847	10,913
Package 02: Construction of switching station	1,100	291	1,339
Consulting services	159	17	173

7) Environmental and Social Considerations for the Transmission Lines and Substations

The design of the 400 kV and the 220 kV transmission line was thoroughly considered by carefully taking into account various options to minimize the environmental and social impacts. In addition, it was confirmed that this Project is environmentally feasible, and that IEE report by CEB met the requirements of the JICA Guidelines.

The result of this study identifies environmental and social impacts arising due to the Project. Though there is none of significant impact, various environmental and social impacts may occur. However, these impacts can be minimized by adopting the proposed mitigation measures.

The social economic impacts which were assessed such as economic deprivation impacts of wayleave clearance on home garden, the paddy filed and other land uses. Community members of the respective areas were consulted.

The environmental management plan as well as the monitoring plan provides a guide for managing mitigation actions and tracking the compliance covering mainly the pre-construction and construction phases.

8) Economic and Financial Analysis

An assumption of analysis was discussed, and the economic and financial analysis based on this assumption was carried out.

Based on the factors such as the Project costs and loss reduction, the EIRR and FIRR were calculated as follows. It was confirmed that the Project was feasible from an economic and financial perspective.

Case	Economic Analysis		Financial Analysis	
	EIRR	B/C	FIRR	B/C
Base Case	32.58 %	2.00	29.50 %	1.23
Cost: +5 %, Benefit: 0 %	27.24 %	-	24.36 %	-
Cost: +10 %, Benefit: 0 %	21.88 %	-	19.35 %	-
Cost: 0 %, Benefit: -5 %	26.94 %	-	24.08 %	-
Cost: +5 %, Benefit: -5 %	21.36 %	-	18.85 %	-
Cost: +10 %, Benefit: -5 %	16.52 %	-	14.07 %	-
Cost: 0 %, Benefit: -10 %	20.78 %	-	18.30 %	-
Cost: +5 %, Benefit: -10 %	15.78 %	-	13.31 %	-
Cost: +10 %, Benefit: -10 %	11.53 %	-	8.76 %	-

9) Sampoor Coal-fired Power Plant

The Sampoor coal-fired power plant project shall be implemented by Trincomalee Power Company Limited (TPCL). The electric power obtained from the power plant shall be transmitted with 400 kV/220 kV transmission line above.

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Abbreviations, Acronyms, and Definitions*

**In this report the given abbreviations, acronyms, and definitions shall generally apply; however, sometimes the full (original) names may also be used interchangeably with these.*

Abbreviation, Acronym, or Definition	Full (Original) Name
ABOP	air-blast over pressure
ADB	Asian Development Bank
AIS	air-insulated switchgear
AP	angular point(s)
AQ	ambient air quality
ARP	Abbreviated Resettlement Plan
BOD	biochemical oxygen demand
BS	British standard
CAA	Coastal Conservation Act
CCD	Coast Conservation Department
CEA	Central Environmental Authority
CEB	Ceylon Electricity Board
CEB Generation Plan	Ceylon Electricity Board Long Term Generation Expansion Plan 2013 – 2032
CIF	cost, insurance and freight
COD	chemical oxygen demand
CT	current transformer
DD	data deficient
DDR	digital disturbance recorder
DS	divisional secretaries
EDS	everyday stress
EIA	environmental impact assessment
EIRR	economic internal rate of return
EMO	environmental management office
EMP	environmental management plan
EPC	engineering, procurement and construction
ESP	electrostatic precipitator
FAO	Food and Agriculture Organization
FC	Foreign Currency
FD	Forest Department
FGD	flue gas desulfurization system
FIRR	financial internal rate of return
FOB	free on board
GIB	gas insulated bus
GIS	gas insulated switchgear
GND	Grama Niladhari Divisions (the smallest administrative unit)
GRO	grievance redress officer
G/S	grid substation
Habarana T/L project	Habarana – Veyangoda Transmission Line Project Lot A
HMNP	hydro maximum generation night peak load profile
HMDP	hydro maximum generation day peak load profile
HPP	hydro power plant

HSD	high speed diesel
HVAC	heating, ventilating, and air conditioning
IDC	interest during construction
IEC	The International Electrotechnical Commission
IEE	initial environmental examination
IRR	internal rate of return
ISO	International Organization for Standardization
IUCN	International Union for Conservation of Nature
JBIC	Japan Bank for International Cooperation
JEC	Japanese Electrical Committee
JICA	Japan International Cooperation Agency
JICA Environmental Regulations	JICA Guidelines for Environmental and Social Considerations (April 2010)
JPY	Japanese yen
LC	local currency
LAA	Land Acquisition Act
LDO	light diesel oil
LF	load factor
LECO	Lanka Electricity Co. (Pvt) Ltd.
LLF	load loss factor
MHWL	maximum high water level
MOPE	Ministry of Power and Energy
MPN/100ml	most probable number per 100 milliliters
MSL	mean seawater level
NBT	Nation Building Tax
NEA	National Environmental (Amendment) Act
NGO	non-government organization
NIRP	National Involuntary Resettlement Policy
NOx	nitrogen oxide
NPV	net present values
NT	near threatened
NTPC	National Thermal Power Corporation
NTU	nephelometric turbidity Unit
O&M	operation and maintenance
ODA	official development assistance
OHWL	ordinary high water level
PAA	project approving agency
PAL	Port and Airport Development Levy
PAH	project affected households
PAP	project affected person
PI	preliminary information
PPA	power purchase agreement
PPV	peak particle velocity
Project	National Transmission and Distribution Network Development and Efficiency Improvement Project (II) in Democratic Socialist Republic of Sri Lanka
PSPP	pumped-storage power plant
PUCSL	Public Utilities Commission of Sri Lanka
OP	off peak
RMAS	remote master analysis station

RSC	Residual Sodium Carbonate
Rs, LKR	Sri Lanka rupee
ROW	Right of Way
S/S	substation
SAR	sodium absorption ration
SAS	substation automation system
SCADA	supervisory control and data acquisition
SCF	standard conversion factors
SPT	standard penetration test
T/L	Transmission Line
Team	The JICA Study team for the Project
TEC	Technical Evaluation Committee
TEPCO	Tokyo Electric Power Company, Inc.
TEPSCO	Tokyo Electric Power Services Co., Ltd.
TMNP	thermal maximum generation night peak load profile
TMDP	thermal maximum generation day peak load profile
TOR	terms of reference
TPCL	Trincomalee Power Company Limited
T-FR	Trincomalee Coal Power Co. Ltd. Feasibility Report
UNESCO	United Nations Educational Scientific and Cultural Organization
USD	United States dollar
VAT	value-added-tax (sales tax)
VU	Vulnerable
WHO	World Health Organization
XLPE	cross-linked polyethylene

Chapter 1. Introduction

1.1. Background and Objectives

Sri Lanka has 2,970 MW electric power supply capability (2012) and 2,146 MW electricity peak demand (2012), and its power system is stable comparison with other South Asian countries. In recent times the country's economy has experienced an annual average growth rate of 7%, with this economic growth bringing with it an increased demand for electricity at an annual average rate of 5-6%. Therefore, in order to meet the rapid expansion of electricity demand and decrease the generation cost, Government of Sri Lanka has actively promoted the construction of large-scale coal-fired power plants based on its long term generation expansion plan.

Recently, Sri Lanka's transmission and distribution system loss rate has been improving year by year (12.0% as at 2012). However, to meet the country's power demand expansion, it is necessary to reduce the system loss rate further through the introduction of transmission and distribution facilities including a high voltage transmission system and low-loss conductors.

Ministry of Power and Energy (MOPE) published the electrical policy for steady power supply and energy efficiency as one of the key policies in the Government's national energy policy (2006). Regarding this, MOPE considered the introduction of high voltage transmission systems which had enough transmission capacity in parallel with the construction of the large-scale power station. In addition, introduction of low-loss conductor is promoted from the point of view of transmission loss reduction.

One component of "National Transmission and Distribution Network Development and Efficiency Improvement Project (II) (hereinafter referred to as 'the Project')" is the to construction of transmission lines from the Sampoor coal-fired power plant (250 MW x 2) to the New Habarana Substation (which is located between the Sampoor coal-fired power plant and the Colombo area) and from the Sampoor coal-fired power plant to Kappalturai substation in order to evacuate the electric power from the Sampoor coal-fired power plant constructed by Trincomalee Power Company Limited (TPCL: a special-purpose company with the co-funding of National Thermal Power Corporation (NTPC) in India and Ceylon Electricity Board (CEB)). In addition, related switching stations and substation are also included in the Project for the stable power supply. Another purpose of the Project is to promote energy efficiency through the introduction of extra high voltage (400 kV) transmission facilities for the first time and low-loss conductors.

In order to facilitate this energy infrastructure, the government of Sri Lanka applied for an official development assistance (ODA) loan from the Government of Japan. To assess this ODA loan application for the Project (including to confirm the purpose, outline, Project costs, Project implementation organization, O&M organization, and environmental and social considerations), the JICA Study Team conducted the "Preparatory Study on National Transmission and Distribution Network Development and Efficiency Improvement Project (II) in Democratic Socialist Republic of Sri Lanka (hereinafter referred to as "the Study").

1.2. Organization Information

Borrower, Executing Agency and Implementing Agency are shown in Table 1.2-1.

Table 1.2-1 Organization Information

Borrower	Government of the Democratic Socialist Republic of Sri Lanka Person in Charge: Secretary, Ministry of Finance and Planning Contacts Address: P.O. Box 277, The Secretariat, Colombo 01, Sri Lanka Phone/FAX: +94 11 2484693 / +94 11 2447633 Email: info@erd.gov.lk
Executing Agency	Ministry of Power and Energy (MOPE) Person in Charge: Secretary Contacts Address: Ministry of Power and Energy No. 72, Ananda Kumaraswami Mawatha, Colombo 3, Sri Lanka Phone: +94 11 2574918
Implementing Agency	Ceylon Electricity Board (CEB) Person in Charge: General Manager Contacts Address: Ceylon Electricity Board 50, Sir Chittampalam A. Gardiner Mawatha, Colombo 2, Sri Lanka Phone/FAX: +94 11 2320953

1.3. Scope of the Project

The scope of the Project is shown in Table 1.3-1. Detailed scope of transmission lines and substation are described in "Chapter 4 Facility Design of Transmission Lines" and "Chapter 5 Facility Design of Substations".

Table 1.3-1 Scope of the Project

Transmission Line	Construction of 400 kV Sampoor – New Habarana T/L (4xZebra equivalent, 95 km, 2 cct, Initially operate at 220 kV)
	Construction of 220 kV Sampoor – Kappalturai T/L (2xZebra equivalent, 45 km, 2 cct)
Substation	Construction of 220 kV indoor GIS, One-and-half circuit breaker scheme at Sampoor S/S

The location of the Project is shown in Figure 1.3-1.

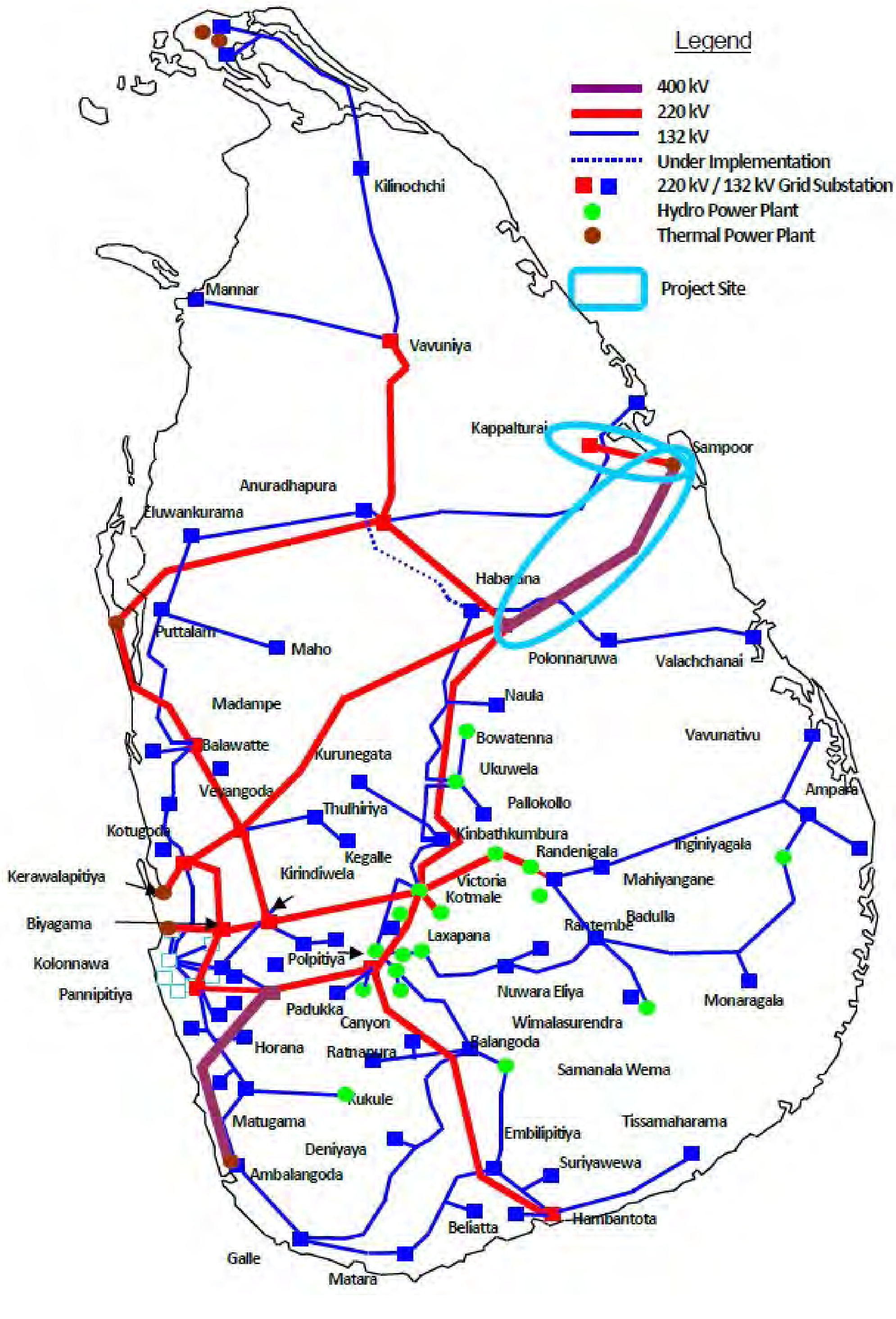


Figure 1.3-1 Location of the Project

1.4. Scope of the Study

The detailed work contents for each TOR are shown below:

1) Confirmation of the Background and Justification of the Project (TOR-1)

The JICA study team (hereinafter referred to as ‘the Team’) will collect the following information;

- ✓ The upper level plan, such as the long term development of power generation (2013), and long term development of the T/L (2013)
- ✓ Related policy
- ✓ The CEB project feasibility study report (Sampoor-New Habarana 400 kV Transmission Line Project Report (2013))
- ✓ The CEB project feasibility study report of Trincomalee Thermal Power Project (2 x 250 MW) Sri Lanka (2013)
- ✓ Data on the power demand, power flow, short circuit current, and power factor improvement, and related matters from the CEB planning division.
- ✓ Data on the number of circuits, design of conductor and earth wire, sag and tension calculation, insulator design, insulation design, tower design, bus bar arrangement, protection and control, earthing design, and related matters from the CEB design division
- ✓ Data on the control scheme, load dispatching method, communication method, and related matters from the CEB operation division
- ✓ Data on the power supply for test runs, the contract condition relating to penalty charges for delays, terminal point between CEB and the power company from Trincomalee coal-fired power plant project office

2) Study on the Scope of the Project (TOR-2)

(i) Site Survey

The Team will review the T/L routes which CEB selects. In addition, the Team shall also confirm the T/L routes by Google Earth for the site survey. On top of this, the Team will carry out the site survey on the important points which have particular technical concerns, including the cross point with rivers, roads, train routes, and other T/Ls, heavy angle points of the T/L ,and the soil survey points.

In terms of the substation, the Team will carry out the site survey mainly around the new substation and both the substation engineer and the transmission engineer shall confirm the angle of incoming T/L by using Google Earth. In addition, the Team will confirm the transportation route for heavy equipment, such as the transformer.

(ii) Preparation of the T/L Route

Based on the site survey, the transmission engineer will review the T/L route prepared by CEB in cooperation with an environmental and social specialist.

In particular, the Team and CEB shall pay particular attention to environmentally sensitive areas in order to minimize the impact on environmental and social aspect.

(iii) Confirmation of the Technical Specification of the T/L and S/S Equipment

The Team will determine the optimum technical specifications in consideration of transmission efficiency, environmental aspect, construction cost, and related matters. In addition, the special foundations of areas with soft ground shall be studied.

As for substation, the Team shall consider and propose the most efficient technical specification in addition to the general standard from the prospective of the location conditions, environmental aspects and construction costs.

The Team will not conduct specific survey for the Habarana G/S. However, it shall confirm and propose the positional relationship between the Habarana G/S and the New Habarana S/S which is currently under construction, the land dimensions to be secured for G/S, the interconnection methods between the Habarana G/S and the New Habarana S/S and the procedures necessary to prevent power outages.

The rated conditions for the equipment in the Sampoor G/S will be proposed based on the power flow and short-circuit current which are calculated by the system analysis. Therefore, the Team shall obtain the latest power plan, and related materials.

3) Survey on Natural Environmental Condition (TOR-3)

The Team will carry out the natural environmental condition survey to ensure the accuracy of deigns, construction schedule and cost estimates for the T/L. The matters to be considered in this survey are described as follows.

(i) Meteorological and Hydrological Survey

- The collection of basic data on the natural conditions, including the maximum wind velocity, the amount of rainfall, the maximum air temperature, the amount of solar radiation and the frequency of lightning strikes.

- The analysis of the river flood water level and flood plain on the T/L routes

(ii) Geological Survey

- Boring by means of standard penetration tests on the T/L routes

The Team will make efforts to collect the existing soil data by means of a geological survey, however, where necessary, it shall entrust a knowledgeable and experienced local consultant to carry out the survey on the planed T/L route based on the site survey. In addition, a topographical survey on T/L routes will be carried out by using Google Earth.

The points for the boring tests on the T/L routes were tentatively selected based on the drawings shown in the "Initial Environmental Examination (IEE) Study for the proposed 400 kV Transmission Line Project from Sampoor to Habanera (2014)".

The Team may, based on the site survey and discussion with CEB, reduce and change the survey points.

A geological survey shall not be carried out for this substation, because the land acquired by CEB for the Sampoor G/S is a thicket and flat, and the first phase construction is only for the a 220 kV GIS station that will not use heavy equipment. Thus, the boring, the standard penetration tests, water content analysis, and the soil resistivity are not important. Therefore, the geological survey is not carried out for this substation.

However, a geological survey for the T/L has been carried out inside of this substation area, and the circumstances of this location are the same as the one of the Sampoor G/S. Therefore, this boring data is available for this substation.

The soil resistivity measurements shall also be carried out at this location in order to design the earth plan for the substation.

4) TOR on Consulting Service (TOR-4)

The Team will propose the manning schedule and draft of the TOR for the consulting services which are required for the implementation of the Project in coordination with CEB.

5) Construction Method and Procurement (TOR-5)

The Team will confirm the construction method for the outline designed equipment and special method which will affect the procurement method.

As for sulfur hexafluoride gas insulated switchgear (SF6 GIS) applied at the Sampoor S/S, the Team will propose the optimum scheme through a comparison with relevant indoor and outdoor types.

In consideration of the nature of the work, the Team will study the procurement methods such as the specifications, procurement package and contract conditions. The procurement method will be determined in accordance with sufficient discussions between CEB and JICA.

6) Power Flow Analysis and Power Loss Analysis (TOR-6)

The power flow analysis shall be implemented in terms of the following objectives.

✓ To review CEB long term transmission development plan 2013-2022, long term generation expansion plan 2013-2032 and the latest revised generation expansion plan submitted by CEB and confirm applied analysis data for power flow analysis.

- ✓ To confirm pre-conditions of power-flow analysis.
- ✓ To calculate the power flow.
- ✓ To analyze the power flow in the Sampoor – New Habarana T/L operated at 220 kV.

The Team will also calculate the short circuit current in this analysis, as this will be a major factor in designing the substation and its construction costs. The Team shall incorporate the results of the analysis in the specifications of substation equipment.

The installation of the 400 kV T/L may increase the short circuit current of the 220 kV and 132 kV substation near the 400 kV substation. Therefore, in the analysis, the Team will confirm the capacity of existing substation's circuit breaker.

7) Implementation Schedule for the Project (TOR-7)

The implementation schedule is reflected the timing of installation of critical construction items, the government's environment approval process and land acquisition procedure.

In addition, the Team will plan each work schedule and study its feasibility.

Furthermore, the critical matter for the construction work is assumed to be power receiving before the commissioning operation of Sampoor coal power plant.

8) Implementation Plan (TOR-8)

The Team will propose Project Management Unit (PMU) and an O&M system (including a training plan) for the Project.

9) Environmental and Social Considerations (TOR-9)

The Team shall review the IEE prepared by CEB and verify the validity of the content.

In addition the Team shall also collect and compile the additional information required for the following matters.

- ✓ The baseline survey of the current environmental and social situation.
- ✓ The confirmation of the legislation and organizations for environmental and social considerations in Sri Lanka.
- ✓ The confirmation of the criteria and procedures for necessary permit/approval of the Project in terms of the environmental and social considerations.
- ✓ The implementation of the scoping.
- ✓ The consideration of multiple alternatives in terms of the environmental and social

considerations.

- ✓ The assessment of the environmental impact and the examination of mitigation measures.
- ✓ The preparation of environmental management plan and the monitoring plan as well as their implementation system.
- ✓ The assistance for holding stakeholders meetings.
- ✓ The confirmation of the Right of Way
- ✓ The support for preparing the Abbreviated Resettlement Plan (ARP) if necessary.

10) Cost Estimates of the Project (TOR-10)

The costs for the Project have been already prepared by CEB. The Team will determine the number of each equipment and material through the site survey and discussion with CEB. Following this, the unit price of each equipment prepared by CEB will be reviewed based on the design by the Team.

The cost estimate for the Project shall be prepared based on the cost estimate support system (a Microsoft Excel file) provided by JICA. At the verification process of the cost calculations, the Team will refer to the latest version of JICA's cost estimate manual, and explain its contents to JICA.

In addition, possibility of cost reduction of the Project will be considered.

The matters to be considered in the cost estimation are:

- ✓ The base costs of the Project
- ✓ The price escalation related to the base costs
- ✓ The contingency costs related to the base costs
- ✓ The interest during construction
- ✓ The front end fee
- ✓ The consultant fee (including price escalation and contingency costs)
- ✓ Incidental issues including: the non-eligible portion, such as compensation cost for land acquisition and resettlement (if necessary), import taxes and levies, administration costs, other agent interest charges during construction, O&M costs after construction, training, publicity, edification costs, and additional operation costs for the Project

11) Confirmation of the Sampoor Coal-fired Power Plant Construction Schedule and its Environmental and Social Considerations (TOR-11)

The Project has a close relationship with the Sampoor coal power plant project and the

Trincomalee-2, Phase-I and II Project (The coal-fired power plant, 4 unit x 300MW, construction project in Sampoor area financed by NEDO). In light of this, the Team will review and hold hearings survey about the Project plan, the progress of the construction, the organization system, and information materials which it has produced for Sampoor coal-fired power plant. In addition, some items related to facilities and environmental aspect shall be confirmed through the meeting with NEDO. The results of these reviews and hearing shall then be incorporated into the Project.

The matters to be reviewed are:

(i) Construction plan

- Overall project
- Plan of connection to the transmission system (T/L route and date of connection)
- Date of power receiving
- Date of commercial operation

(ii) Progress of construction

- Actual progress
- Any obstacle to construction

(iii) Organization system

According to the Gazette in Sri Lanka regarding to the environmental impact assessment (Gazette no. 772/22 of the 24th of June 1993, 859/14 of the 23rd of February 1995, 1104/22 of the 5th of November 1999, and 1108/1 of the 29th of November 1999) stipulates that the thermal power plants that have a generation capacity exceeding 25 MW at a single location, are subject to the EIA requirements.

The Team will confirm the official EIA progress of the Sampoor coal-fired power plant, and examine the contents of EIA report in reference to the JICA Guidelines for Environmental and Social Considerations (JICA Environmental Guidelines).

The Team will check that any negative impacts on the above matters, which have occurred due to the Project implementation, are examined so that these can be minimized during the EIA process. If it is confirmed that some matters have been examined insufficiently in reference to the JICA environmental guidelines, the Team shall then propose the effective and required activities from the perspective of the relevant environmental and social considerations.

12) Evaluation of the Project (TOR-12)

The effect by the Project will be evaluated by the availability factor of facilities, power flow at the sending point and power loss.

As for the reduction of greenhouse gas emission, these will be calculated based on the power loss reduction calculated by the power system analysis.

The Economic Internal Rate of Return (EIRR) will be calculated by using the revised cost of the Project based on the Study. The benefit from the Project will be calculated from their directly effect (economic effect from additional supply) and their indirect effect (including reducing greenhouse gas emission). The Team will also calculate the benefits on a scenario-by-scenario basis.

1.5. Schedule of the Study

The entire study period is approximately fourteen months: from November 2014 to December 2015.

The first survey in Sri Lanka was conducted from 7 to 25 December 2014 (shown in Figure 1.5-1); the second survey from 18 to 31 January 2015 (shown in Figure 1.5-2); and the third survey from 22 February to 2 April 2015 (shown in Figure 1.5-3).

		Kitamura (Team Leader)	Tada (Deputy Team Leader)	Minagawa (Transmision Line)	Tokunaga (Substation)	Miwa (Power Development)	Takase (Power System)	Tanaka (Environment 1)
7-Dec	Sun	Move to Colombo		Move to Colombo	Move to Colombo	Move to Colombo	Move to Colombo	Move to Colombo
8-Dec	Mon	Kick-off Meeting		Kick-off Meeting	Kick-off Meeting	Kick-off Meeting	Kick-off Meeting	Kick-off Meeting
9-Dec	Tue	Data Collection/ Meeting, etc.		Data Collection/ Meeting, etc.	Data Collection/ Meeting, etc.	Data Collection/ Meeting, etc.	Data Collection/ Meeting, etc.	Data Collection/ Meeting, etc.
10-Dec	Wed	Site Survey		Site Survey	Site Survey	Site Survey	ditto	Site Survey
11-Dec	Thu	ditto		ditto	ditto	ditto	ditto	ditto
12-Dec	Fri	ditto		ditto	ditto	ditto	ditto	ditto
13-Dec	Sat	ditto		ditto	ditto	ditto	Work	ditto
14-Dec	Sun	ditto	Move to Colombo	ditto	ditto	ditto	ditto	ditto
15-Dec	Mon	Data Collection/ Meeting, etc.	Data Collection/ Meeting, etc.	Data Collection/ Meeting, etc.	Data Collection/ Meeting, etc.	Data Collection/ Meeting, etc.	Data Collection/ Meeting, etc.	Data Collection/ Meeting, etc.
16-Dec	Tue	ditto	ditto	ditto	ditto	ditto	ditto	ditto
17-Dec	Wed	ditto	ditto	ditto	ditto	ditto	ditto	ditto
18-Dec	Thu	ditto	ditto	ditto	ditto	ditto	ditto	ditto
19-Dec	Fri	ditto	ditto	ditto	ditto	JICA/Move to Tokyo	ditto	ditto
20-Dec	Sat	Internal Meeting	Internal Meeting	Internal Meeting	Internal Meeting	Arrive at Tokyo	Internal Meeting	Internal Meeting
21-Dec	Sun	ditto	ditto	ditto	ditto		ditto	ditto
22-Dec	Mon	Data Collection/ Meeting, etc.	Data Collection/ Meeting, etc.	Data Collection/ Meeting, etc.	Data Collection/ Meeting, etc.		Data Collection/ Meeting, etc.	Data Collection/ Meeting, etc.
23-Dec	Tue	Contract with Local Consultant, etc.	Contract with Local Consultant, etc.	Contract with Local Consultant, etc.	ditto		ditto	Contract with Local Consultant, etc.
24-Dec	Wed	Meeting with JICA/ Move to Tokyo	Meeting with JICA/ Move to Tokyo	Meeting with JICA/ Move to Tokyo	Meeting with JICA/ Move to Tokyo		Meeting with JICA/ Move to Tokyo	Meeting with JICA/ Move to Tokyo
25-Dec	Thu	Arrive at Tokyo	Arrive at Tokyo	Arrive at Tokyo	Arrive at Tokyo		Arrive at Tokyo	Arrive at Tokyo

Figure 1.5-1 Schedule of First Survey in Sri Lanka

		Kitamura (Team Leader)	Tada (Deputy Team Leader)	Minagawa (Transmision Line)	Tokunaga (Substation)	Miwa (Power Development)	Takase (Power System)	Tanaka (Environment 1）	Tanabe (Environment 2)	Suzuki (Economisit)
18-Jan	Sun	Move to Colombo		Move to Colombo	Move to Colombo	Move to Colombo	Move to Colombo	Move to Colombo	Move to Colombo	Move to Colombo
19-Jan	Mon	Kick-off Meeting		Kick-off Meeting	Kick-off Meeting	Kick-off Meeting	Kick-off Meeting	Kick-off Meeting	Kick-off Meeting	Kick-off Meeting
20-Jan	Tue	Work		Work	Work	Work	Work	Site Survey (Kerawarapitiya SS)	Site Survey	Work
21-Jan	Wed	ditto		ditto	ditto	ditto	ditto	Work	ditto	ditto
22-Jan	Thu	ditto		ditto	ditto	ditto	ditto	ditto	ditto	ditto
23-Jan	Fri	ditto		ditto	ditto	ditto	ditto	ditto	Work	ditto
24-Jan	Sat	Internal Meeting	Move to Colombo	Internal Meeting	Internal Meeting	Internal Meeting	Internal Meeting	Internal Meeting	Internal Meeting	Internal Meeting
25-Jan	Sun	ditto	Internal Meetng	ditto	ditto	ditto	ditto	ditto	JICA/Move to Tokyo	ditto
26-Jan	Mon	Work	Work	Work	Work	Work	Work	Work	Arrive at Tokyo	Work
27-Jan	Tue	ditto	ditto	ditto	ditto	ditto	ditto	ditto		ditto
28-Jan	Wed	ditto	ditto	ditto	ditto	ditto	ditto	ditto		ditto
29-Jan	Thu	ditto	ditto	ditto	ditto	ditto	ditto	ditto		ditto
30-Jan	Fri	Work/ Move to Tokyo	Work/ Move to Tokyo	Work/ Move to Tokyo	Work/ Move to Tokyo	Work/ Move to Tokyo	Work/ Move to Tokyo	Work/ Move to Tokyo		Work/ Move to Tokyo
31-Jan	Sat	Arrive at Tokyo	Arrive at Tokyo	Arrive at Tokyo	Arrive at Tokyo	Arrive at Tokyo	Arrive at Tokyo	Arrive at Tokyo		Arrive at Tokyo

Figure 1.5-2 Schedule of Second Survey in Sri Lanka

		Kitamura (Team Leader)	Minagawa (Transmision Line)	Tokunaga (Substation)	Tanaka (Environment 1)	Tanabe (Environment 2)	Suzuki (Economisit)
22-Feb	Sun	Move to Colombo	Move to Colombo	Move to Colombo	Move to Colombo		
23-Feb	Mon	Work	Work	Work	Work		
24-Feb	Tue	ditto	ditto	ditto	ditto		
25-Feb	Wed	ditto	ditto	ditto	ditto		
26-Feb	Thu	ditto	ditto	ditto	ditto		
27-Feb	Fri	ditto	ditto	ditto	ditto		
28-Feb	Sat	Internal Meeting	Internal Meeting	Internal Meeting	Internal Meeting		
1-Mar	Sun	ditto	ditto	ditto	ditto		
2-Mar	Mon	Meeting with CEB	Meeting with CEB	Meeting with CEB	Meeting with CEB		
3-Mar	Tue	Work	Work	Work	Work		
4-Mar	Wed	ditto	ditto	ditto	ditto		
5-Mar	Thu	ditto	ditto	ditto	ditto		
6-Mar	Fri	ditto	ditto	ditto	ditto		
7-Mar	Sat	Internal Meeting	Internal Meeting	Internal Meeting	Internal Meeting		
8-Mar	Sun	ditto	ditto	ditto	ditto		
9-Mar	Mon	Work	Work	Work	Work		
10-Mar	Tue	ditto	ditto	ditto	ditto		
11-Mar	Wed	ditto	ditto	ditto	ditto		
12-Mar	Thu	ditto	ditto	ditto	ditto		
13-Mar	Fri	ditto	ditto	JICA/Move to Tokyo	ditto		
14-Mar	Sat	Internal Meeting	Internal Meeting	Arrive at Tokyo	Internal Meeting		
15-Mar	Sun	ditto	ditto		ditto		
16-Mar	Mon	Work	Work		Work		
17-Mar	Tue	ditto	ditto		ditto		
18-Mar	Wed	ditto	ditto		ditto		
19-Mar	Thu	ditto	ditto		ditto		
20-Mar	Fri	ditto	ditto		ditto		
21-Mar	Sat	Internal Meeting	Internal Meeting		Internal Meeting		
22-Mar	Sun	ditto	ditto		ditto		
23-Mar	Mon	Work	Work		Work	Move to Colombo	Move to Colombo
24-Mar	Tue	ditto	ditto		ditto	Work	Work
25-Mar	Wed	ditto	ditto		ditto	ditto	ditto
26-Mar	Thu	Move to Site	ditto		Move to Site	ditto	ditto
27-Mar	Fri	Stakeholder Meeting	ditto		Stakeholder Meeting	ditto	ditto
28-Mar	Sat	ditto	Internal Meeting		ditto	Internal Meeting	Internal Meeting
29-Mar	Sun	Move to Colombo	ditto		Move to Colombo	ditto	ditto
30-Mar	Mon	Work	Work		Work	Work	Work
31-Mar	Tue	ditto	ditto		ditto	ditto	ditto
1-Apr	Wed	JICA/Move to Tokyo	JICA/Move to Tokyo		JICA/Move to Tokyo	JICA/Move to Tokyo	JICA/Move to Tokyo
2-Apr	Thu	Arrive at Tokyo	Arrive at Tokyo		Arrive at Tokyo	Arrive at Tokyo	Arrive at Tokyo

Figure 1.5-3 Schedule of Third Survey in Sri Lanka

The forth survey in Sri Lanka was conducted from 29 June to 3 July 2015 for the explanation of draft final report and the fifth survey for additional environmental and social consideration survey was performed from 3 to 17 August 2015.

The reports to be submitted during the study period are as follows:

- ✓ Inception Report: beginning of December 2014
- ✓ Interim Report: middle of February 2015
- ✓ Draft Final Report: middle of April 2015
- ✓ Draft Final Report 2: middle of October 2015
- ✓ Final Report: middle of November 2015 (this report)

1.6. The Study Team Members

The names and positions of the members of the Team are shown in Table 1.6-1.

Table 1.6-1 Organization of the Team

Name	Position
Kenichi KITAMURA	Team Leader
Masahiko TADA	Deputy Team Leader
Fumiyasu MINAGAWA	Transmission Line Engineer (1)
Hiroaki YOSHIZAWA	Transmission Line Engineer(2)
Ryosuke TOKUNAGA	Substation Engineer
Yasuhide MIWA	Power Development Specialist
Hidekazu TAKASE	Power System Analysis Specialist
Tetsujiro TANAKA/ Shinjiro OKUSAWA	Environmental and Social Specialist (1)
Tomoaki TANABE	Environmental and Social Specialist (2)
Shigeru SUZUKI	Economist

Chapter 2. Power Sector

2.1. Institutions

Institutions under the purview of Ministry of Power and Energy (MOPE) are shown in Figure 2.1-1.

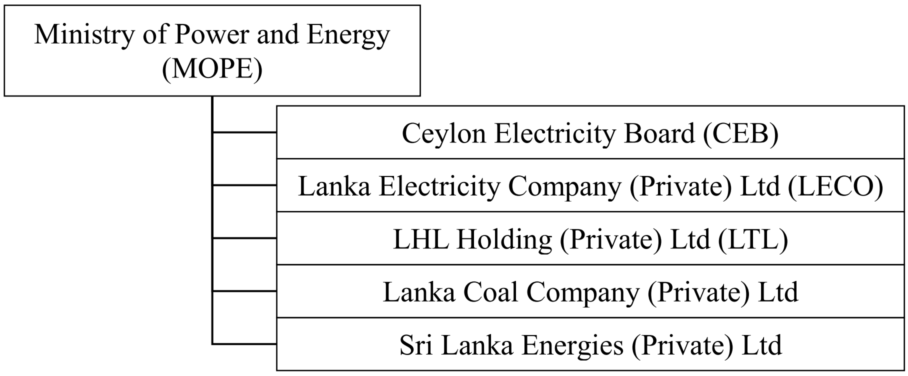


Figure 2.1-1 Institutions of Power Sector

MOPE has a responsibility of formulating and implementing of the policies for the generation, transmission, distribution and retailing of electrical energy. The electricity is supplied by CEB and LECO, and Public Utilities Commission of Sri Lanka (PUCSL) will regulate those utilities in the safety aspect and price.

2.2. Ministry of Power and Energy (MOPE)

As mentioned-above, formulating and implementing policies for the generation, transmission, distribution and retailing of electrical energy is the responsibility of the MOPE.

According to “Performance 2014 and Programmes for 2015” published by MOPE, following mandates are mentioned;

- ✓ The formulation of policies, programmes and projects in regard to the subjects of Power and Energy and all subjects of that come under the purview of Statutory Institutes of the Ministry on the basis of Mahinda Chinthana – Vision for the Future and any other over-all National Policies that may be adopted by the Government

- ✓ The direction of the implementation of such policies, programmes and projects with a view to achieving the relevant national objectives within time lines agreed with the national planning authorities and within budgeted resources

- ✓ The provision of all public services that come under the purview of the Ministry in an efficient manner deploying modern management techniques and technology where application and waste

- ✓ The reforming of all systems and procedures to ensure the conduct of business in an efficient manner deploying modern management techniques and technology where applicable while eliminating corruption and waste

- ✓ The investigation, planning and development of electricity facilities throughout the Island including hydropower, thermal power and coal
- ✓ The rural electrification
- ✓ The development of a sound, adequate and uniform electricity policy for the control, regulation and utilization of national power Resources
- ✓ All other subjects that come under the purview of Statutory Institutions of the Ministry
- ✓ The supervision of Statutory Institutions of the Ministry

Based on the above-mentioned mandate, power sector development activities and investment programme has been formulated, and following targets are set out;

- ✓ Providing 100% electricity to entire population in the country, at all times, though grid and off grid schemes by end 2014
- ✓ <u>Increasing the generation capacity of the system from present level of 4,015 MW to 6,400 MW by 2025</u>
- ✓ <u>Reducing the generation cost by adding aggregate base load capacity of about 2,000 MW of coal fired power plants in 2002</u>
- ✓ Increase the share in grid energy supply by Non-Conventional Renewable energy sources from 4.1 % in 2007 to 10% by 2015 and 20% by 2020
- ✓ Reduce the technical and commercial losses of the transmission and distribution network from 14.5% in 2009 to 11.2% by 2012, 11.0% by 2016 and 10% by 2020

In order to meet the above-mentioned underlined purpose, Sampoor coal-fired power plant will be constructed. In addition, the 400 kV Sampoor – New Habarana T/L, the 220 kV Sampoor – Kappalturai T/L and the 220 kV GIS at the Sampoor switching station shall be constructed in order to evacuate the generated power.

Then, MOPE published "Sri Lanka Energy Sector Development Plan for a Knowledge-based Economy 2015-2025" at the end of March, 2015, and energy sector target is added/modified as follows;

- ✓ <u>To make Sri Lanka an energy self-sufficient nation by 2030</u>
- ✓ <u>Increase the share of electricity generation from renewable energy sources from 50% in 2014 to 60% by 2020 and finally to meet the total demand from renewable and other indigenous energy resources by 2030</u>
- ✓ Increase the electricity generation capacity of the system from 4,050 MW to 6,400 MW by 2025
- ✓ <u>Generate a minimum 1,000 MW of electricity using indigenous gas resources discovered in Mannar basing by 2020</u>

- ✓ Increase generation capacity of low cost thermal power plants fired by natural gas and biomass to 2,000 MW to reduce the generation costs and to diversify generation mix by 2020

- ✓ Provide affordable electricity coverage to 100% of the people of the country on a continuous basis before end 2015

- ✓ Reduce the technical and commercial losses of the electricity transmission and distribution network from 11% to 8% by 2020

- ✓ Reduce annual energy demand growth by 2% through conservation and efficient use

- ✓ Reduce the petroleum fuel use in the transport sub-sector by 5% by introducing alternative strategies such as efficient modes of transport and electrification of transport by 2020

- ✓ Produce the total petroleum product demand of the country through our own refinery by 2025

- ✓ Upgrade quality of Gasoline and Diesel to EURO IV and EURO III respectively by 2018

- ✓ Further enhance the quality and reliability of electricity and fuel supply

- ✓ Broadening energy sector investment widows to include bonds, debentures, public private partnerships and other such novel financial instruments

- ✓ Reduce the carbon footprint of the energy sector by 5% by 2025

Therefore, it is considered that electricity generated by coal-fired power plant will be reduced based on the above-mentioned underlined purposes. However, the Project is included because of the strengthening of the electricity transmission network to meet additional generation capacity.

At present, CEB is estimating demand forecast and preparing generation expansion plan based on the above-mentioned targets.

2.3. Public Utilities Commission of Sri Lanka

The Public Utilities Commission of Sri Lanka (PUCSL) was established by the Act No. 35 of 2002 as a national multi-sector infrastructure regulator. Initially PUCSL Act provided for regulation of the Electricity and Water Service industries, later in March 2006 Petroleum industry was also added to the list of industries to be regulated by PUCSL.

With the enactment of the Sri Lanka Electricity Act, No. 20 of 2009, the PUCSL became the economic, safety and technical regulator for the electricity industry.

Subject to the provisions of the PUCSL act, PUCSL shall, among other things,

- ✓ Exercise, perform and discharge the powers, functions and duties conferred on or assigned to the PUCSL by or under this Act or any industry Act

- ✓ Consult, to the extent the PUCSL considers appropriate, any person or group who or which may be affected, or likely to be affected by the decisions of the PUCSL

- ✓ Advice the Government, as the PUCSL deems appropriate, on all matters concerning any industry falling within the purview of this Act

- ✓ Collect, record, and disseminate, information concerning any public utilities industries

- ✓ Prepare within six months of its establishment a regulatory manual containing a code of good practice governing the functions of the PUCSL and revise it as and when required

- ✓ Exercise licensing, regulatory and inspection functions in respect of all matters provided for in any industry Act

- ✓ Enforce the provisions of licenses, contracts and other instruments issued under the authority of any industry Act

- ✓ Regulate tariffs and other charges levied by regulated entities where required by any industry Act

- ✓ Determinate by mediation disputes arising in any public utilities industry

- ✓ Set and enforce technical and other standards relating to the safety, quality, continuity and reliability of the public utilities industries

- ✓ Undertake such other incidental or ancillary activities which the PUCSL may consider appropriate for the effective discharge of any of its functions

2.4. Electric Power Utilities

CEB and LECO are the only two electric power utilities in the power sector. Organization of CEB is shown in Figure 2.1-2.

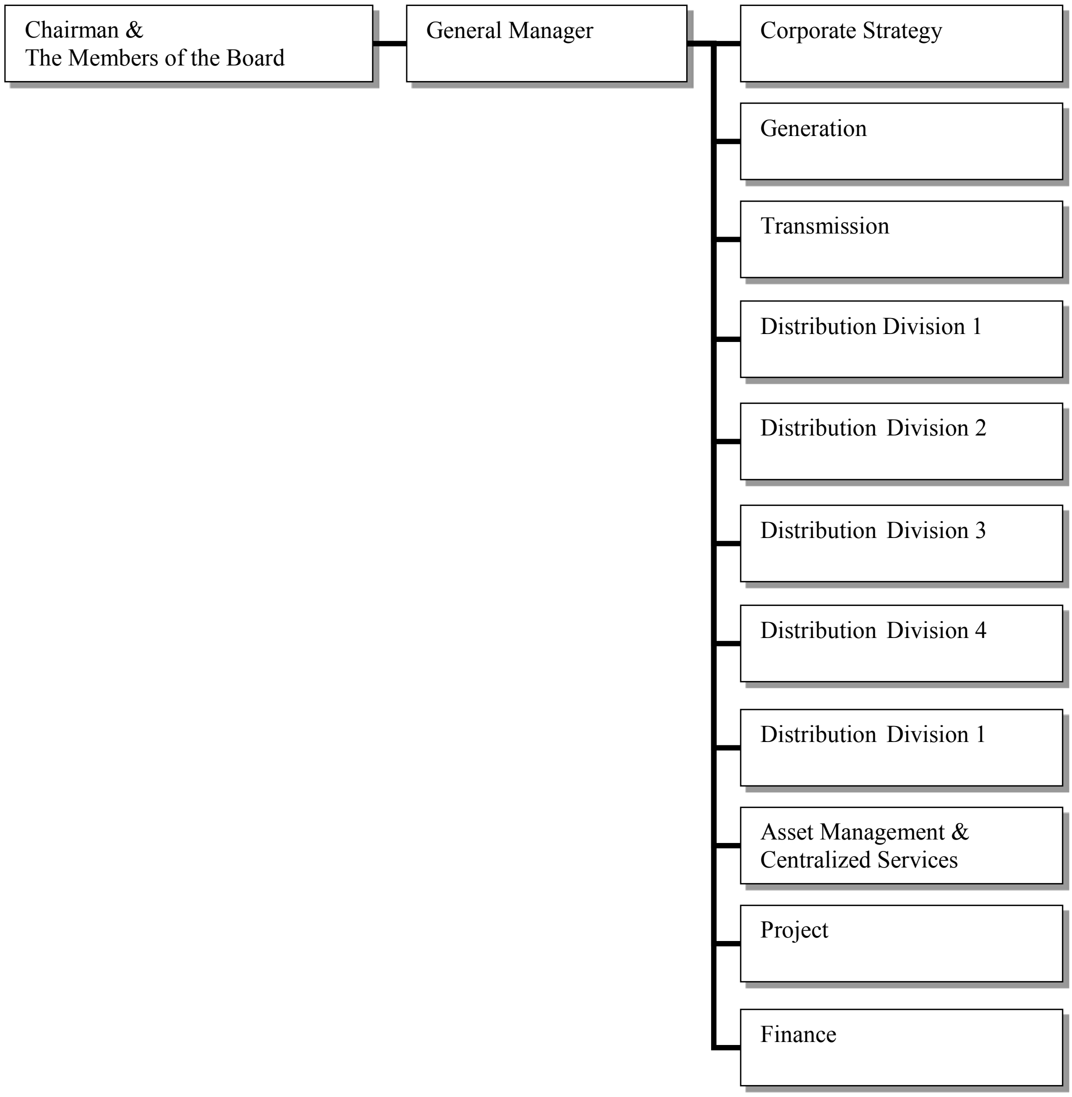


Figure 2.1-2 CEB Organization Chart

CEB was established in terms of the Act of Parliament No.17 of 1969 as a state-owned, vertically integrated utility. CEB is responsible for power generation, transmission, and distribution. It raised 89.7% of electricity sales in Sri Lanka and served 5.2 million consumer accounts in 2013.

LECO commenced operations by taking over of the electricity distribution systems in the Kotte urban council area in 1984 to serve a then customer base of 12,000 customers. It purchases electric power from CEB and in 2013, it distributed 1,222 GWh of energy to approximately 500,000 consumers.

Summary statistics are shown in Table 2.1-1.

Table 2.1-1 Summary Statistics

Item	2012	2013	Growth Rate (2012 – 2013) (%)
Total Installed capacity (MW)	3,312	3,362	1.5
Installed capacity by CEB (MW)	2,214	2,228	0.6
Hydro	1,357	1,361	0.3
Thermal - Oil	554	564	1.8
Thermal - Coal	300	300	0.0
Wind	3	3	0.0
Installed capacity by IPPs (MW)	1,098	1,134	3.3
Hydro - Small	227	267	17.6
Thermal	784	771	-1.7
Non-Conventional Renewable Energy	87	96	10.3
Gross Generation (GWh)	11,801	11,962	1.4
Gross Generation by CEB (GWh)	6,162	8,808	42.9
Hydro	2,727	6,010	120.4
Thermal - Oil	2,029	1,326	-34.6
Thermal - Coal	1,404	1,469	4.6
Wind	2	2	0.0
Gross Generation by IPPs (GWh)	5,640	3,154	-44.1
Hydro - Small	565	916	62.1
Thermal	4,906	1,977	-59.7
Non-Conventional Renewable Energy	169	260	53.8
Electricity sales by CEB (GWh)	10,475	10,621	1.4
Domestic and Religious	3,577	3,546	-0.9
Industrial	3,285	3,344	1.8
General Purpose and Hotel	2,202	2,227	1.1
Government	-	89	-
Bulk Sales to LECO	1,302	1,308	0.5
Street Lighting	109	108	-0.9
Electricity Sales by LECO (GWh)	1,217	1,222	0.4
Domestic and Religious	539	522	-3.2
Industrial	236	239	1.3
General Purpose and Hotel	412	431	4.6
Government	-	5	-
Temporary Connections	1	1	0.0
Street lighting	29	24	-17.2
Overall System Loss of CEB (%)	11.2	11.1	-0.9
Transmission & Distribution Losses	10.7	10.8	1.1
No. of Consumers (CEB+LECO) ('000)	5,477	5,717	4.4
Domestic and Religious	4,842	5,047	4.4
Industrial	54	56	3.7
General Purpose and Hotel	576	607	5.4

(Source: Central Bank of Sri Lanka Annual Report 2013 and CEB Statistical Digest 2013)

Chapter 3. Power System Analysis

3.1. Demand Forecast

The CEB Sri Lanka power demand forecast for 2015–2039 is shown in Table 3.1-1. According to this, Sri Lanka's power demand was 2,398 MW in 2014. The power demand is expected to increase annually at 4.7% from 2014 to 2039. Its maximum power demand is expected to be 7,493 MW in 2039. On the other hand, the power loss is expected to decrease from 10.79% in 2014 to 9.40% in 2039. This loss is expected to be reduced by the expansion of the transmission line network.

Table 3.1-1 Econometric Base Demand Forecast 2015 - 2039

Year	Demand (GWh)	Losses (%)	Generation (GWh)	Peak (MW)	Off-Peak (MW)
2014	10,953	10.79	12,278 *	2,398	959
2015	11,516	10.73	12,901 **	2,515	1,006
2016	12,015	10.68	13,451 **	2,611	1,044
2017	12,842	10.62	14,368	2,791	1,116
2018	13,726	10.57	15,348	2,926	1,170
2019	14,671	10.51	16,394	3,124	1,250
2020	15,681	10.46	17,512	3,294	1,318
2021	16,465	10.40	18,376	3,458	1,383
2022	17,288	10.35	19,283	3,630	1,452
2023	18,155	10.29	20,238	3,812	1,525
2024	19,069	10.23	21,243	4,003	1,601
2025	20,033	10.18	22,303	4,096	1,638
2026	21,050	10.12	23,421	4,304	1,722
2027	22,125	10.07	24,601	4,525	1,810
2028	23,243	10.01	25,829	4,754	1,902
2029	24,402	9.96	27,100	4,991	1,966
2030	25,598	9.90	28,410	5,100	2,040
2031	26,827	9.84	29,756	5,346	2,138
2032	28,087	9.79	31,135	5,597	2,239
2033	29,395	9.73	32,565	5,858	2,343
2034	30,759	9.68	34,055	6,131	2,452
2035	32,184	9.62	35,611	6,253	2,501
2036	33,673	9.57	37,235	6,542	2,617
2037	35,231	9.51	38,934	6,845	2,738
2038	36,862	9.46	40,711	7,162	2,865
2039	38,569	9.40	42,571	7,493	2,997

* Fixed base on Energy Dispatch Forecast 2014 from system control center

** Fixed base on Energy Marketing Branch Energy Demand Forecast 2015-2016

(Source: CEB Planning Section (As at December 19, 2014))

3.2. Generation Expansion Plan

3.2.1. Generation Expansion Plan

The CEB generation expansion plan for Sri Lanka is shown in Table 3.2-1. This generation expansion is planned based on demand forecast (Table 3.1-1) and generation plan that has been clarified at the time in January 30, 2015. The gas turbine generation plants planned for 2018, 2019, and 2021 will be installed at the Kelanitissa power station.

The coal-fired power plants around the Sampoor substation are planned to be constructed and commissioned in 2020, 2022, 2023, and 2024. Other coal-fired power plants are planned to be constructed around Hanbantota. At present, CEB is preparing the revised generation expansion plan based on the materials including the revised demand forecast and MOPE targets.

Table 3.2-1 Generation Expansion Planning (Base Case 2015-2034)

Year	Renewable Additions	Thermal Additions	Thermal Retirement
2015	-	-	-
2016	-	-	-
2017	35 MW Broadlands HPP 120 MW Uma Oya HPP	-	5 x 17 MW Kelanitissa Gas Turbines
2018	-	3 x 35 MW Gas Turbine	8 x 6.13 MW Asia Power
2019	-	1 x 105 MW Gas Turbine	4 x 18 MW Sapugaskanda diesel
2020	31 MW Moragolla HPP 15 MW Thalpitigala HPP	2 x 250 MW Sampoor Coal-fired Power Plants	6 x 16.6 MW Heladanavi Puttalam 14 x 7.11 MW ACE Power Embilipitiya 4 x 15 MW Colombo Power
2021	-	2 x 35MW Gas Turbine	-
2022	20 MW Seethawaka HPP 20 MW Gin Ganga HPP	2 x 300 MW Ad. Sub Critical Coal-fired Plants – Trincomalee-2, Phase-I	-
2023	-	1 x 300 MW Ad. Sub Critical Coal-fired Plants - Trincomalee-2, Phase-II	163 MW AES Kelanitissa Combined Cycle Plant 115 MW Gas Turbine 4 x 9 MW Sapugaskanda Diesel Ext. 6 x 5 MW Northern Power
2024	-	1 x 300 MW Ad. Sub Critical Coal-fired Plants - Trincomalee-2, Phase-II	-
2025	1 x 200 MW PSPP	-	4 x 9 MW Sapugaskanda Diesel Ext.
2026	-	-	-
2027	2 x 200 MW PSPP	1 x 300 MW Ad. Sub Critical Coal-fired Plant	-
2028	-	1 x 300 MW Ad. Sub Critical Coal-fired Plant	-
2029	-	-	-
2030	-	1 x 300 MW Ad. Sub Critical Coal-fired Plant	-
2031	-	1 x 300 MW Ad. Sub Critical Coal-fired Plant	-
2032	-	-	-
2033	-	2 x 300M W Ad. Sub Critical Coal-fired Plant	165 MW Combined Cycle Plant (KPS)
2034	-	-	-

(Source: CEB Planning Section (As at 30 January 2015))

3.2.2. Power System Conditions around the Sampoor Substation

The Sampoor coal-fired power plant and Trincomalee-2 power plant will be constructed around the Sampoor substation. These coal-fired power plants will be connected to the Sampoor substation.

The Sampoor coal-fired power plant which is planned to be built and commissioned in 2020 will be interconnected with the Sampoor substation by 220 kV transmission lines. The transmission lines between the Sampoor substation and the New Habarana substation will also be operated at 220 kV. However, this transmission lines are designed for 400kV system. The power system condition as predicted for 2020 is shown in Figure 3.2-1.

The Trincomalee-2 Phase–I power plant to be built and commissioned in 2022 will be interconnected with the Sampoor substation by 400 kV transmission lines. To facilitate this, CEB will need to construct 400 kV substation facilities in the Sampoor substation. Following this the transmission lines between the Sampoor substation and the New Habarana substation will then be stepped-up to 400 kV. The power system condition as predicted for 2022 is shown in Figure 3.2-2.

The Trincomalee-2 Phase–II power plant scheduled to be built and commissioned between 2023 and 2024 will be interconnected with the 400 kV transmission line. The power system condition as predicted for 2024 is shown in Figure 3.2-3.

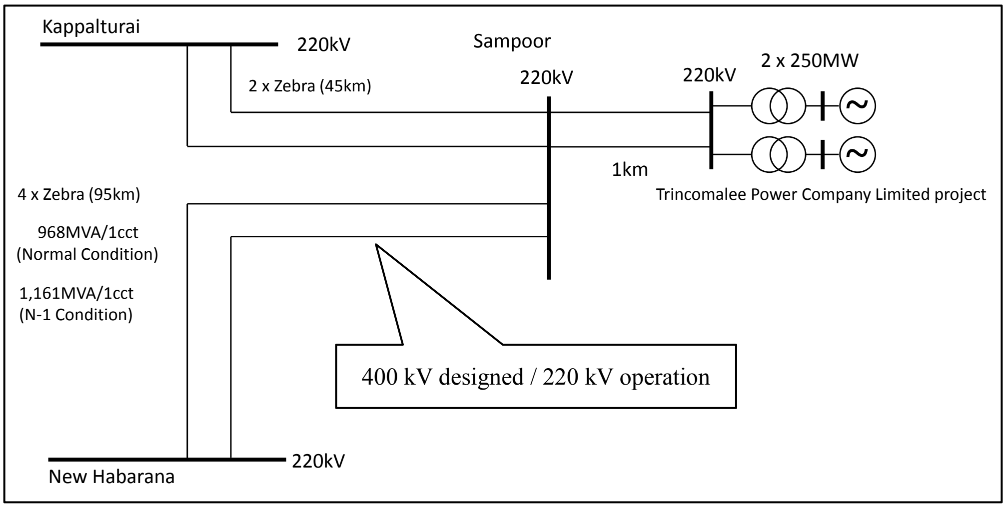


Figure 3.2-1 Power System Conditions around the Sampoor Substation in 2020

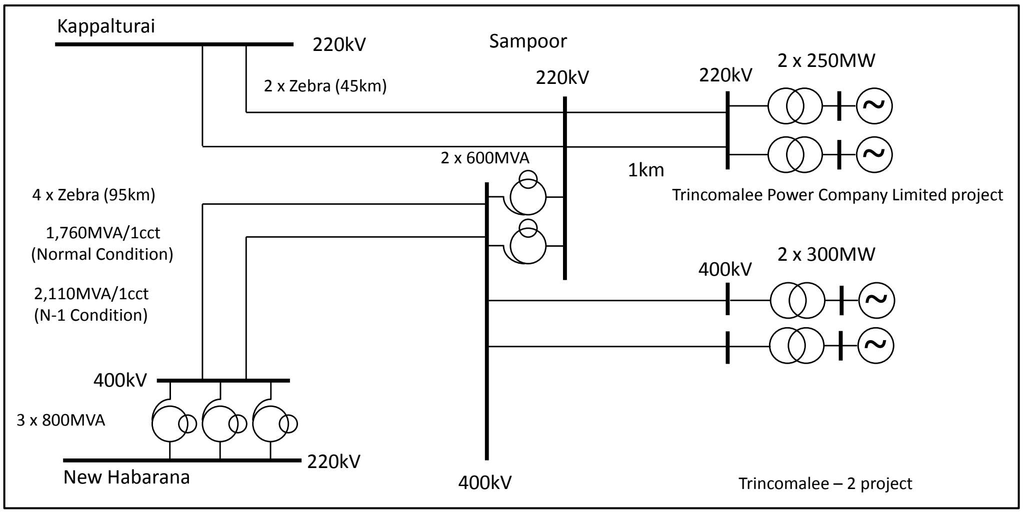


Figure 3.2-2 Power System Conditions around the Sampoor Substation in 2022

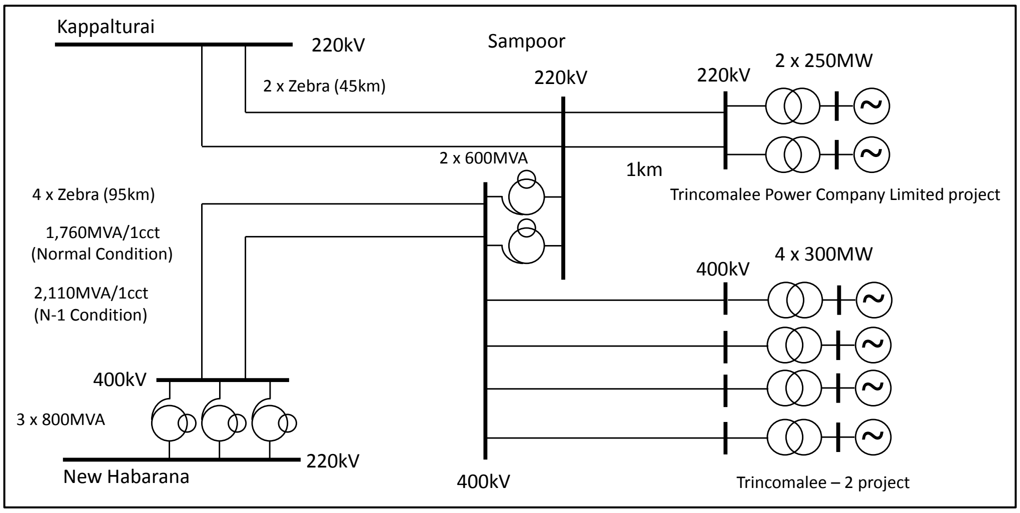


Figure 3.2-3 Power System Conditions around the Sampoor Substation in 2024

3.2.3. Coal-fired Power Plant Parameters

The Coal-fired power plant parameters provided by CEB are shown in Table 3.2-2. According to this table, the maximum net output power of the Sampoor coal-fired power plant is 227 MW and the Trincomalee-2 power plant is 270 MW. The house rate is expected to be approximately 10% in both power plants. The minimum operating level of the Trincomalee-2 power plant is predicted to be 35% - meaning that the plant will have a high adjustment capability.

Table 3.2-2 Summary of the Coal-fired Power Plant Parameters

Parameter		Units	Puttalam Plant	Sampoor Coal-fired Power Plant	Trincomalee-2 Coal-fired Power Plant
Unit Capacity [Gross]		MW	300	250	300
Unit Capacity [Net]		MW	275	227	270
Minimum Operating level		% (MW)	73% (200 MW)	60% (136.2 MW)	35% (95 MW)
Operation Range	Leading	%	90	90	90
	Lagging	%	85	85	85

(Source: CEB Planning Section)

3.2.4. Examining the Scope of the Transmission Line Capacity

The Team examined transmission line capacity under the conditions of full generation output of the Sampoor coal-fired power plant and the Trincomalee-2 coal-fired power plant as predicted for 2024. The net values described in Table 3.2-2 were used as the maximum output of the generation power. These power system conditions around the Sampoor substation as predicted for 2024 under normal generation conditions are shown Figure 3.2-4. In this case, the power factor of the generator was assumed to be 85% and the power demand of the Kappalturai substation and the Sampoor substation was assumed to be zero MW. As a result it is likely that the power flow would be lower than the transmission line capacity.

Furthermore, the Team also examined the transmission line capacity under the N-1 situation as predicted for 2024. This situation is shown Figure 3.2-5, according to which it is likely that the power flow would be lower than the transmission line capacity.

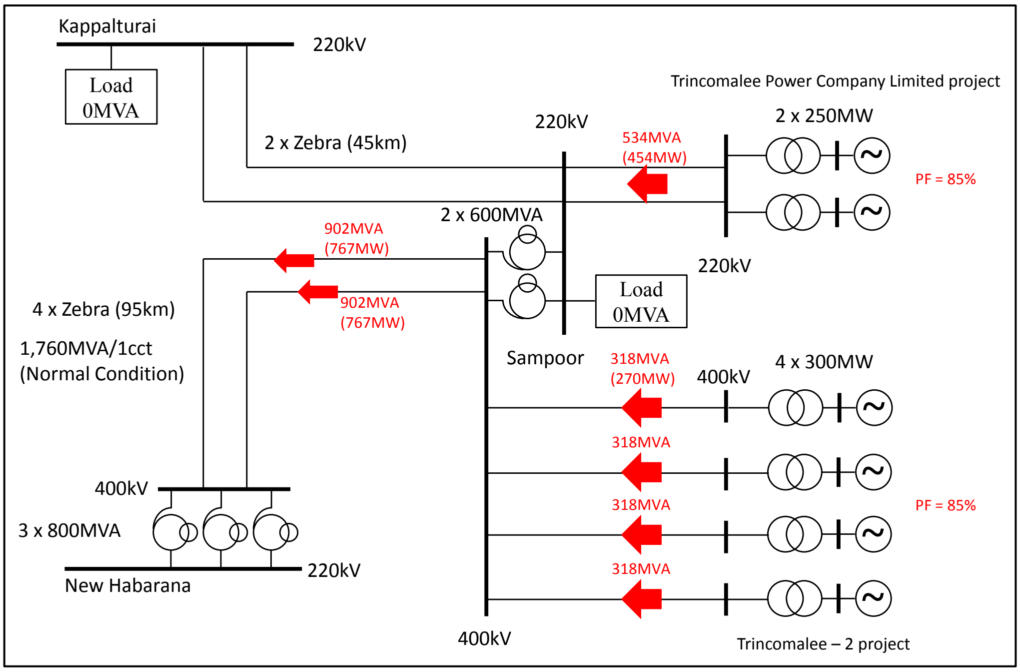


Figure 3.2-4 Power Flow of the Maximum Generation Output in 2024 under Normal Generation Conditions

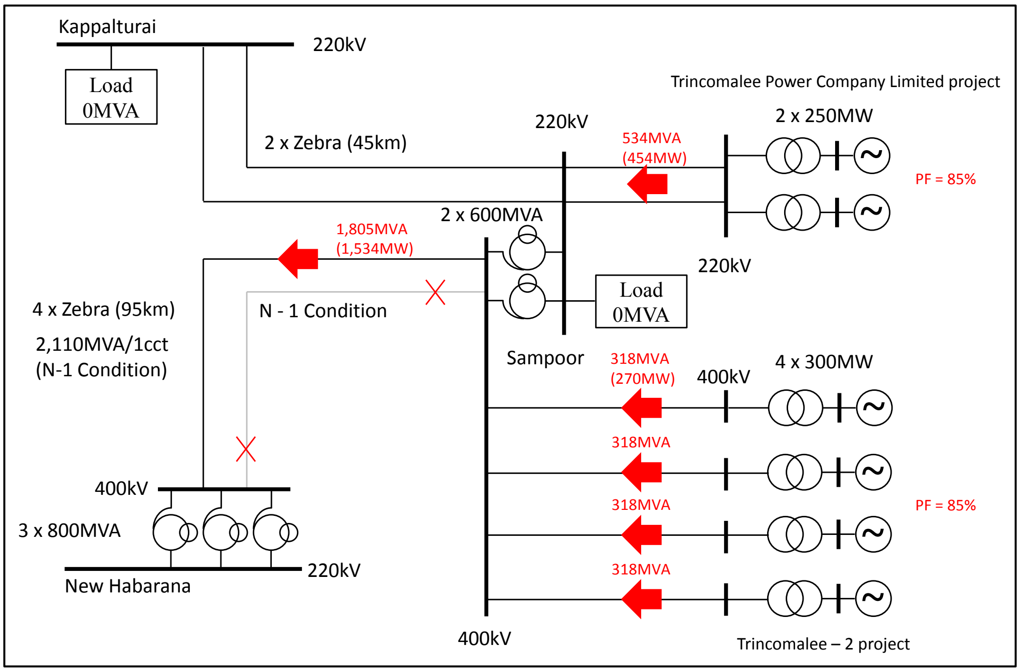
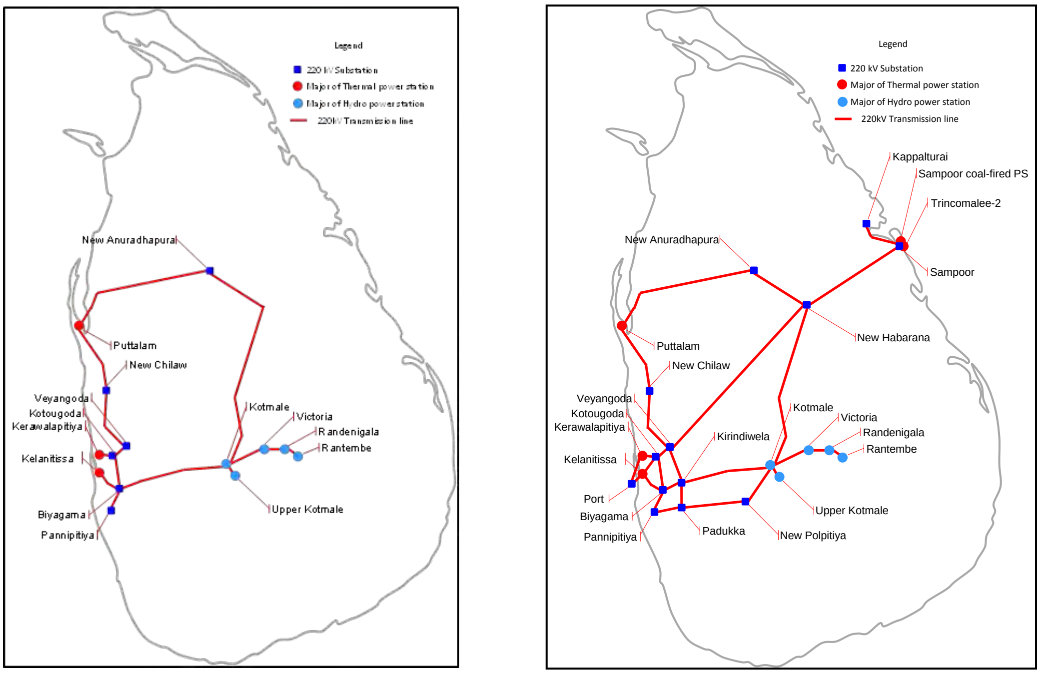


Figure 3.2-5 Power Flow of the Maximum Generation Output in 2024 under N-1 Conditions

3.3. Transmission Line Expansion Plan

The 220 kV transmission networks in Sri Lanka provided by CEB are shown in Figure 3.3-1 and Figure 3.3-2. The current 220 kV transmission network (2015) is shown in Figure 3.3-1 (a). This transmission network has been formed in order to supply to the Colombo district with large power demand. Major power plants are connected by the 220 kV transmission network.

The predicted 2020 220 kV transmission network is shown in Figure 3.3-1 (b). At this time it is expected that the transmission line between Sampoor and New Habarana will commence the transportation of power from the Sampoor coal-fired power station. The transmission line between New Habarana and Veyangoda is also scheduled to be constructed by 2020. These transmission lines should ensure the smooth transmission of power from the east coast-based thermal power stations to the power hungry region in western Sri Lanka. It is also expected that by 2020 the power grid around the Colombo district will have been enhanced.



(a) Year 2015

(b) Year 2020

Figure 3.3-1 220 kV Transmission Network

The 400 kV and 220 kV transmission networks as predicted for 2022 and 2024 are shown in Figure 3.3-2. In 2020, it is expected that the main power grid in the high electricity demand western area will be set up. The transmission lines under this Project will be stepped-up to 400 kV by 2022 which will increase their capacity to transport power. As the major 220 kV transmission lines are expected to have been constructed by 2020, it should be possible to transport the power generated in the eastern part of the country even if it takes until 2022 to complete the 400 kV transmission system.

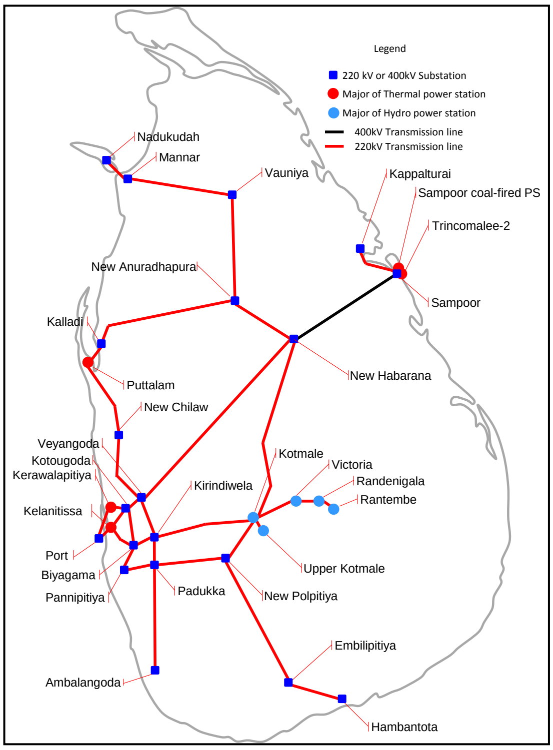


Figure 3.3-2 400 kV and 220 kV Transmission Network in 2022 and 2024

As stated above, it is understood that the transmission lines within the scope of this Project will play a very important role in improving the Sri Lankan transmission network, especially in transporting the large power generation of the eastern power plants.

3.4. Checking for the Sampoor – Kappalturai transmission line

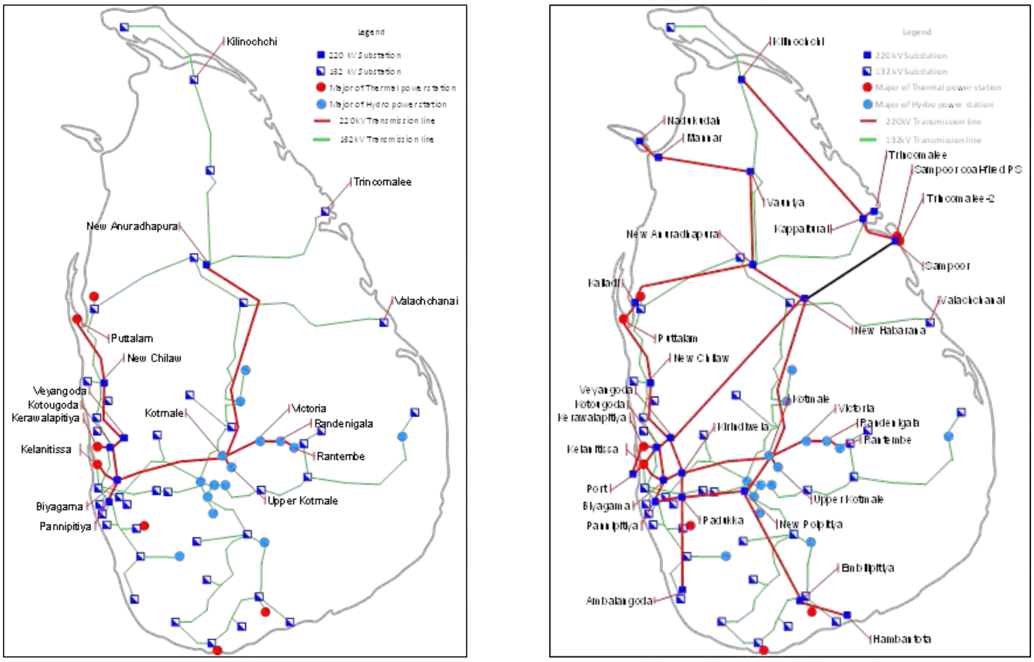
The 220 kV Sampoor – Kappalturai transmission will supply power to the Kappalturai substation. But, there is the existing Trincomalee substation of 132 kV near the Kappalturai substation. The Trincomalee substation has been connected by 2 circuits of 132 kV transmission lines from the New Anuradhapura substation. The 132 kV New Anuradhapura – Trincomalee transmission line capacity is 100 MVA (1 circuit) according to PSS/E data.

Demand forecast of the Kappalturai substation and the Trincomalee substation are shown in Table 3.4-1. Demand of 2 substations exceeds the 100 MVA in total. Therefore, the existing 132 kV transmission line is enough capacity under the normal condition, but this transmission line is overloaded under N-1 condition. The new transmission line is necessary.

The team confirmed need for 220 kV Sampoor – Kappalturai transmission line as described above. It is expected that power flow trend of this transmission line is low demand in 2024. This transmission line is planned to extend from the Kappalturai substation to the Kilinochchi substation.

Table 3.4-1 Demand forecast around the Kappalturai substation

Substation	2020	2021	2022	2023	2024
Kappalturai [MVA]	81.5	86.3	91.4	105.8	118.4
Trincomalee [MVA]	33.6	34.1	34.9	35.6	36.5
Total [MVA]	115.1	120.4	126.3	141.4	154.9



(a) Year 2015 (b) Year 2032

Figure 3.4-1 Major Transmission Network in 2015 and 2032

3.5. Scenario of the Power System Analysis

3.5.1. Generation and Loading Scenario of the Power Flow Analysis

The power flow analysis was carried out in the scenarios shown in Table 3.5-1. The generator conditions were set as “thermal maximum” and “hydro maximum”, and the load conditions were as “night peak”, “day peak”, and “off peak”.

Table 3.5-1 Generation and Loading Scenario for the Power System Analysis

Scenario	Generator Condition	Load	Generation	
TMNP	Thermal maximum	Night peak	Thermal	Max
			Wind	0 %
			Mini Hydro	33%
			Dendro	100%
			Hydro	Balance
TMDP	Thermal maximum	Day peak	Thermal	Max
			Wind	0 %
			Mini Hydro	33%
			Dendro	100%
			Hydro	Balance

HMNP	Hydro maximum	Night peak	Thermal	Balance
			Wind	100 %
			Mini Hydro	100%
			Dendro	0%
			Hydro	Max
HMDP	Hydro maximum	Day peak	Thermal	Balance
			Wind	100 %
			Mini Hydro	100%
			Dendro	0%
			Hydro	Max
OP	-----	Off-peak	Thermal	Partial
			Wind	100 %
			Mini Hydro	100%
			Dendro	0%
			Hydro	Partial

3.5.2. Power Flow Analysis in Particular Years

Power flow analysis is based on demand forecast and power generation plan as described above. Year of analysis was set as when the transmission line and power plants around the Sampoor substation start the operation. This analysis is performed in order to confirm the effect on power flow of the transmission line and whole power system,

Power flow analysis was carried out by modeling the power system conditions for the following years:

- ✓ Year 2020: To install the Sampoor coal-fired power plant

  The transmission line operation starts at 220 kV

- ✓ Year 2022: To install the Trincomalee-2 Phase-I coal-fired power plant

  The transmission line step-up to 400 kV

- ✓ Year 2024: To install the Trincomalee-2 Phase-II coal-fired power plant

  All the generators planned around the Sampoor substation are installed

3.5.3. Fault Current Analysis

The fault current analysis was conducted by calculating the short circuit current using the following conditions based on the master plan:

- ✓ The power system condition for a short circuit calculation was considered for 2024.
- ✓ The uniform voltage profile was at unity magnitude and zero phase angle at generator buses.
- ✓ All the transformers including generator transformers were at nominal turn ratios and zero phase shift angles

- ✓ The loads, fixed bus shunts, and switched shunts were neglected in the positive sequence network
- ✓ The line charge capacitance and the line connected shunts were neglected in the positive sequence network.
- ✓ All the resistive parts of the impedances were neglected.
- ✓ Sub-transient reactance (saturated) was used for the synchronous machines.
- ✓ There parallel operations of the T off lines are assumed.

3.6. Results of the Power System Analysis

3.6.1. Power Flow Analysis

The power flow analysis was carried out under the conditions described above. The allowable voltage variation of power system is shown in Table 3.6-1 below.

The generator’s operating conditions were configured as far as possible to match the conditions in the generation and loading scenarios. If there was surplus power when running a power generation scenario, any stoppage of the generator was considered not to impact on the scenario. In the case of the mini hydro scenario, the generator could not be stopped as was a run-of-the-river hydroelectric generator.

Table 3.6-1 Allowable Voltage Variation

Bus bar standard voltage	Allowable voltage variation	
	Normal operation condition	Single contingency condition
220 kV	±10%	±10%
132 kV	±10%	±10%

(Source: CEB Master plan)

3.6.1.1. Year 2020

It is predicted that in 2020, the transmission line(s) will commence operation when the TCPL’s power plant begins generating electricity.

The analysis results of the power flow around the Sampoor substation are shown in Table 3.6-2 and Table 3.6-3, with more details on the power flow available in Annex 3.6-1. In addition, the Team performed the N-1 analysis, with the results shown in Table 3.6-4 and Table 3.6-5. Below is a summary of the analysis results:

- ✓ The transmission line(s) were not overloaded under the normal conditions and the N-1 conditions.
- ✓ The Sampoor substation and the New Habarana substation were not overloaded under the normal conditions and the N-1 conditions.

- ✓ The other transmission lines and substations were not overloaded under the normal conditions.
- ✓ The voltage profile appeared to be within the acceptable range of 0.90~1.10 P.U.
- ✓ Some of the 132 kV transmission lines were overloaded under the N-1 conditions.
- ✓ Some of transformers were overloaded under the N-1 conditions.

Table 3.6-2 Forecasted Power Flow around the Sampoor Substation in 2020

Transmission Line		Generator Output	Power Flow [MVA/1cct]					Current carrying capacity [MVA/1cct]
			TMNP	TMDP	HMNP	HMDP	OP	
From	To	Trincomalee 1	100%	100%	60%	60%	60%	
		Trincomalee 2	---	---	---	---	---	
Sampoor	~Kappalturai		40	33	40	33	16	581
Sampoor	~New Habarana		188	194	97	104	121	1161
New Habarana	~New Anuradhapura		27	60	73	16	41	348
New Habarana	~Veyangoda		78	88	91	76	61	1000
New Habarana	~Kotmale		49	92	31	21	65	290

Table 3.6-3 Forecasted Power Flow Rate around the Sampoor Substation in 2020

Transmission Line		Generator Output	Power Flow Rate [1cct]					Current carrying capacity [MVA/1cct]
			TMNP	TMDP	HMNP	HMDP	OP	
From	To	Trincomalee 1	100%	100%	60%	60%	60%	
		Trincomalee 2	---	---	---	---	---	
Sampoor	~Kappalturai		7%	6%	7%	6%	3%	581
Sampoor	~New Habarana		16%	17%	8%	9%	10%	1161
New Habarana	~New Anuradhapura		8%	17%	21%	5%	12%	348
New Habarana	~Veyangoda		8%	9%	9%	8%	6%	1000
New Habarana	~Kotmale		17%	32%	11%	7%	22%	290

Table 3.6-4 Forecasted Overloaded Transmission Lines under the N-1 Conditions in 2020

Transmission line			Overload level				
Voltage	From	To	TMNP	TMDP	HMNP	HMDP	OP
132 kV	New Laxapana	Balangoda	161%	108%	118%	---	---
132 kV	Samanalawewa	Embilipitiya	127%	---	151%	---	---
132 kV	Balangoda	Deniyama	---	---	105%	---	---
132 kV	Kurunegala	Kiribathkumbura	---	---	102%	---	---

Table 3.6-5 Forecasted Overloaded Transformers under the N-1 Conditions in 2020

Substation		Overload level				
Voltage	Name	TMNP	TMDP	HMNP	HMDP	OP
220/132/33 kV	New Anuradhapura	138%	---	138%	---	---
220/132/33 kV	Biyagama	108%	100%	108%	108%	---

3.6.1.2. Year 2022

It is predicted that in 2022, the transmission line(s) will be stepped-up to 400 kV when the Trincomalee-2 Phase- I comes into operation.

The analysis results of the power flow around the Sampoor substation are shown in Table 3.6-6 and Table 3.6-7, with more details on the power flow available in Annex 3.6-2. In addition, the Team performed N-1 analysis, with the results shown in Table 3.6-8 and Table 3.6-9. Below is a summary of the analysis results:

- ✓ The transmission line(s) were not overloaded under the normal condition and the N-1 conditions.
- ✓ The Sampoor substation and the New Habarana substation were not overloaded under the normal conditions and the N-1 conditions.
- ✓ The other transmission lines and substation were not overloaded under the normal conditions.
- ✓ The voltage profile appeared to be within the acceptable range of 0.90~1.10 P.U.
- ✓ As in 2020, the 132 kV transmission line was overloaded under the N-1 conditions.
- ✓ Some of the transformers were overloaded under the N-1 conditions.

Table 3.6-6 Forecasted Power Flow around the Sampoor Substation in 2022

Transmission Line		Generator Output	Power Flow [MVA/1cct]					Current carrying capacity [MVA/1cct]
			TMNP	TMDP	HMNP	HMDP	OP	
From	To	Trincomalee 1	100%	100%	60%	60%	60%	
		Trincomalee 2	100%	100%	35%	35%	35%	
Sampoor	~Kappalturai		45	37	45	37	18	581
Sampoor	~New Habarana		453	461	187	198	219	2110
New Habarana	~New Anuradhapura		46	22	72	24	29	348
New Habarana	~Veyangoda		149	162	128	103	86	1000
New Habarana	~Kotmale		147	196	68	37	101	290

Table 3.6-7 Forecasted Power Flow Rate around the Sampoor Substation in 2022

Transmission Line		Generator Output	Power Flow Rate [1cct]					Current carrying capacity [MVA/1cct]
			TMNP	TMDP	HMNP	HMDP	OP	
From	To	Trincomalee 1	100%	100%	60%	60%	60%	
		Trincomalee 2	100%	100%	35%	35%	35%	
Sampoor	~Kappalturai		8%	6%	8%	6%	3%	581
Sampoor	~New Habarana		21%	22%	9%	9%	10%	2110
New Habarana	~New Anuradhapura		13%	6%	21%	7%	8%	348
New Habarana	~Veyangoda		15%	16%	13%	10%	9%	1000
New Habarana	~Kotmale		51%	68%	23%	13%	35%	290

Table 3.6-8 Forecasted Overloaded Transmission Line under the N-1 Conditions in 2022

Transmission line			Over load level				
Voltage	From	To	TMNP	TMDP	HMNP	HMDP	OP
132 kV	Kurunegala	Kiribathkumbura	---	---	112%	---	---

Table 3.6-9 Forecasted Overloaded Transformers under the N-1 Conditions in 2022

Substation		Over load level				
Voltage	Name	TMNP	TMDP	HMNP	HMDP	OP
220/132/33 kV	New Anuradhapura	154%	102%	154%	100%	---
220/132/33 kV	Biyagama	115%	105%	115%	105%	---
220/132/33 kV	Kotugoda	111%	---	111%	---	---

3.6.1.3. Year 2024

It is predicted that in 2024, the Trincomalee-2 Phase- II power plant will come into operation.

The analysis results of the power flow around the Sampoor substation are shown in Table 3.6-10 and Table 3.6-11, with more details on the power flow available in Annex 3.6-3. In addition, the Team performed the N-1 analysis, with the results shown in Table 3.6-12 and Table 3.6-13. Below is a summary of the analysis results:

- ✓ The transmission line(s) were not overloaded under the normal conditions and the N-1 conditions.
- ✓ The Sampoor substation and the New Habarana substation were not overloaded under the normal conditions.
- ✓ The other transmission lines and substations were not overloaded under the normal conditions.
- ✓ The voltage profile appeared to be within acceptable range of 0.90~1.10 P.U.

- ✓ The transmission line from Kotmale to New Habarana was overloaded under N-1 conditions. When Trincomalee power plant is operating at full power, this power is likely to flow into the transmission line. In the future, there is a strong likelihood that this transmission line would become overloaded even under normal conditions. Therefore it will be necessary to adopt some measures to counteract this possibility.

- ✓ The other 132 kV transmission line was overloaded under the N-1 conditions.

- ✓ The transformer of the New Habarana substation for 220/110/33 kV was overloaded under the N-1 conditions. However, as this was only a slight overload, if an accident occurs, it will be necessary to reduce the output of the Trincomalee generators.

- ✓ In addition to the above, some of transformers were overloaded under the N-1 conditions.

Table 3.6-10 Forecasted Power Flow around the Sampoor Substation in 2024

Transmission Line		Generator Output	Power Flow [MVA/1cct]					Current carrying capacity [MVA/1cct]
			TMNP	TMDP	HMNP	HMDP	OP	
From	To	Trincomalee 1	100%	100%	60%	60%	60%	
		Trincomalee 2	100%	100%	35%	35%	35%	
Sampoor	~Kappalturai		59	48	59	48	23	581
Sampoor	~New Habarana		714	730	269	280	303	2110
New Habarana	~New Anuradhapura		115	86	73	11	26	348
New Habarana	~Veyangoda		219	242	156	142	111	1000
New Habarana	~Kotmale		231	272	102	83	129	290

Table 3.6-11 Forecasted Power Flow Rate around the Sampoor Substation in 2024

Transmission Line		Generator Output	Power Flow Rate [1cct]					Current carrying capacity [MVA/1cct]
			TMNP	TMDP	HMNP	HMDP	OP	
From	To	Trincomalee 1	100%	100%	60%	60%	60%	
		Trincomalee 2	100%	100%	35%	35%	35%	
Sampoor	~Kappalturai		10%	8%	10%	8%	4%	581
Sampoor	~New Habarana		34%	35%	13%	13%	14%	2110
New Habarana	~New Anuradhapura		33%	25%	21%	3%	7%	348
New Habarana	~Veyangoda		22%	24%	16%	14%	11%	1000
New Habarana	~Kotmale		80%	94%	35%	29%	44%	290

Table 3.6-12 Forecasted Overloaded Transmission Lines under N-1 Conditions in 2024

Transmission line			Over load level				
Voltage	From	To	TMNP	TMDP	HMNP	HMDP	OP
220 kV	Kotmale	New Habarana	100%	121%	---	---	---
132 kV	Sapugaskanda	Kelaniya	109%	---	109%	---	---
132 kV	Pannipitiya	Dehiwala	---	114%	---	102%	---
132 kV	Kolonnawa	Colombo 1	---	108%	---	---	---
132 kV	Kolonnawa	Kelanitissa	---	106%	101%	---	---
132 kV	Kurunegala	Kiribathkumnura	---	---	116%	108%	---

Table 3.6-13 Forecasted Overloaded Transformers under the N-1 Conditions in 2024

Substation		Over load level				
Voltage	Name	TMNP	TMDP	HMNP	HMDP	OP
220/132/33 kV	New Anuradhapura	172%	128%	172%	111%	---
220/132/33 kV	Biyagama	124%	112%	124%	112%	---
220/132/33 kV	Kotugoda	112%	---	125%	---	---
220/132/33 kV	Habarana	107%	---	---	---	---

3.6.2. Fault Current Analysis

The power flow analyses were carried out under the conditions described above. The allowable maximum 3 phase short circuit levels are as shown in Table 3.6-14. The calculation results are shown in Table 3.6-15.

In light of these results, we can confirm that the short-circuit current does not exceed the current value of the allowable levels and the existing circuit breakers.

Table 3.6-14 Allowable Maximum 3 Phase Short Circuit Levels

Bus bar voltage	System	Maximum 3 Phase fault level [kA]
132 kV and above	Overhead	40.0
	UG cable	40.0
33 kV	Overhead	25.0
	UG cable	25.0
11 kV	UG cable	25.0

(Source: CEB Master plan)

Table 3.6-15 Fault Analysis Results of the Maximum 3 Phase Short Circuit Levels

Substation	Voltage	Existing Switch gear capacity	Maximum 3 phase fault level [kA]		
			2020	2022	2024
Sampoor	400 kV	-----	-----	9.9	13.1
	220 kV	-----	11.2	13.9	16.1
Kappalturai	220 kV	-----	6.4	8.1	8.8
	33 kV	-----	11.6	12.6	12.9
New Habarana	400 kV	-----	-----	10.3	11.8
	220 kV	-----	15.8	20.4	22.3
Habarana	220 kV	-----	15.8	20.4	22.3
	132 kV	25 kA	12.8	14.1	14.3
	33 kV	-----	9.5	10.3	10.4
New Anuradhapura	220 kV	40 kA	12.7	15.3	15.5
	132 kV	25 kA	11.0	9.6	9.6
	33 kV	-----	4.6	4.8	4.8
Veyangoda	220 kV	-----	25.1	27.2	25.4
	132 kV	25 kA	13.5	13.9	13.5
Kotmale	220 kV	40 kA	23.9	26.0	25.2

3.7. Conclusion

In relation to the transmission line(s) under the scope of the Project, we conclude that there are no problems with the following elements (please also refer to the additional comments regarding these elements).

- ✓ The transmission line(s) are planned to transport the power generation of the eastern as per the latest development plan of CEB.
- ✓ The generated power to be supplied through other transmission line(s) to Sri Lanka's western region where power demand is very high.
- ✓ The transmission line(s) are planned in harmony with the other transmission lines.
- ✓ The transmission lines have an appropriate current carrying capacity.
- ✓ In view of the power flow analysis results, the transmission line(s) will not become overloaded under the normal conditions and the N-1 condition.
- ✓ The short-circuit current shall not exceed the allowable current value levels and that of the existing circuit breakers.
- ✓ The power flow of the 220 kV Sampoor – Kappalturai transmission line is only 10% of the forecasted capacity of the conductor for 2024. However, the type of conductor for the existing 132 kV transmission line from Anuradhapura to Trincomalee via Kappalturai is Lynx and this transmission capacity is small in

comparison with the total forecasted demand of Trincomalee (33.6 MVA) and Kappalturai (81.5 MVA) for 2020. Additionally, CEB has a plan to extend this transmission line to Kilinochchi in the future. Therefore, we conclude that this transmission line should also be included in the Project.

The power system stability may become unstable when the power plants are concentrated on one location. The power generation output of power plants around the Sampoor substation will be 1,700 MW in total. This power generation output accounts for 43% of the maximum demand of 4,003 MW in 2024. Therefore, power system might become unstable depend on the power system condition even after completion of 400 kV transmission line.

JICA Survey team did not carry out the power system stability analysis, since the equipment specifications of the power plant around the Sampoor substation has not been finalized and CEB is under reviewing the master plan and therefore power generation planning and transmission line planning might change. For this reason, it is recommended that CEB is to analyze the power system stability after reviewing the master plan.

Chapter 4. Facility Design of Transmission Lines

4.1. Scope of the Transmission Lines

The Project provides for the construction of two transmission lines (T/L) in Sri Lanka. The first of these is, as described in section 3.2, a 400 kV double circuit T/L from the Sampoor S/S to the New Habarana G/S. The T/L length will be approximately 95 km with a capacity of around 2,110 MVA. The T/L's operating voltage will initially be 220 kV, and this will be increased to 400 kV before the installation of the Trincomalee-2 coal-fired power plant. The facilities for this T/L will be constructed on a 400 kV scale.

The second T/L is a 220 kV double circuits T/L from the Sampoor S/S to the Kappalturai G/S. This will be about 45 km in length and have a capacity of around 580 MVA.

Originally, according to the CEB report "Construction of Sampoor – New Habarana 400 kV Transmission Line" a third T/L -from Sampoor Power Station to Sampoor S/S - was intended to be included in the Project. However, CEB subsequently changed their plan so that this T/L will now be constructed as a part of the Sampoor coal-fired power plant project.

4.2. Meteorological Conditions

4.2.1. Temperature

The ambient temperature conditions around proposed T/Ls are shown in Table 4.2-1. The data were collated by the Government Department of Meteorology with the observations being from 1994 for the Trincomalee meteorological station and from 2009 for the Polonnaruwa meteorological station.

According to the observation, maximum temperature around the T/L is about 40^{o}C, and minimum temperature is about 14^{o}C.

Table 4.2-1 Ambient Temperature in the Project Area

Year	Trincomalee (^oC)			Polonnaruwa (^oC)		
	Max.	Min.	Avg.	Max.	Min.	Avg.
1994	38.2	21.6	28.7	-	-	-
1995	37.8	22.1	28.9	-	-	-
1996	**39.6**	21.2	28.7	-	-	-
1997	39.0	20.1	28.2	-	-	-
1998	39.3	22.4	29.4	-	-	-
1999	39.3	20.8	28.7	-	-	-
2000	38.2	22.0	28.9	-	-	-
2001	39.0	20.7	28.9	-	-	-
2002	39.1	21.6	29.2	-	-	-
2003	38.4	21.9	29.0	-	-	-
2004	39.2	20.9	28.7	-	-	-
2005	38.2	20.0	28.9	-	-	-
2006	38.3	20.7	29.1	-	-	-
2007	38.2	**19.0**	28.7	-	-	-
2008	38.7	21.1	28.6	-	-	-
2009	38.4	19.6	28.9	38.5	**14.4**	28.5
2010	38.6	19.0	29.2	37.3	17.9	28.1
2011	37.4	23.4	30.0	38.3	16.5	28.3
2012	39.5	21.2	29.1	**39.0**	18.0	28.8
2013	38.3	20.6	28.5	38.2	18.2	28.6
2014	39.1	20.0	28.8	38.5	16.4	28.6

(source: Department of Meteorology Sri Lanka)

4.2.2. Wind

The wind conditions around proposed T/Ls are shown in Table 4.2-2. The data were observed at the both Trincomalee and Polonnaruwa meteorological stations at 8:30am and 5:30pm every day. The wind speed was measured at a 10m height and at 10 minute average wind speed.

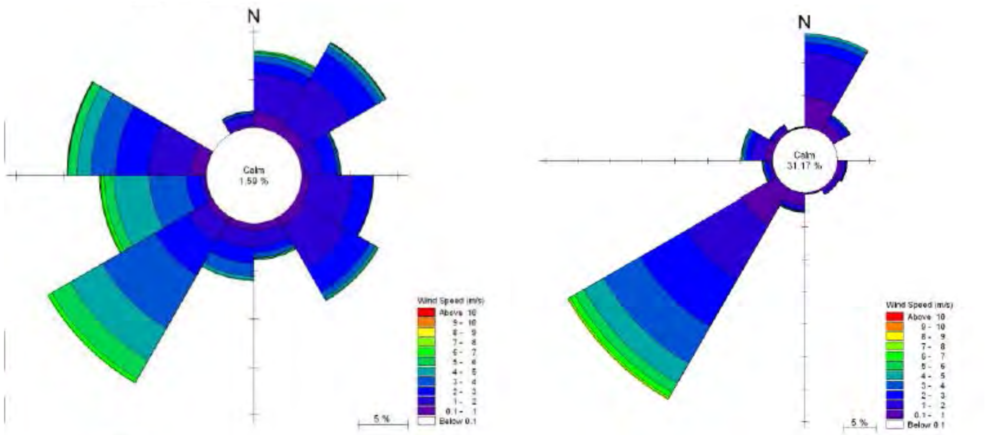
According to the observation data, the maximum wind speed in this area was 10.3 m/sand the 50-year return period extreme wind speed is calculated using Gumbel distribution was 12.3 m/s at Trincomalee.

Table 4.2-2 Wind Speed in the Project Area

Year	Trincomalee (m/s)			Polonnaruwa (m/s)		
	Max.	Min.	Avg.	Max.	Min.	Avg.
1994	3.5	0.0	1.0	-	-	-
1995	3.6	0.0	0.7	-	-	-
1996	9.0	0.0	1.1	-	-	-
1997	4.8	0.0	0.4	-	-	-
1998	7.3	0.0	0.8	-	-	-
1999	8.3	0.0	2.5	-	-	-
2000	9.6	0.0	1.8	-	-	-
2001	7.0	0.0	1.6	-	-	-
2002	7.2	0.0	2.2	-	-	-
2003	8.7	0.0	2.3	-	-	-
2004	7.6	0.0	2.1	-	-	-
2005	8.1	0.0	2.2	-	-	-
2006	8.5	0.0	2.1	-	-	-
2007	**10.3**	0.0	2.3	-	-	-
2008	6.2	0.0	2.0	-	-	-
2009	9.3	0.0	2.4		-	-
2010	4.6	0.0	1.8	6.4	0.0	1.3
2011	-	-	-	6.9	0.0	1.2
2012	8.2	0.0	2.7	8.4	0.0	1.4
2013	6.3	0.0	2.3	7.8	0.0	1.6
2014	7.2	0.0	2.4	**8.9**	0.0	1.6

(source: Department of Meteorology Sri Lanka)

The wind directions at Trincomalee and Polonnaruwa (2010 – 2014) are shown in Figure 4.2-1. The data was obtained from the department of meteorology Sri Lanka. At Polonnaruwa the wind mainly came from the southwest and northeast, and the west and east at Trincomalee.

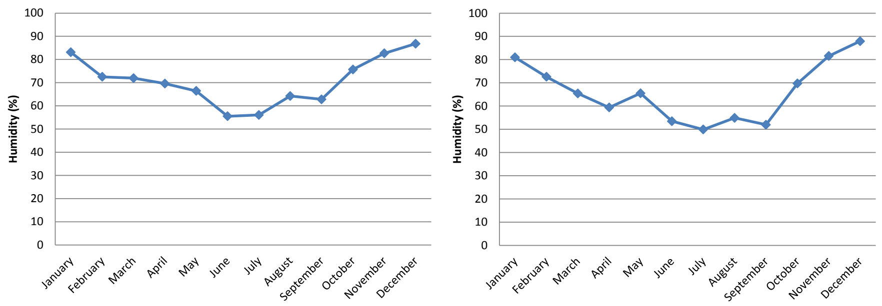


Trincomalee (2010 – 2014)　　Polonnaruwa (2010 - 2014)

Figure 4.2-1 Wind Directions in the Project Area

4.2.3. Humidity

Around the Project area, the average humidity for each month in 2014 at both the Trincomalee and Polonnaruwa meteorological stations are shown in Figure 4.2-2. The data was obtained from the department of meteorology Sri Lanka. The maximum humidity is 100%.



Trincomalee (2014)　　Polonnaruwa (2014)

Figure 4.2-2 Average Humidity in the Project Area

4.2.4. Rainfall

The rainfall at three sites around the Project area is shown in Figure 4.2-3. According to these observations, the rainy season is estimated to be from October to February. The data was obtained from the department of meteorology Sri Lanka.

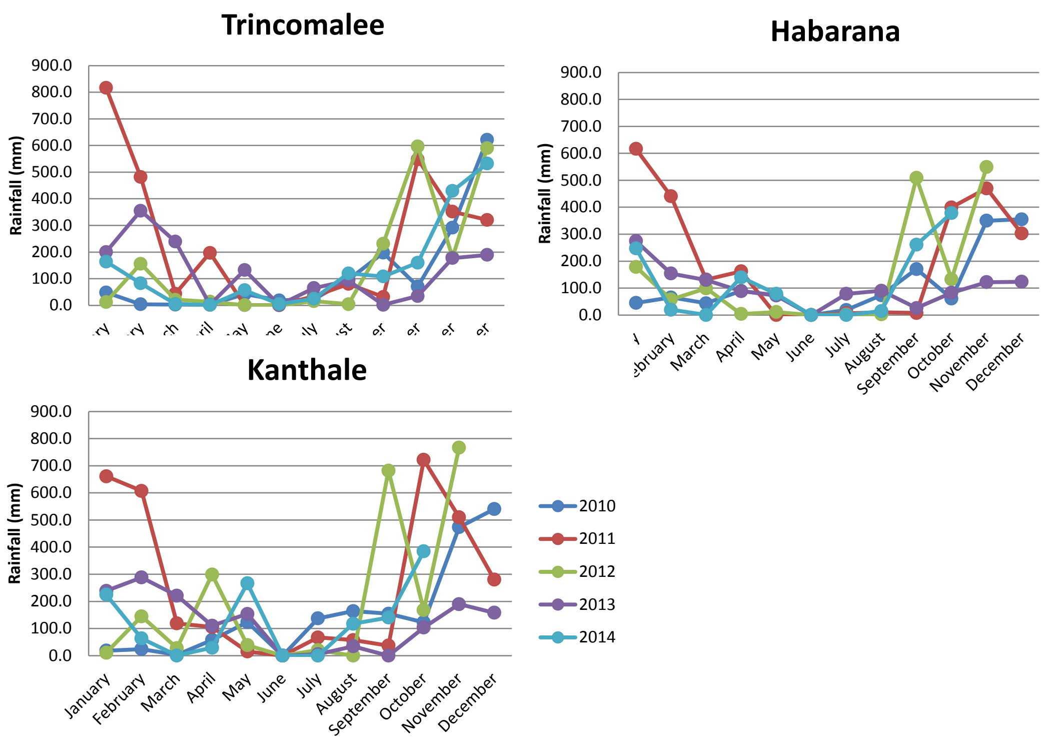


Figure 4.2-3 Rainfall in the Project Area

4.2.5. Solar Radiation

The monthly maximum solar radiation as observed from July 2011 to September 2012 at the Polonnaruwa meteorological station is shown in Table 4.2-3. From these observations the maximum solar radiation was 1019 W/m^2 and the average was 961 W/m^2.

Table 4.2-3 Maximum Solar Radiation in the Project Area

Month	Date	Hour	Solar Radiation (W/m^2).	Notes
July	2011/07/20	12-13	958	
August	2011/08/23	12-13	983	
September	2011/09/17	12-13	1000	
October	2011/10/17	11-12	956	
November	2011/11/13	10-11	850	
December	-	-	-	No data
January	2012/01/01	12-13	894	
February	2012/02/11	11-12	989	
March	2012/03/24	12-13	983	
April	2012/04/05	12-13	**1019**	
May	2012/05/03	11-12	1006	
June	2012/06/23	11-12	911	
July	2012/07/30	11-12	964	
August	2012/08/12	12-13	969	
September	2012/09/02	12-13	967	

(source: Department of Meteorology Sri Lanka)

4.2.6. Thundery Days

The annual numbers of thundery days around the Project area are shown in Table 4.2-4.

Table 4.2-4 Annual Thundery Days in the Project Area

Year	Trincomalee	Polonnaruwa
2011	91	64
2012	60	58
2013	55	57
Average	69	60

(source: Department of Meteorology Sri Lanka)

4.2.7. High Water Level at the Mahaweli River Crossing

The Team investigated the ordinary high water level (OHWL) and maximum high water level (MHWL) at the point where the transmission line cross the Mahaweli River. The investigation results are shown in Annex 4.2-1.

Subsequent to this the OHWL and MHWL were calculated using the investigation results and through a numerical simulation using MIKE21 HD. The plot for the OHWL water level variation (estimated from 5-year period) in the vicinity of the river crossing area is shown in Figure 4.2-4.

- ✓ OHWL: 3.30 m MSL(Mean Sea Level)
- ✓ MHWL: 3.52 m MSL

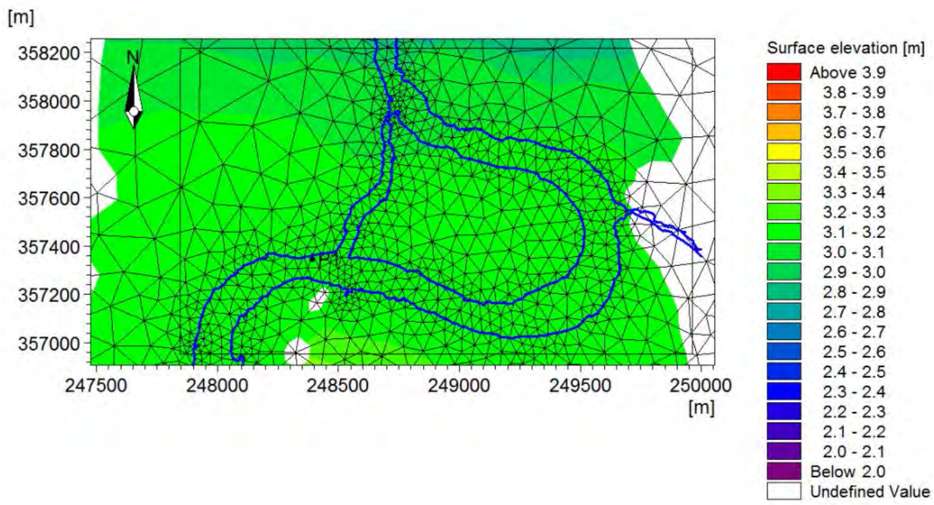


Figure 4.2-4 Water Level Variation in the Crossing Area (OHWL)

The Team also took the ground level measurements under the planed T/L around Mahaweli River. The measurement points are shown in Figure 4.2-5 and the ground levels are shown in Table 4.2-5.

Therefore, water depth around Mahaweli River basin is around 1m in the rainy season.

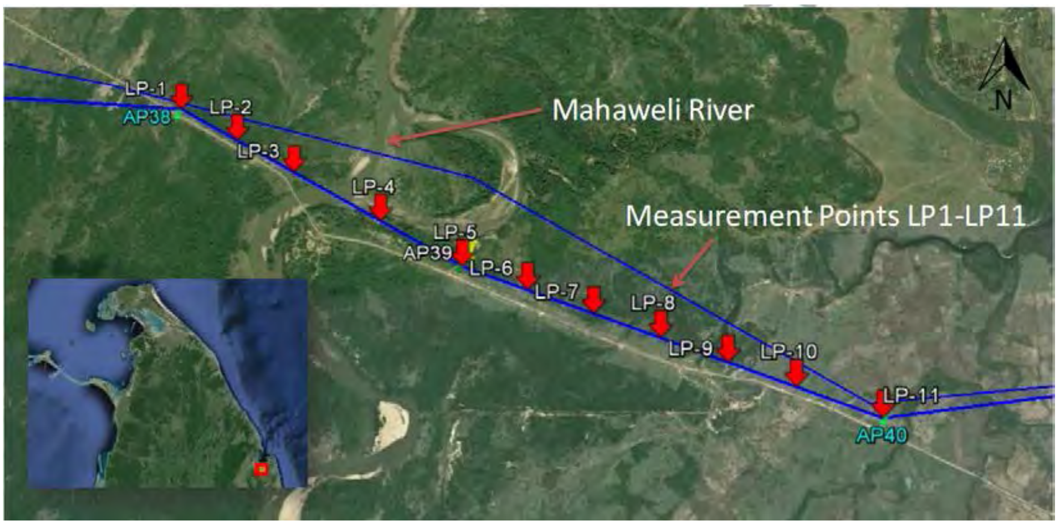


Figure 4.2-5 Ground Level Measurement Points

Table 4.2-5 Ground Levels around the Mahaweli River Crossing Area

Point	Coordinate (UTM)		Ground level (m) MSL
LP1	522446.43m E	931697.93mN	2.515
LP2	522836.37m E	931475.79mN	2.999
LP3	523226.75mE	931252.33mN	2.923
LP4	523809.56mE	930918.48mN	3.115
LP5	524347.96mE	930611.15mN	2.505
LP6	524768.70mE	930456.42mN	2.969
LP7	525190.93mE	930300.70mN	2408
LP8	525612.87mE	930144.29mN	2072
LP9	526033.98mE	929987.60mN	2229
LP10	526455.24mE	929832.80mN	2131
LP11	526982.92mE	929639.64mN	2023

(source: The Team study)

4.3. 400 kV Sampoor – New Habarana Transmission Line

4.3.1. Outline of the Transmission Line Route

The proposed route for the 400 kV Sampoor – New Habarana T/L is shown in Figure 4.3-1.

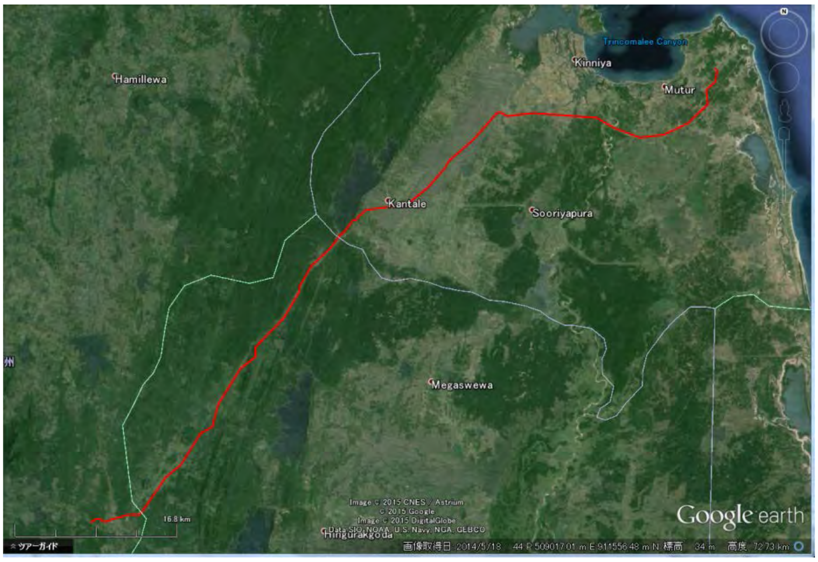


Figure 4.3-1 400 kV Sampoor – New Habarana Transmission Line Route

In general the proposed transmission line runs through a flat terrain with short stretches of hilly terrain in the sections near to Hatares Kotuwa and Morakanda. A dry undulating topography dominates the Project area. The geological formations in the project areas vary from Sampoor (coastal zone) to Habarana (dry inland areas). The soils in the coastal areas are mostly sandy regosols and recent beach and dune sands, with areas of riverine alluvial soils. Reddish Brown earth dominates the entire area from Agbopura to Habarana with varying degrees of granties and charnikites in the hilly slopes. The paddy cultivation areas from Sampoor to Agbopura, which cover more than a one third of the proposed power line distance, are largely made up of Low Humic Gley soil. In the Project area, apart from the hilly areas, the other areas don't tend to have erosion issues because of the flat terrain and the adequate ground cover along the proposed power line(s). In these hilly areas, approximately 2% of the Project area, more than 80% of the ground is covered with forest so erosion is not such a major problem. Furthermore, the Team observed that there were no prominent hazardous or unstable areas in and around the locations on the proposed route for the transmission line.

At the present time, the land has not been recurred for the transmission line. CEB doesn't have a plan to acquire land for T/L. However, there will be restrictions such as land use restriction for tower footings / temporally access road, tree cutting / removing under / beside of T/L for safety. CEB plans to pay compensation for these restrictions. Details of compensation policy for Right of Way are written in Clause 11.2.

4.3.2. Design

The 400 kV Kirindiwela - Padukka T/L (financed through the 45th Japanese ODA loan) and the 400 kV Sampoor - New Habarana T/L will be the first 400 kV T/L to be installed in Sri Lanka. All the design conditions for the 400 kV transmission line under this Project needed to be newly considered (this included making reference to some design technics and ideas used for the 500 kV transmission line in Japan).

4.3.2.1. Determination of Design Conditions

1) General Condition

The general conditions for the 400 kV Sampoor – New Habarana T/L are shown in Table 4.3-1.

Table 4.3-1 General Conditions

Item	Value	Note
Normal (Basic) span	450 m	
Wind span	540 m	1.2 times normal span
Wind span (broken wire condition)	410 m	0.75 times wind span
Weight span	900 m	2.0 times normal span
Weight span (broken wire condition)	680 m	0.75 times weight span
Everyday outside temp.	32 ^{o}C	
Minimum outside temp.	7 ^{o}C	
Maximum temp of conductor	75 ^{o}C	

(Source: CEB Technical specification)

2) Wind Pressure

The wind pressure for the T/L is shown in Table 4.3-2. Up until now, the wind pressure has not been considered in relation to the height of the T/L towers. The 400 kV T/L tower height will be between 50 m to 60 m, therefore wind speed at the top of tower will be higher than that of the lower voltage T/L system towers whose is around 40 m. Basically, an increase in the wind would increase the wind pressure applied to the towers. Therefore, the Team suggests that new design wind pressure is used for the towers on the 400 kV T/L.

Table 4.3-2 Wind Pressure

Item	Value	Note
Conductor and earth wire	970 Pa	Same as 132 kV and 220 kV
Insulator	1170 Pa	Same as 132 kV and 220 kV
Tower	1640 Pa	This value is on the 1.5 times of projected area of tower

(Source: CEB Technical specification)

As stated in section 4.2.2, the 10 minutes average 50-year return period maximum wind speed in the projected area at 10m height (V_{10}) was 12.3 m/s.

However, CEB applies 40 m/s wind speed for all existing T/L designs and plan to use this value for the 400 kV T/L designs. This 40m/s wind speed includes the wind condition of projected area.

According to the JEC-127(1979) standard, wind pressure (P) is calculated using the formula below.

$$P = C \times q \times A$$

P: Wind pressure (Pa)

C: Coefficient of wind force

q: Unit wind pressure for design (Pa)

A: Area (m^2)

The unit pressure for the design is calculated from the formula below.

$$q = q_0 \times \alpha$$

q_0: Standard wind pressure in the area (Pa)

α : Height increasing returns coefficient

The standard wind pressure in the area is calculated from the formula below.

$$q_0 = \frac{1}{2} \times \rho \times {V_{10}}^2$$

ρ : Air density (kg/m^3)

In this context, CEB calculated this value 0.1248 (kg s^2/m^4). α is calculated using the formula below.

$$\alpha = \left(\frac{h}{h_0}\right)^{\frac{1}{n}}$$

h: Height (m)

h0: Observation height (m), in this case 10m

n: Height increasing level (JEC uses four)

According to the JEC (1979) and JEC (1965) standards, the equivalent wind pressure for a 500 kV system tower is calculated as shown in Table 4.3-3. This JEC equivalent wind pressure value considers the effect of the front face members and leeward side members. According to CEB's technical specifications, the wind load for the tower is calculated by multiplying the unit wind pressure with 1.5 times the projected area of the members of one face of the tower. The value 0.5 considers the effect of the leeward side members. Therefore, the CEB value is obtained from the JEC value divided by 1.5. The JEC (1965) value is used for Japanese regulation.

Table 4.3-3 Wind Pressure for the Tower

Tower height (m)	JEC(1979) (Pa)	JEC(1965)	JEC(1979)/1.5 (Pa)	JEC(1965)/1.5 (Pa)
40	3,727	3,040	2,485	2,027
50	3,962	3,240	2,641	2,160
60	4,178	3,430	2,785	2,287
70	4,374	3,630	2,916	2,420
80	4,561	3,820	3,041	2,547
90	4,727	4,020	3,151	2,680
100	4,874	4,220	3,249	2,813
Air density: 1.223 kg/m^3, Wind speed 40m/s				

The wind pressure for insulator is about 1.4 times of conductor wind pressure because of its shape. Therefore, the wind pressure for the insulator is 1,358 Pa. Here, there is no big difference for CEB's value of 1,170 Pa, which will be adequate for the T/L.

CEB is now considering reducing the wind pressure to fit for the projected area.

3) Safety Factor

The safety factor for the T/L is as follows.

Conductor at 32 ^{o}C no wind:	4.5
Conductor at 7 ^{o}C 40 m/s wind:	2.5
Insulator:	3.0

(Source: CEB Technical specification)

4) Withstand Voltage for the Insulation

The withstand voltage for the tower insulation is as follows. CEB has not yet implemented the system analysis regarding the proposed 400 kV system. Thus, the switching surge voltage and lightning surge voltage were gleamed from the International Electrotechnical Commission (IEC) standards.

Switching surge voltage (phase-to-earth):	1,050 kV
Lightning surge voltage:	1,425 kV

4.3.2.2. Conductor and Earth Wire Design including Loss Reduction Calculation

1) Conductor

The four-bundle Zebra equivalent conductor has been selected for the 400 kV Sampoor – New Habarana T/L. From the generation plan it was predicted that the necessary transmission capacity in 2024 should be 1,805 MVA. The capacity of the four-bundle Zebra equivalent conductor at 400 kV is 2,110 MVA. The Team has confirmed that this is adequate for the transmission line.

In comparison with the conventional ACSR conductor (Zebra), the low loss type conductor (hereafter LL-ACSR) is more energy efficient (please refer to section 4.4.4). Overall, the energy efficiency advantage that the LL-ACSR conductor would bring in comparison to the ACSR Zebra conductor would lead to a required material cost gap for the Project. Therefore, the Team recommends that the LL-ACSR is more suitable for this 400 kV T/L than the conventional conductor.

The technical characteristics of the LL-ACSR conductors and conventional conductors are shown in table 4.3-4.

Table 4.3-4 Technical Characteristics of the Conductors

Type		LL-ACSR/AS (Zebra equivalent)	Zebra/AS (Conventional)
Cross sectional area		590.5 mm^2	484.5 mm^2
Sectional area	Aluminum	550.4 mm^2	428.9 mm^2
	Steel core	40.08 mm^2	55.6 mm^2
Overall diameter		28.62 mm	28.62 mm
Nominal weight		1,814 kg/km	1,554 kg/km
Ultimate tensile strength		140.9 kN	137.9 kN
Modulus of elasticity		7,050 kg/mm^2	7,470 kg/mm^2
Coefficient of linear expansion		21.2 $10^{-6}/^{o}C$	20.5 $10^{-6}/^{o}C$
DC resistance at 20 ºC		0.0519 Ω/km	0.06456 Ω/km
Cross sectional view (Sample)			

(Source: Hitachi AS wire catalog, JPS information)

The T/L will be planning to use a four-bundle conductor with a width of 500 mm this value comes from a South African study. Moreover, Tokyo Electric Power Company (TEPCO) uses a width of 400 mm – 500 mm for this size of conductor for three technical reasons.

The first reason is to avoid potential the damage from the conductor hitting each other. According to TEPCO study, such situation may be avoided when the diameter of the conductor to bundle width ratio is more than 12.

The second reason is reduction of wind pressure. The multi-bundle conductor can reduce potential wind pressure behind the conductor. The effect of the wind pressure reduction is obtained from the bundle width, which must be 20 times that of conductor's diameter.

The third reason is for maintenance. Basically, for maintenance purposes the 400mm – 500 mm width bundle be easy to ride for maintenance. Thus the team recommends that the conductor bundle with 500 mm width is suitable for this for this T/L.

2) Earth Wire

CEB plans to install the tower with two earth wires. One is the AS wire and the other is OPGW. At the present the size of the earth wire has not yet been determined because earth fault current calculation has still to be done. In the CEB "Design Report 400 kV Sampoor – New Habarana Transmission Line", it is stated that short circuit capacity of earth wires would be less than 100 kA^2s, and AS 110mm^2 and OPGW 120 mm^2 were selected. As a result, the Team shall these two earth wires for the cost estimations.

The Team recommends that CEB should confirm the magnitude of the maximum earth fault current of the 400 kV system in Sri Lanka and also the duration time of fault.

Table 4.3-5 Technical Characteristics of the Earth Wires

Type	AS 110 mm^2	OPGW 120 mm^2
Cross sectional area	111.3 mm^2	136.5 mm^2
Overall diameter	13.5 mm	15.2 mm
Nominal Weight	704.8 kg/km	734.2 kg/km
Ultimate tensile strength	123.0 kN	82.0 kN
Modulus of elasticity	140 GPa	124.2 GPa
Coefficient of linear expansion	13.4 10^{-6}/ºC	14.5 10^{-6}/ºC
Number of optical fibers	-	24

(Source: HITACH AS wire catalog, J-power systems specification)

Shielding design of the earth wires are determined below.

- ✓ Number of earth wires: 2
- ✓ Maximum shielding angle: 0 º (top phase), 5 º (middle and bottom phase)

4.3.2.3. Insulator Design

1) General Conditions for Insulator Design

The general conditions for the insulator design are shown in Table 4.3-6. All the basic conditions for the insulation are based on IEC standards. However, there is a possibility to reduce the maximum voltage and switching surge voltage through a system analysis. Therefore, the Team recommends that this analysis should be carried out in order to reduce the number of insulators and the clearance from the conductor and tower size.

Table 4.3-6 General Conditions for the Insulator Design

Item	Value	Note
Nominal voltage	400 kV	
Maximum voltage	420 kV	IEC 60815
Switching surge voltage	1050 kV	IEC 60071
Lightning surge voltage	1425 kV	IEC 60071

2) Numbers of Insulator String

For tension insulator set, the maximum tension should be approximately 210 kN, and three as the safety factor for the insulator. Therefore, CEB has selected a quarto tension insulator set with 160 kN strength insulators.

In relation to the suspension insulator set, the maximum tension should be approximately 92 kN. For this, CEB has chosen the double suspension insulator set with 160 kN strength insulators. Basically, this insulator is used for 132 kV and 220 kV transmission lines, and it is reasonable for maintenance.

The number of insulator strings for suspension and tension insulators are shown in Table 4.3-7.

Table 4.3-7 Numbers of Insulator Strings

Tower type	Nos. of strings
Suspension	2
Tension	4

3) Number of Insulators for the Insulator Set and Designation of the Insulator

The number of insulators required for the insulator set is determined based on pollution this mainly consists of sea salt in Project area. In 2014, CEB implemented a pollution survey in Sampoor and the result was “Medium” according to the IEC standards (Annex 4.3-1).

Nevertheless, CEB – based on previous experience with pollution rating issues from Sri Lanka’s northwest coastal area – determined that the pollution level should be “Heavy” for the area 10 km inland from coast.

The number of insulators for the insulator set and the designation of the insulators are shown in Table 4.3-8. CEB plans to use fog type of insulator for the “Heavy” pollution area to reduce the length of the insulator set. Thus, in light of this the Team has added to each relevant insulator set.

Table 4.3-8 Numbers of Insulators for Insulator Set and Designation of Insulator

Pollution	Tower type	Designation	Mechanical failing Load	Nos.	Total length
Heavy	Suspension	U160 BLP	160 kN	21	3570 mm
	Tension	U160 BLP	160 kN	21	3570 mm
	Light duty tension	U70 BLP	70 kN	25	3650 mm
	Jumper suspension	U70 BLP	70 kN	25	3650 mm
Medium	Suspension	U160 BS	160 kN	28	4088 mm
	Tension	U160 BS	160 kN	28	4088 mm
	Light duty tension	U70 BL	70 kN	30	4380 mm
	Jumper suspension	U70 BL	70 kN	30	4380 mm

4) Arcing Horn Gap

The arcing horn gap has to be determined in order not to flashover in normal conditions, such as a switching surge. In addition, flashover caused by a lightning surge may be fixed at the arcing horn.

In Japan, the gap for the arcing horn is calculated by using the ratio for the arcing horn gap (Z) to the length of insulator (Z_0). The ratio of CEB's existing 132 kV and 220 kV transmission lines is approximately 90%. However, the Japanese verification test proves that the ratio should be less than 75% because the risk of flashovers occurring on the surface of the insulator– which can cause significant damage to the insulator – greatly increase when this ratio is above 75%.

Thus, in light of this, the Team has determined that the arcing horn gap should be 2600 mm 75% of minimum insulator set length 4088 mm.

On the other hand, the switching surge voltage, 1050 kV from IEC, needs more than 2450 mm distance to withstand flashover according to Japanese verification test.

As a result, the Team firmly believes that an arcing horn gap of 2600 mm will be suitable.

4.3.2.4. Ground Clearance

According to CEB criteria, the electric field strength should not exceed 5 kV/m on the ground in uninhabited area and/or open ground. As a result, CEB determined that the minimum clearance from the ground should be 8.5 m. According to Japanese regulations, minimum ground clearance for a 400 kV T/L in an uninhabited area is 7.88 m.

Ground clearances including other location and/or terrain condition are shown in Table 4.3-9.

Table 4.3-9 Ground Clearance for the 400 kV T/L

Ground Clearance	Location / Terrain Condition	Factors governing the selected value
8.5 m	Open ground, Uninhabited areas	General design of the 400 kV transmission line
11 m	Paddy fields where large harvesting machines are used	To provide clearance for the tall machines and waste ejected upwards
15 m	Highways, Main roads	To provide room for lighting poles and 33 kV lines along roads
19.3 m	Railway lines	As requested by the Railways Department
13 m	Forests, reservations, Sanctuaries, Elephant crossings	To minimize the cutting down of trees
15 m	Households, Villages, Public buildings, Buildable areas and areas earmarked for development As recommended by respective divisional secretaries of the area	To provide a low electric field strength (below 5 kV/m) at ground level and upper floor level of a house.

(Source: Initial environmental examination (IEE) study for the proposed 400 kV transmission line project from Sampoor to Habarana)

4.3.2.5. Determination of Tower Configuration

CEB plans to configure 1 type of suspension tower and 4 types of tension towers. The configurations of 400 kV towers are shown in Table 4.3-10.

Table 4.3-10 Tower Types for the 400 kV T/L

Name	Type
TDL	Suspension tower
TD1	0 – 10 deg. angle and section tower
TD3	10 – 30 deg. angle tower
TD6	30 – 60 deg. angle tower
TDT	Terminal tower

4.3.2.6. Tower Design

1) Insulation Distance

The insulation distances for 400 kV T/L are based on a report published by the Institute of Electrical Engineers of Japan. The insulation distances are shown in Table 4.3-11.

(i) Standard Insulation Distance

The standard insulation distance makes inevitably flashover at the gap of arcing horn in the lightning condition. From the Japanese verification test, this distance shall be the distance from 111% to 114% of the arcing horn gap.

The formula to calculate this distance (A mm) is as follows. This distance should be maintained in ordinary wind conditions.

$$A = 1.115 \times Z + 21$$

Z: Arcing horn gap (mm)

(ii) Switching Surge Distance

The switching surge distance is the distance that does not flashover in the case of switching. This value is obtained from the result of Japanese verification test which is written in the report of “The Institute of Electrical Engineers of Japan”. As for the 400 kV T/L, the switching surge voltage should be 1050 kV, and the necessary distance should be 2450 mm. This distance should be maintained in windy conditions.

(iii) Power Frequency Distance

The power frequency distance is the distance that does not flashover during the power frequency condition. The power frequency distance is calculated from the Japanese experimental formula which was obtained from the verification test. The experimental formula is as follows. This distance should be maintained in stormy wind condition.

$$d = Vm/0.316$$

d: Power frequency distance (mm)

V_m: Maximum voltage (phase-to-earth) (kV)

Table 4.3-11 Insulation Distance for the 400 kV T/L

Insulation distance	Value	Estimated wind speed
Standard insulation distance	2,920 mm	10 m/s
Switching surge distance	2,450 mm	20 m/s
Power frequency distance	930 mm	40 m/s

2) Clearance

The clearances between tower and conductor are calculated as follows (based on Japanese calculation methods which the Team has applied). The clearances for the tower design are shown in Table 4.3-12. In the case of a drawing clearance diagram, it is necessary to consider the width of tower members, the bundle width and the conductor diameter.

(i) Standard Clearance

The standard clearance (Cs) is determined by the following formula.

$$Cs = A + K + B$$

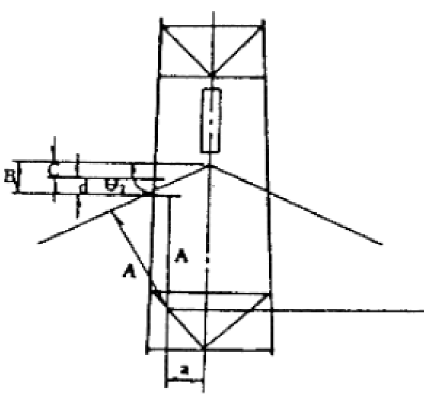
A: Standard distance

K: Effect of tower arm

$$\mathrm{K} = 0.5 \times (\text{arm member width})$$

B: Effect of catenary

$$\mathrm{B} = \mathrm{a} \times \tan\theta_2 + A \times (\cos^{-1}\theta_2 - 1)$$



(ii) Switching Surge Clearance

The switching surge clearance (E) is determined by the following formula.

$$E = D + L$$

D: Switching surge distance

L: Effect of main post member width

$$L = 0.7 \times \left(Step\ bolt\ length + \frac{Width\ of\ mainpost\ menmber}{2} \right)$$

(iii) Power Frequency Clearance

The power frequency clearance is the same as power frequency distance.

(iv) Safety Clearance for Worker

The safety clearance is the clearance that does not flashover between the conductor and a worker carrying out maintenance on the tower. CEB intends to implement hot line maintenance for the 400 kV T/L. Therefore, the Team determined the safety clearance in consideration of the above situation.

The safety clearance was obtained from TEPCO's experimental formula which comes from the verification test. The formula is shown in below.

$$V_{50} = K_g \times 1080 \times \ln(0.46 \times d + 1)$$

V_{50}: 50% flashover voltage (kV)

Kg: Coefficient of gap (= 1.2)

d: Safety clearance (mm)

The 400 kV safety clearance is 2800 mm under the switching surge voltage of 1050 kV. The safety clearance plus human body height/width distance has to be maintained between conductor and the tower in order to avoid danger.

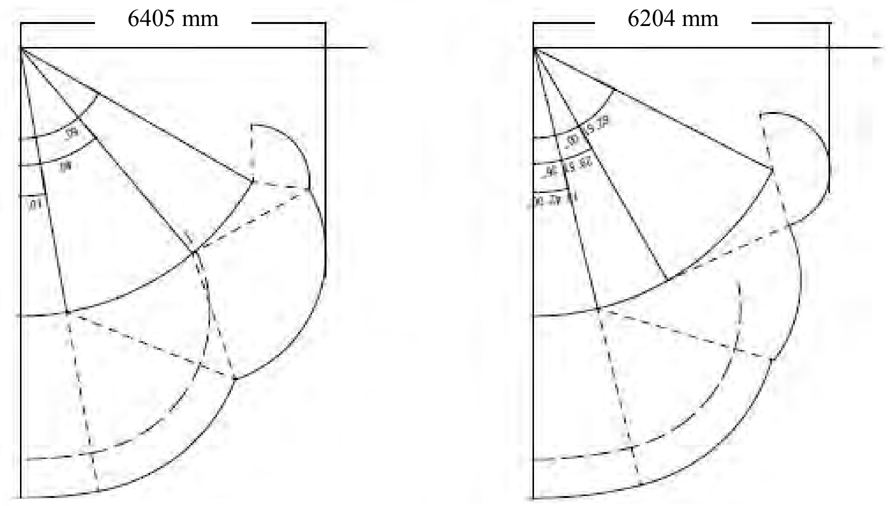
Table 4.3-12 Clearance for the 400 kV T/L

Item	Clearance
Standard clearance	3,430 mm
Switching surge clearance	2,520 mm
Power frequency clearance	930 mm
Safety clearance	2,800 mm

3) Clearance Diagram for the Suspension Tower

The clearance diagram has to be made to keep adequate clearance from conductor to tower members in order to determine the tower configuration.

Based on the methodology applied by Japanese power companies, the swing angle caused by the wind is different to that determined by CEB (this is illustrated in Figure 4.3-2). Thus, in order to reduce width of T/L and construction costs, the Team recommended that CEB adopt the Japanese model for the 400 kV T/L. Nevertheless, CEB selected its existing clearance design for the 400 kV transmission line. The existing clearance is shown in Table 4.3-13.



CEB's diagram　　　　Japanese power company diagram

Figure 4.3-2 Difference of Clearance Diagram between Japan and CEB

Table 4.3-13 Value of Clearance Diagram for the Suspension Tower

Swinging angle of conductor	Clearance
0^{o}	3,430 mm
10^{o}	3,430 mm
40^{o}	2,520 mm
60^{o}	930 mm

4) Clearance Diagram for the Tension Tower

Initially the jumper depth was determined in terms of clearance by applying TEPCO's methodology. This methodology utilizes the circular arc approximation to the jumper with the procedure to determine the jumper depth being as follows.

- ✓ Determine the insulator set length with the extension rod.
- ✓ Calculate the insulator set catenary angle of the tension tower at minimum conductor temperature.
- ✓ Calculate both sides of the location of the jumper socket at the minimum conductor temperature.
- ✓ Draw the clearance diagram at the minimum conductor temperature (Figure 4.3-3).

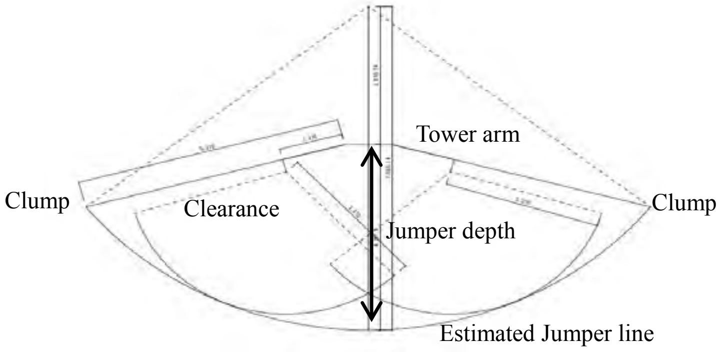


Figure 4.3-3 Circular Arc Approximation for the Jumper

- ✓ Calculate the jumper length at the minimum conductor temperature.
- ✓ Calculate the catenary angle at the maximum conductor temperature
- ✓ Calculate both sides of the location of the jumper socket at the maximum conductor temperature.
- ✓ Draw the jumper diagram (arc) which go through the location of both jumper sockets at the maximum conductor temperature and apply the jumper length calculated above

To design the tower, the Team tentatively determined the jumper depth 5100 mm in consideration of a 15 ^{o} catenary angle.

In order to draw the clearance diagram, the jumper swing angle caused by wind has to be calculated.

Each jumper swing angle is calculated using various wind conditions by using a Japanese experimental formula obtained from the verification test. The values for this are shown in Table 4.3-14 and the clearance diagram is shown in Figure 4.3-4.

Table 4.3-14 Assumed Swing Angle for the Jumper

Wind speed (m/s)	10	20	40
Swing angle (^{o})	10	20	45

* Zebra x 4 conductor, Jumper spacer 12 kg/unit x 6 are considered

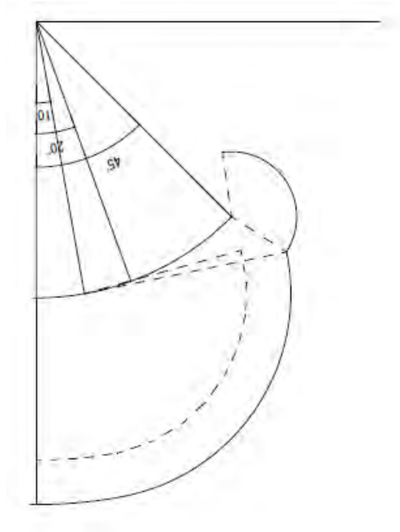


Figure 4.3-4 Assumed Clearance Diagram for the Jumper

5) Tower Design for Cost Estimation

Based on the above conditions, the Team designed the 400 kV suspension towers and tension towers. The configurations for these towers are shown in Figures 4.3-5 to 8.

For the designs the Team suggests different arm length design for the deep angled TD3 and TD6 towers because this can reduce the tower weights by 2% for the TD3 and 4% for the TD6, and this different arm could also reduce the ROW. Comparison of tentative designed tower weight is shown in Table 4.3-15.

Table 4.3-15 Comparison of the Tower Weights

Tower Type	Tower weight (t)	
	Different arm	Same arm
TD1	45.779	46.464 101%
TD3	56.159	57.321 102%
TD6	67.733	70.717 104%

6) Strength Calculations

The strength calculations will be implemented by using TEPCO’s simulation program “TT-2000” after agreement with CEB about the designs of towers...

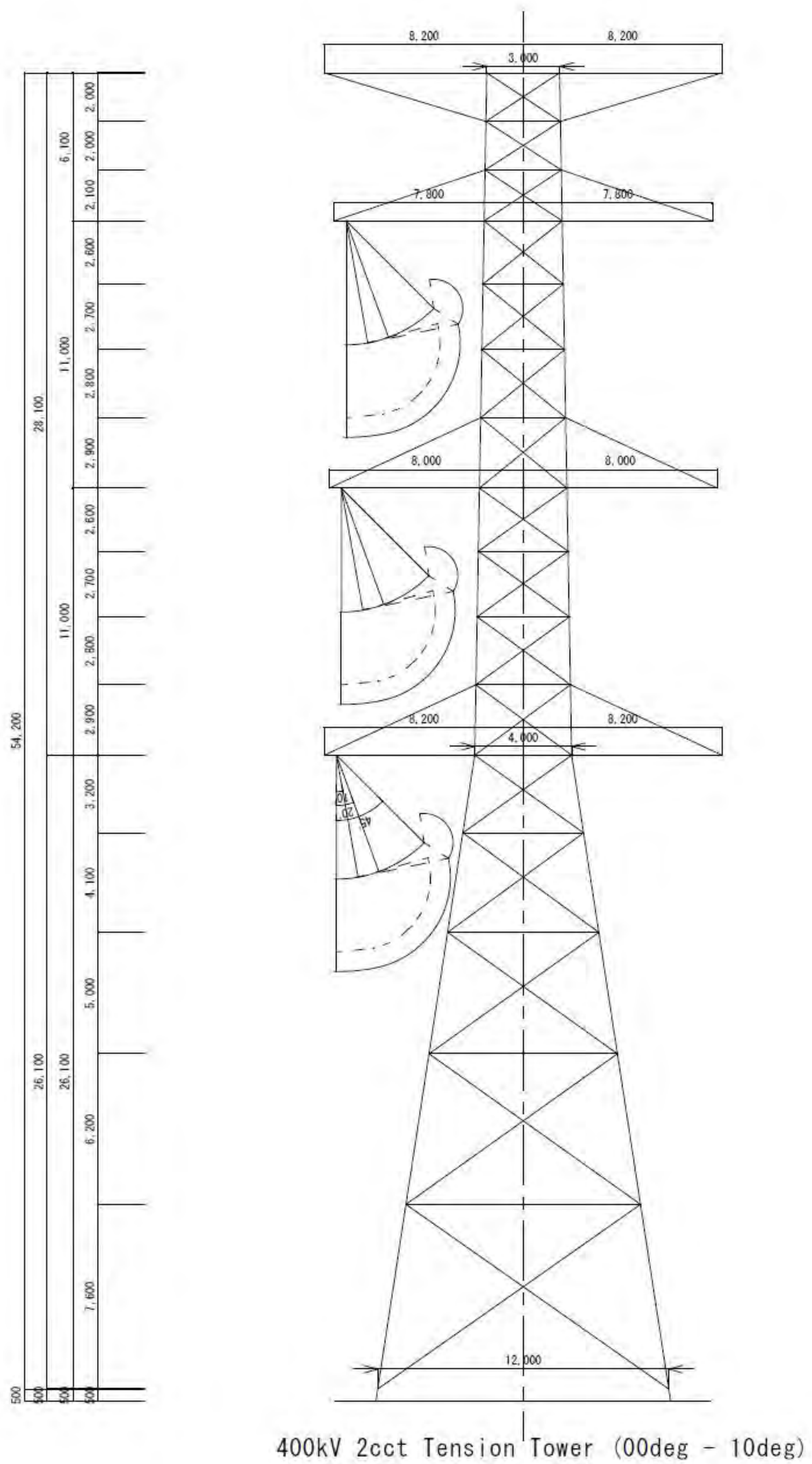
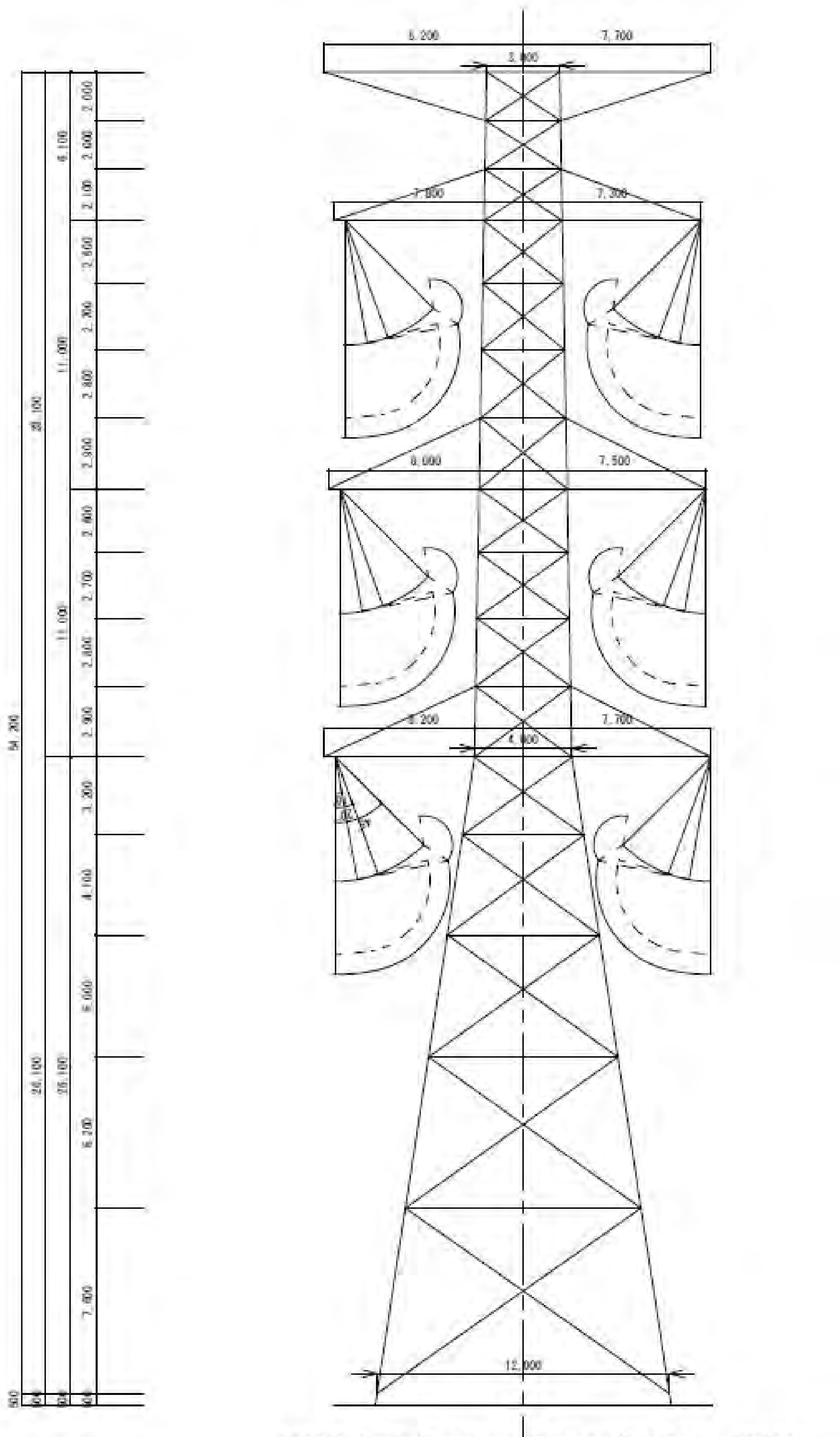


Figure 4.3-5 Assumed 400 kV Suspension Tower (TDL)



400kV 2cct Tension Tower (00deg - 10deg)

Figure 4.3-6 Assumed 400 kV Tension Tower (TD1, TDT)

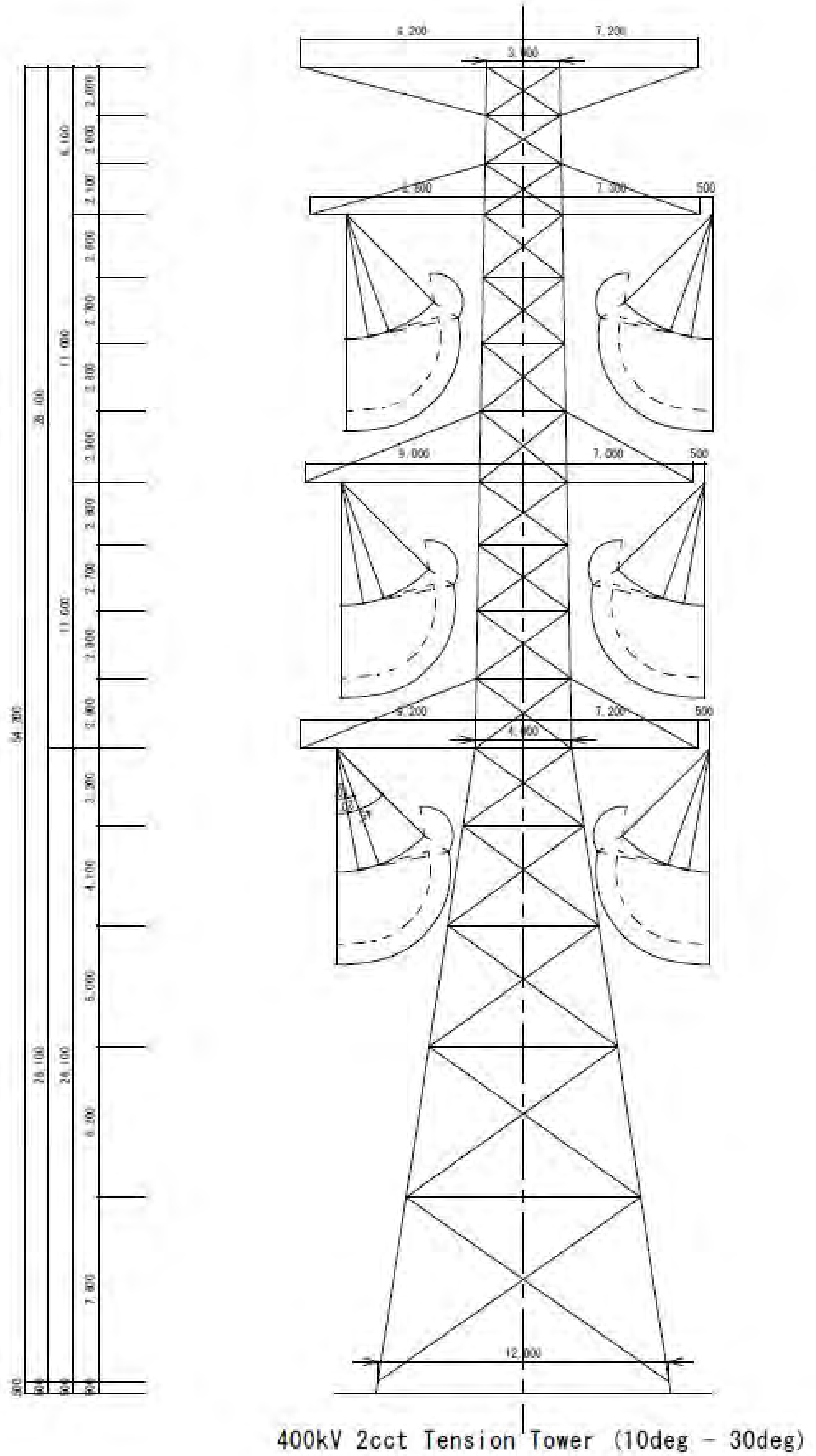


Figure 4.3-7 Assumed 400 kV Tension Tower (TD3)

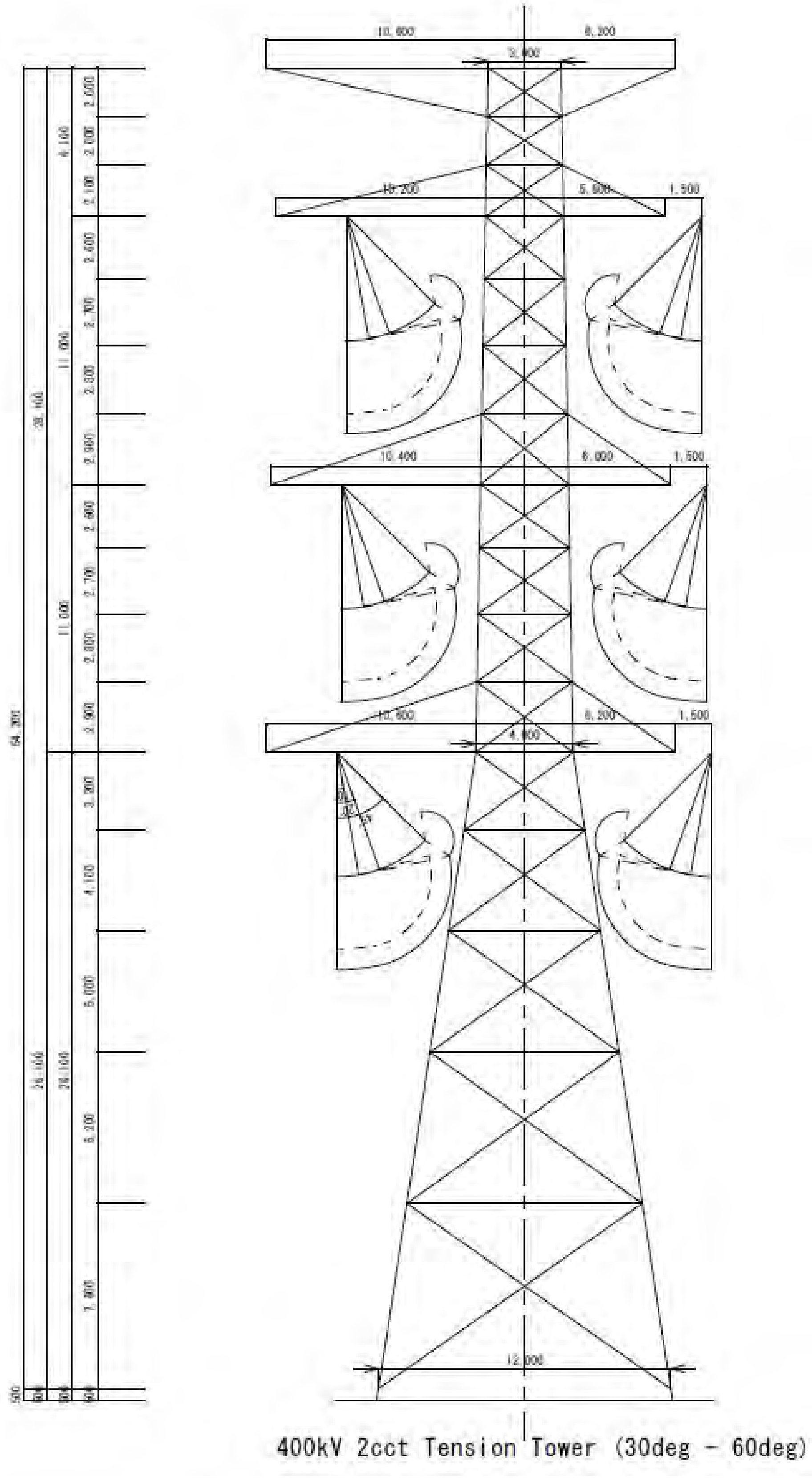


Figure 4.3-8 Assumed 400 kV Tension Tower (TD6)

4.3.2.7. Foundation Design

1) Soil Condition

The Team conducted Standard Penetration Test (SPT) at the various points on the Project site, which are shown in Table 4.3-16 and Figure 4.3-9.

From the viewpoint of soil conditions, there were no areas of particular concern for the proposed T/L except for its crossing point with the Mahaweli River. Therefore, the Team decided the SPT points at even distances along the proposed T/L route and at both sides of the Mahaweli River.

Table 4.3-16 Survey Points for the SPT

Survey Point	Coordinate (UTM)		Note
TT1	469925.99 m E	889856.50 m N	Terminal Tower
AP9	477707.47 m E	894523.58 m N	Forest
AP17	489980.66 m E	910993.46 m N	Forest
AP20	492864.38 m E	916390.60 m N	Forest
AP 32	504909.78 m E	924441.02 m N	Paddy field
AP 36A	512514.68 m E	932212.64 m N	Paddy field
AP 38	522443.44 m E	931688.98 m N	Crossing river
AP 39	524349.76 m E	930607.46 m N	Crossing river
AP 44	533906.00 m E	934586.00 m N	Paddy field
TT2	534721.00 m E	936689.06 m N	Terminal tower

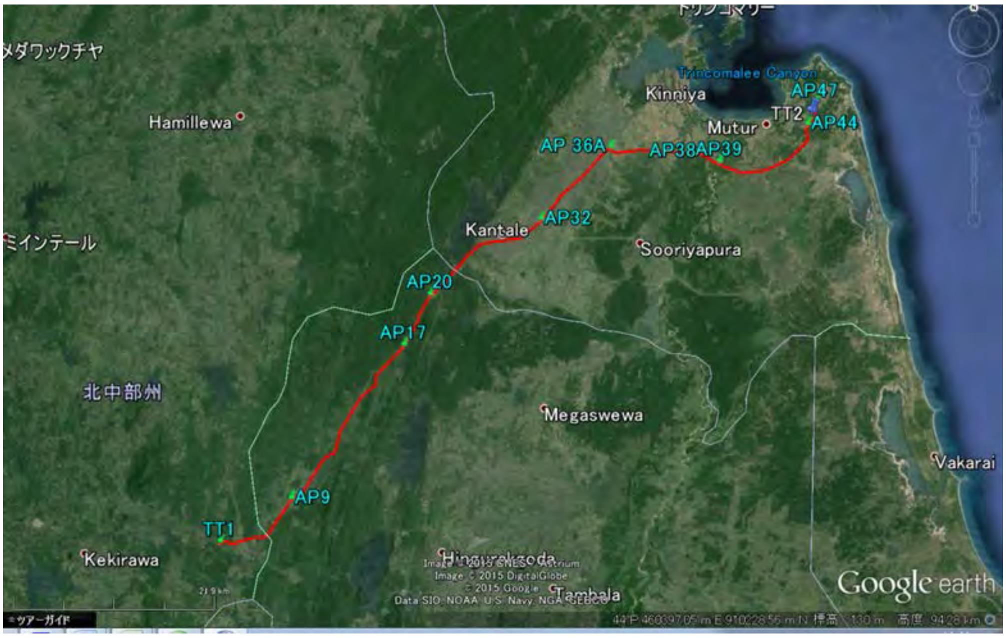


Figure 4.3-9 Survey Points for the SPT

One of the most important factors in assessing the soil conditions is to look for consecutive N-value profile at each boring point. The foundation types of the towers are examined from this trend.

Basically, the pad and chimney foundations might be preferable in the case that the bearing layer is shallow and the ground water level is deep. Such foundations are likely to be applied in most of the hilly areas. Pile foundation should be chosen at the part of the flood plain areas.

If some heavy machinery is available, excavation will be applicable for all area. However, some treatment for access routes and working space would be required during construction, especially in the rainy season. However, such excavation and construction work would probably be very difficult in the areas around the Mahaweli River due to high water levels in the rainy season.

The soil conditions are as follows.

(i) AP39

The borehole log for point AP39 located at the west bank of the Mahaweli River is shown in Annex 4.3-2. The log shows a low N-value continued from ground level to a depth of 30 m. Support layer was not founded until 40 m. This means that this area requires a long pile foundation or another special foundation.

(ii) Other Point

The borehole logs from TT1 to TT2 except AP39 are also shown in Annex 4.3-2. The log shows that the N-value from the depth of 3 m to 10m (the foundation's pad depth) is about 30 or more. This condition can expect normal foundation (not pile foundation) for the T/L. In case of constructing pile foundation, the pile may become short so that cost of construction becomes cheap.

2) Foundation Design

According to the above SPT results, pile type foundation would be applied around the Mahaweli River and the pad and chimney type foundation would be applied to the other areas. The assumed foundation loads that are transmitted from each tower type are shown in Table 4.3-17.

The actual foundation types at each tower as well as pile length shall be examined from the results of more detailed boring in the detailed design stage.

Table 4.3-17 Assumed Foundation Loads

Tower type (extension: +0)	Compressive load	Tensile load
TDL	1420.0 kN	789.1 kN
TD1	1682.6 kN	1059.6 kN
TD3	2403.5 kN	1729.7 kN
TD6	3408.6 kN	2678.0 kN
TDT	4978.1 kN	3776.4 kN

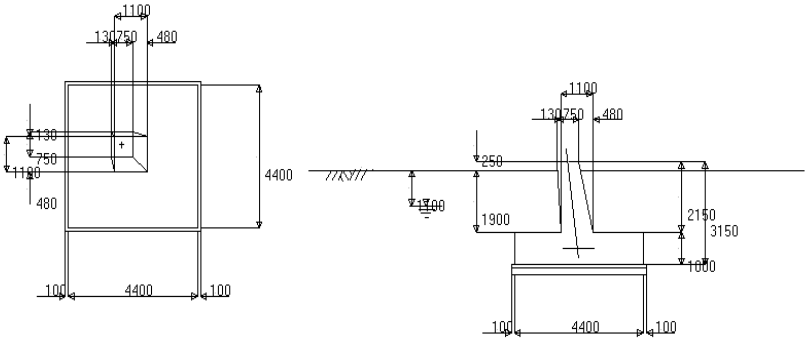


Figure 4.3-10 Assumed Design of Foundation for TDL

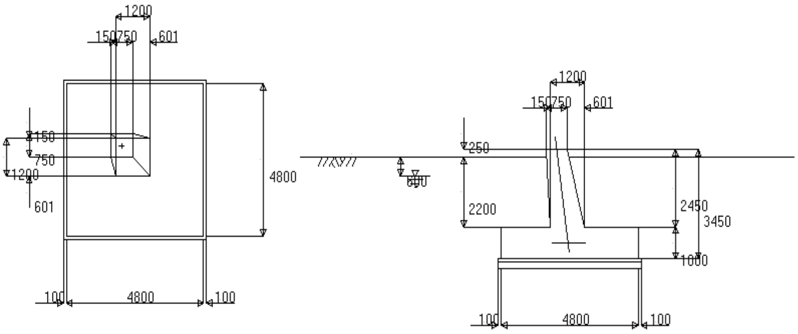


Figure 4.3-11 Assumed Design of Foundation for TD1

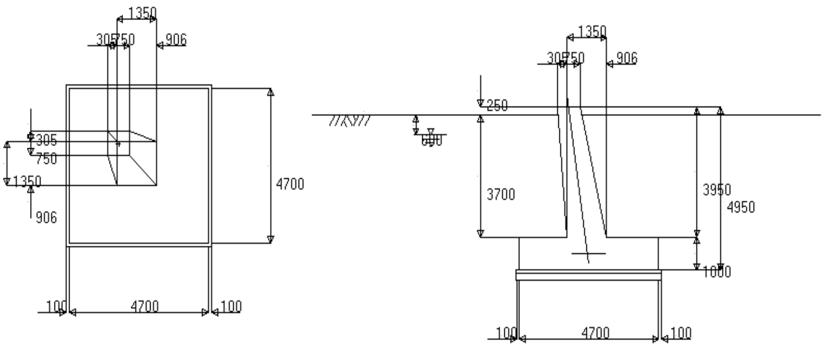


Figure 4.3-12 Assumed Design of Foundation for TD3

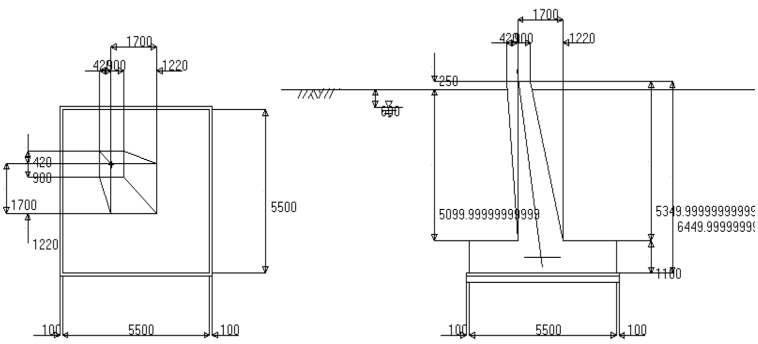


Figure 4.3-13 Assumed Design of Foundation for TD6

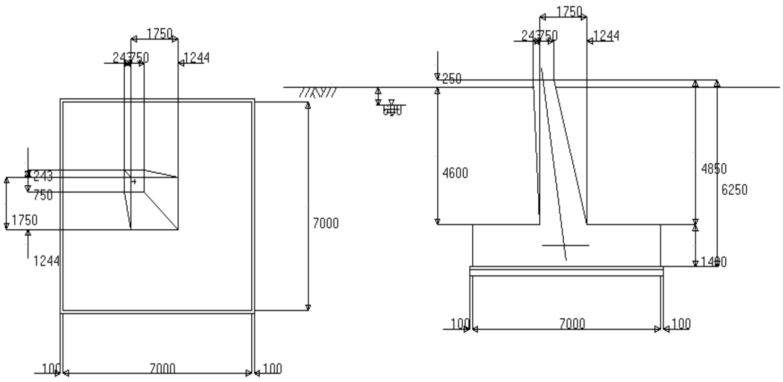


Figure 4.3-14 Assumed Design of Foundation for TDT

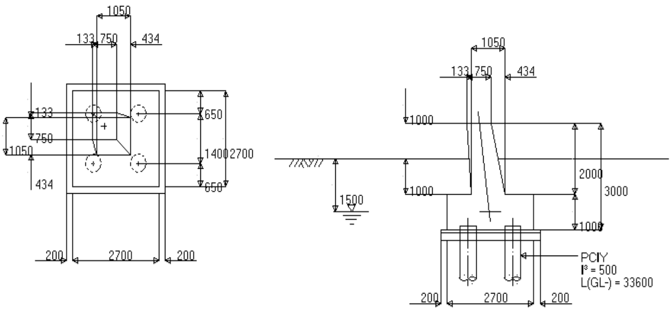


Figure 4.3-15 Assumed Design of Pile Foundation for TDL

In the Mahaweli River basin, water comes up in the rainy season as described in clause 4.2-7. CEB plans to use long chimney foundation in this area to prevent corrosion of tower.

Figure 4.3-16 Long Chimney Foundation (Existing CEB T/L)

4.3.2.8. Crossing Point with 132 kV Transmission Lines

There are two points where the 400 kV T/L will cross the existing 132 kV Anuradhapura – Trincomalee T/L. Crossing points are shown in Figure 4.3-17. The 132 kV T/L was constructed about 40 years ago and its strength is doubtful for reconstructing to cross the 400 kV T/L.

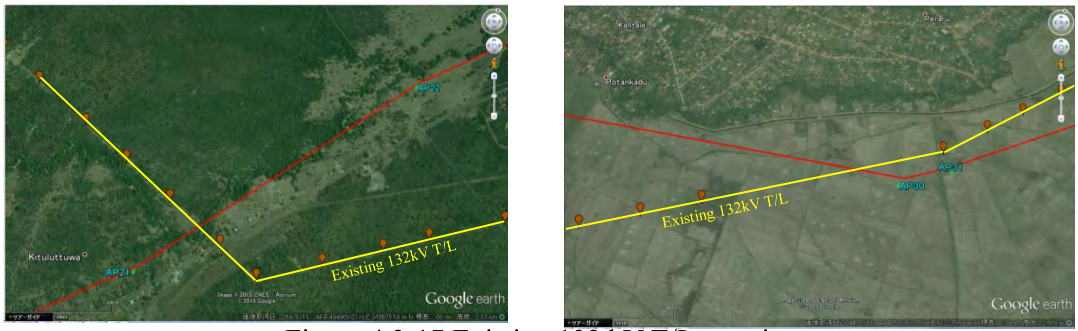


Figure 4.3-17 Existing 132 kV T/L crossing

The Team suggests using TDT towers to cross the 132 kV T/L to reduce tower height. Basically, upper conductor height of the 132 kV T/L is about 25m at the stringing point. At condition that conductor temperature of 7 ^{o}C, maximum tension of 54kN and span at 350m, calculated sag is about 7.2m at middle of the span. In this case, the height of the upper conductor at middle of the span is about 18m. Then the height of the lower conductor of the 400 kV T/L should be less than 24.5m in consideration of a 6.5m clearance.

If the TDT towers are constructed side by side (these towers need adequate distance from the 132 kV T/L considering the 132 kV T/L conductor's swing) at the middle of span of the 132 kV T/L and make it cross at right angle, no body extension or 3m body extension TDT tower can use for crossing.

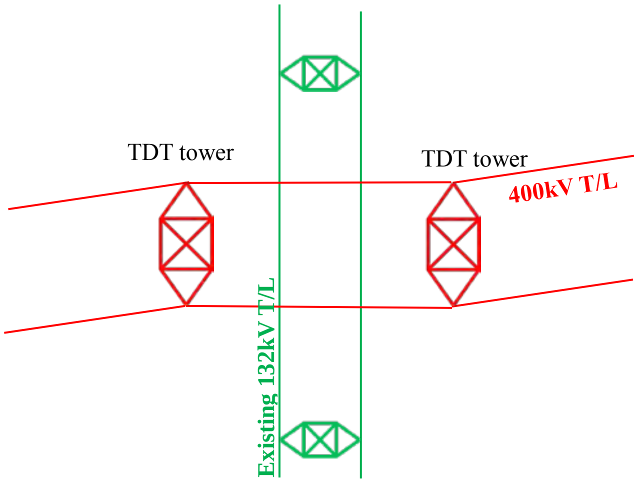


Figure 4.3-18 132 kV Crossing By Using TDT Tower

4.3.2.9. Quantities of Line Materials

In this chapter, the tentative quantities of the T/L materials for the Project are summarized. The quantities of the 400 kV T/L materials will be finalized after the completion of the route survey.

1) Number of Towers and Weight of Towers

The assumed number and weight of the towers for the 400 kV T/L are summarized in the following tables.

Table 4.3-18 Assumed Tower Weight and Number of Towers

Tower type	Extension (m)	Unit weight (t)	Nos. of towers (unit)	Total weight (t)
TDL (Suspension)	0	49.1	22	1080.2
	+3	55.4	143	7922.2
	+6	94.4	3	283.2
	+9	61.8	1	61.8
TD1 (Horizontal angle 0°-10°)	0	45.5	6	273.2
	+3	47.6	2	95.2
	+6	54.3	2	108.6
	+9	60.1	0	0.0
TD3 (Horizontal angle 10°-30°)	0	56.2	17	954.7
	+3	58.8	3	176.5
	+6	64.8	2	129.5
	+9	72.2	0	0.0
TD6 (Horizontal angle 30°-60°)	0	67.7	10	677.3
	+3	71.0	5	354.9
	+6	77.7	2	155.4
	+9	85.6	0	0.0
TDT (Terminal)	0	151.9	1	151.9
	+3	167.3	5	836.4
	+6	184.3	0	0.0
	+9	194.4	0	0.0
Total				13261.0

2) Quantities of Conductors and Ground Wires

The quantities of conductors and earth wires for the T/L are calculated by multiplying the number of conductors or ground wires by the route length.

Table 4.3-19 Assumed Quantities of Conductor and Earth Wire

Conductor/Earth wire	Nos. of bundles	Nos. of phases	Nos. of circuits	Route length (km)	Total length (km)
Low loss ACSR	4	3	2	91.2	2188.8
OPGW 120 mm^2	1	-	1	91.2	91.2
AS 110 mm^2	1	-	1	91.2	91.2

3) Quantities of Insulators

The quantities of insulators and insulator assemblies for the 400 kV T/L were calculated from the number of suspension and tension towers considering number of strings. These calculations and shown in Table 4.3-20.

Table 4.3-20 Assumed Quantities of Insulator and Insulator Assemblies

Tower Type	Assembly type	Insulator type	Nos. of insulator per strings	Nos. of strings per tower	Nos. of towers	Subtotal of strings	Subtotal of insulators
Suspension	Double	160BS	28	6	116	696	38,976
Tension	Quattro	160BS	28	12	38	456	51,072
Terminal	Quattro	160BS	28	6	5	30	3,360
	Single	70BL	28	6	5	30	840
Gantry	Single	70BL	28	6	1	6	168
Suspension	Double	160BLP	21	6	53	318	13,356
Tension	Quattro	160BLP	21	12	11	132	11,088
Terminal	Quattro	160BLP	21	6	1	6	504
	Single	70BLP	21	6	1	6	126
Gantry	Single	70BLP	21	6	1	6	126
Total		160BS					93,408
		70BL					1008
		160BLP					24,948
		70BLP					252

4) Quantities of Tower Foundation

At present the Team assumes that almost all of the tower foundations are to be pad and chimney, whereas the section around the Mahaweli River basin is to be pile. However, in consideration of further studies to be conducted, the Team predicts that it may be necessary to apply more pile foundation to the towers in paddy field areas due to potential geological conditions such as deep bearing layers. The assumed quantities of foundations for the 400 kV T/L are shown in Table 4.3-21.

Table 4.3-21 Assumed Quantities of Foundation

Tower Type	Foundation Type	Nos. of towers	Concrete Volume (m3/unit)	Total Concrete Volume (m3)	Pile length (m)
TDL	P&C	162	84.8	13,737.6	-
	Pile	7	35.6	249.2	34
TD1	P&C	10	101.6	1,016.0	-
TD3	P&C	22	106.4	2,340.8	-
TD6	P&C	17	174.0	2,958.0	-
TDT	P&C	6	306.4	1,838.4	-

P&C: Pad and Chimney

4.4. 220 kV Sampoor – Kappalturai Transmission Line

4.4.1. Outline of the Transmission Line Route

The 220 kV Sampoor – Kappalturai T/L route is shown in Figure 4.4-1.

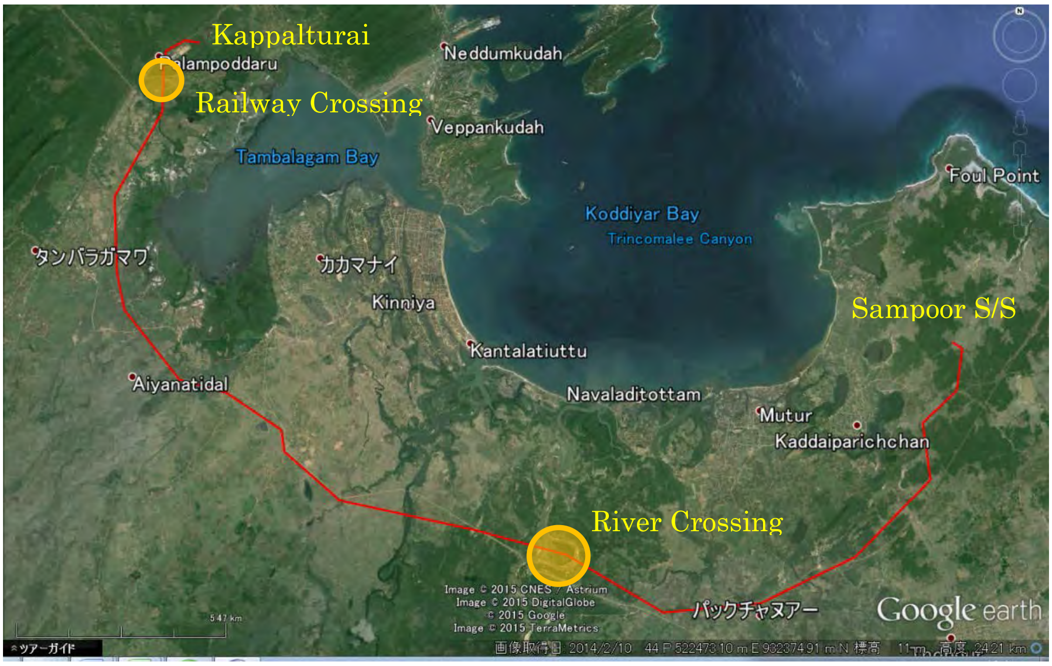


Figure 4.4-1 220 kV Sampoor – Kappalturai T/L Route

The proposed T/L connects Sampoor S/S and Kappalturai G/S. In general, the T/L runs through a flat terrain. The area around the T/L is used for paddy field, and the T/L is 25 km parallel to the 400 kV Sampoor – New Habarana T/L from Sampoor S/S.

According to route survey conducted by the Team, it seems that no critical obstacles exist along the proposed transmission line route, except for the crossing points of wide rivers, national roads, railways and existing transmission lines. The current conditions of the surveyed points are shown below.

National Road Crossing

Mahaweli River Crossing

Existing 132 kV T/L Crossing

Railway Crossing

4.4.2. Design

The design for the proposed T/L uses the existing 220 kV T/L design.

4.4.2.1. Design Condition

The basic design conditions for the Project are as below.

1) General condition

Table 4.4-1 General Conditions for the 220 kV T/L

Item	Value	Note
Normal (Basic) span	350 m	
Wind span	420 m	1.2 times normal span
Wind span (broken wire condition)	315 m	
Suspension Tower		
Weight span	700 m	2.0 times normal span
Weight span (broken wire condition)	525 m	0.75 times weight span
Tension Tower		
Weight span	1,050m	

Weight span (broken wire condition)	790m	
Everyday outside temp.	32 ^{o}C	
Minimum outside temp.	7 ^{o}C	
Maximum temp of conductor	75 ^{o}C	

(Source: CEB Technical specification)

2) Wind Pressure

The wind pressure for the conductors, insulator string and towers are shown in Table 4.4-2.

Table 4.4-2 Wind Pressure

Item	Value
Conductor and earth wire	970 Pa
Insulator	1,170 Pa
Tower	1,640 Pa

(Source: CEB Technical specification)

3) Safety Factor

Safety factor for the 220 kV T/L is as follows.

Conductor at 32 ^{o}C no wind:	4.5
Conductor at 7 ^{o}C 40 m/s wind:	2.5
Insulator:	3.0
Tower	
Suspension	2.0
Tension	2.5
Breaking wire condition	1.25
Foundation	1.5

(Source: CEB Technical specification)

4) Insulator

The electrical and mechanical characteristics of the insulator for the 220 kV T/L is shown in Table 4.4-3.

Table 4.4-3 Electrical and Mechanical Characteristics of Insulator for the 220 kV T/L

Dimensions	Unit	Suspension	Tension
IEC Designation		U120B	U160BS
Nominal diameter of disc	mm	225	280
Nominal spacing of disc	mm	146	146
Nominal creepage distance	mm	295	315
Electro-mechanical failure load	kN	120	160

(Source: CEB Technical specification, IEC 60305)

The number of insulator string for the 220 kV T/L is shown in Table 4.4-4.

Table 4.4-4 Number of the Insulator String for the 220 kV T/L

	Nos. of strings per set	Nos. of units per string
Normal suspension string	1	16
Heavy Suspension string	2	16
Jumper suspension string	1	16
Normal tension string	2	16
Light duty tension string	1	16

(Source: CEB Technical specification)

5) Ground and Other Clearance

The most severe state for the ground clearance of the conductors will occur when the conductor's temperature rises to 75 ^{o}C in still air conditions. The minimum height of the conductors above the ground at 220 kV level have been determined as shown in Table 4.4-5.

Table 4.4-5 Ground and Other Clearance for the 220 kV T/L

Description of Clearance	Minimum Clearance (m)
Minimum ground clearance at any point not over roads	7.0
Line conductors to road surfaces	7.4
Line conductors to high load route surfaces	8.5
Line conductors to railway crossings	8.2
To cradle guards	4.0
To road surfaces where cradle guards can be used (Note 1)	9.8
Where power lines cross or are in close proximity (Note 2)	3.7
To any object on which a person may stand including ladders, access platforms etc. (Note 3)	4.6
To any object to which access is not required and on which a person cannot stand or lean a ladder (Note 3)	2.4
Support of upper line and any conductor of lower line	15.0
Survey and sagging error (Note 4)	0.3
To trees adjacent to line (i) Unable to support ladders/ climber (ii) Capable of supporting ladder/ climber (iii) Trees falling towards line with line conductors hanging vertically only	 2.4 4.6 2.4

(Source: CEB Technical specification)

Note 1: These clearances are possible for situations where sky cradle can be used for conductor erection and maintenance. These clearances allow for the positioning of Sky cradle and erection of temporary scaffoldings under a live circuit.

Note 2: Clearances shall be defined in a way that the upper conductor at its maximum temperature and coincides with the lower conductor, which at its minimum temperature and deflected by an angle of 45^0 degrees.

Note 3: Clearances shall be defined with the conductor at its specified maximum temperature and deflected by any angle up to 45^0 degrees.

Note 4: To account for minor variations in ground topography and foundation installation, the transmission line profile shall be plotted with an additional clearance of 0.3m for 220 kV lines over those specified in the above table.

4.4.2.2. Conductor and Earth Wire

1) Conductor

As described in section 3.2, the double-bundle Zebra equivalent conductor is required for 220 kV Sampoor – Kappalturai T/L. The Team will analyze and compare the conventional conductor (Zebra) to low-loss conductor (LL-ACSR) to confirm which is the most energy efficient. The conductors are shown in Table 4.4-6.

Table 4.4-6 Technical Characteristics of the Conductors

Type		LL-ACSR/AC (Zebra equivalent)	Zebra/AS (Conventional)
Cross sectional area		590.5 mm^2	484.5 mm^2
Sectional area	Aluminum	550.4 mm^2	428.9 mm^2
	Steel core	40.08 mm^2	55.6 mm^2
Overall diameter		28.62 mm	28.62 mm
Nominal weight		1,814 kg/km	1,554 kg/km
Ultimate tensile strength		140.9 kN	137.9 kN
Modulus of elasticity		7,050 kg/mm^2	7,470 kg/mm^2
Coefficient of linear expansion		21.2 10^{-6}/ºC	20.5 10^{-6}/ºC
DC resistance at 20 ºC		0.0519 Ω/km	0.06456 Ω/km
Cross sectional view (Sample)			

(Source: Hitachi AS wire catalog, JPS information)

2) Earth Wire

As for the earth wires, AS 60 mm^2 and OPGW 80 mm^2 are applied. The technical characteristics of the ground wires are shown in the Table 4.4-7.

Table 4.4-7 Technical Characteristics of the Earth Wire

Type	AS 60 mm^2	OPGW 80 mm^2
Cross sectional area	58.07 mm^2	85.53 mm^2
Overall diameter	9.75 mm	14.3 mm
Nominal Weight	387 kg/km	652 kg/km
Ultimate tensile strength	70.26 kN	116.72 kN
Modulus of elasticity	162 GPa	131.38 GPa
Coefficient of linear expansion	12.6 10^{-6}/ºC	13.0 10^{-6}/ºC
Number of optical fibers	-	24

(Source: CEB Technical specification)

3) Sags and Tensions of the Earth Wires

The sags of the earth wires under EDS condition must be smaller than the conductors' sag at the standard span length to avoid a reverse flashover from the earth wires to the conductors and direct lightning strikes to the conductors. The tensions of the earth wires were determined to satisfy the safe separation of conductors and earth wires in the mid-span. The conductor and the earth wire tensions shall be selected that the sag of the earth wire at mid span, everyday tension, and basic span is less than the sag of the conductor by 1.5 m.

4.4.2.3. Tower Design

1) Clearance Design

The clearance for 220 kV T/L is shown in Table 4.4-8.

Table 4.4-8 Clearance for the 220 kV T/L

Item	Clearance (mm)
Minimum clearance from live metal to earthed metal for suspension towers	
From still air to 10° swing of insulator	2,200
From 10° to 40° swing of insulator	2,050
Minimum clearance from live metal to earthed metal at tension towers	
Jumper loops from still air to 10° swing	2,200
Jumper loops from 10° to 40° swing	2,050
Minimum plan clearance from arc horn tip to tower steelwork	2,200
Minimum separation between phases in down leads	3,500

(Source: CEB Technical specification)

2) Insulation Design of the Earth Wires

The number and shielding angle of the earth wires are determined as below:

- ✓ Number of ground wires: 2
- ✓ Maximum shielding angle: 0 ° to top phase conductor and less than 5 ° to middle and bottom phases

3) Tower Configurations

The double-circuit towers shall normally be the following five standard types. The types of towers are shown in Table 4.4-9.

Table 4.4-9 Standard Tower Type for the 220 kV T/L

Tower Type	Position of Use	Angle of Deviation/Entry	Insulator Type
TDL	Straight line	0 ° – 2°	Suspension
TD1	Angle/Section	0 ° – 10 °	Tension
TD3	Angle	10 ° – 30 °	Tension
TD6	Angle	30 ° – 60 °	Tension
TDT	Terminal	-	Tension

(Source: CEB Technical specification)

4) Jumper Swing Angle

The assumed maximum transverse jumper swing from vertical positions is shown in Table 4.4-10.

Table 4.4-10 Maximum Transverse Jumper Swing

Jumper loops	40 ^{o}
Jumper suspension insulator strings at tension towers	20 ^{o}

(Source: CEB Technical specification)

4.4.2.4. Foundation

1) Foundation Configurations

The foundations for the T/L shall normally be the following nine standard types. The types of foundation are shown in Table 4.4-11.

Table 4.4-11 Type of Foundation for the 220 kV T/L

Foundation class	Foundation type	Soil Classification	Presumed allowable bearing value kN/m2	Design uplift frustum angle	Level of Water table	Concrete density kg/m3	Soil density kg/m3
1	Rock Anchor	S1	>2000	45		2240/1200	2000/1000
2	Concrete pad & chimney	S2	>600	30	Below Datum* level	2240	1800
3	Concrete pad & chimney	S3	>200	20	Below Datum* level	2240	1600
4	Concrete pad & chimney	S4	>100	10	Below Datum* level	2240	1500
4A	Concrete pad & chimney	S4A	>100	10	Below Datum* level	2240/1200	1500/1000
5	Concrete pad & chimney	S5	>50	0	Below Datum* level	2240	1400
5A	Concrete pad & chimney	S5A	>50	0	Below Datum* level	2240/1200	1400/960
6	Piling	S6	Subject to soil investigation	0	Below Datum* level	2240/1200	Subject to soil investigation
7	Any other special	S7	Subject to soil investigation	0	Below Datum* level	2240/1200	Subject to soil investigation

* Datum level is 0.5m below the level of the bottom of the pad
(Source: CEB Technical specification)

Table 4.4-12 Soil Classification

S1	Homogeneous Rock
S2	Fractured rock/ Dense sand and Gravel
S3	Medium dense gravel/ Medium dense gravel with sand/ Compact sand/ Very stiff to stiff clay/ Hard clay
S4	Loose sand and gravel/Medium dense sand/ Stiff clay/ Firm clay
S4A (Water logged)	Loose sand and gravel/Medium dense sand/ Stiff clay/ Firm clay
S5	Soft clay, silt/ loose sand
S5A (Water logged)	Soft clay, silt/ loose sand
S6	Very soft clays and silts/ Peat and organic soils/ Made ground or fill
S7	Alternative

(Source: CEB Technical specification)

2) Estimated Foundation

According to the Team's site survey and the soil investigation, long pile foundation would be applied around the Mahaweli River area. However, as the paddy field areas typically have a greater than 20 N-value at the depth of 2 m – 3 m, the pad and chimney foundation would be applied to almost all tower foundations.

Actual pile length at each tower including the possibility of application of pad and chimney type foundation shall be examined in the detailed design stage.

4.5. Loss Reduction

4.5.1. Power Generation Estimation in the Trincomalee Area

According to CEB's long term generation expansion plan (2013 – 2032), power generation plan of the new thermal plant is as shown in Table 4.5-1. However, generation plan about coal power is changed and CEB is now remaking the energy generation dispatch plan. It is in light of this, the Team estimated the coal power energy generation dispatch plan in Trincomalee area including Trincomalee-2 project.

Table 4.5-1 Power Generation Plan for the New Thermal Plant

Plant Name	2017	2018	2019	2020	2021	2022	2023	2024
Coal	0	0	3,025	3,221	4,637	5,918	7,716	8,354
Coal Trinco	0	3,337	3,331	3,360	3,381	3,400	3,416	3,425

(Source: CEB Long Term Generation Expansion Plan 2013 - 2023) Condition in GWh

Due to construction delays, the TPCL Sampoor coal-fired power plant is estimated to start operation in 2020. According to the long term generation expansion plan, estimated coal power generation at Trincomalee in 2020 is 3,360 GWh. After the Sampoor coal-fired plant commences operation, the Trincomalee-2 Phase-I plant is expected to begin its operation in 2022. Estimated generation is 3,221GWh that is from Table 4.5-1 coal power generation in 2020. At this time, the Sampoor – New Habarana T/L operation voltage will be upgraded to 400 kV to enhance capacity. In 2023 and 2024, the second Trincomalee-2 Phase-II plant is expected to commence operation. Estimated total power generation of the Trincomalee-2 plant are respectively 4,637 GWh and 5,918 GWh that is from Table 4.5-1 coal power generation in 2021 and 2022.

Table 4.5-2 Power Generation Estimation for the Trincomalee Area

Plant Name	2017	2018	2019	2020	2021	2022	2023	2024
Coal Trincomalee-2	0	0	0	0	0	3,221	4,637	5,918
Coal Trinco	0	0	0	3,360	3,381	3,400	3,416	3,425
Total	0	0	0	3,360	3,381	6,621	8,053	9,343

(Source: Prepared by the Team)

4.5.2. Load factor of the Sampoor – New Habarana T/L

The load factor of the Sampoor – New Habarana T/L is estimated as follows.

- ✓ CEB's 220 kV T/L load factor is 0.582
- ✓ Energy from Sampoor to Kappalturai is calculated by following formula. 'Load to Kappalturai' is from PSS/E simulation.

$$\begin{aligned}&\text{Energy to Kappalturai (GWh)}\\&\quad= \text{Load of Kappalturai (MW)} \times \text{Load factor} \times 8760(\text{h}) \div 1000\end{aligned}$$

- ✓ Energy to the 400 kV T/L is estimated as generation energy at Sampoor minus 'Energy to Kappalturai'
- ✓ Load factor of the 400 kV T/L is calculated as following formula.

$$\text{Load factor of 400 kV T/L} = \frac{\text{Sending Power to New Habarana (MW)}}{8760\ (h) \times 2(cct) \times 1000}$$

4.5.3. Loss Reduction and Benefit of the LL-ACSR

In light of conditions stated above, the Team calculated the loss reduction and benefits which are shown in Annex 4.5-1 and Annex 4.5-2.

4.5.3.1. 400 kV Sampoor – New Habarana T/L

In relation to the 400 kV Sampoor – New Habarana T/L, the Team predicts that in 2020 there will be an annual loss reduction of about 6,350 MWh across the entire 91.2km T/L. After that, the Trincomalee-2 Phase-I plant should commence operation and the T/L operating voltage will be upgraded in 2022. At this point the annual loss reduction will is predicted to increase to 8750 MWh. Furthermore, the Team calculated that once the Trincomalee-2 Phase-II plant begin operation in 2023 to 2024, the annual loss reduction then increase to around 18,080 MWh.

In light of this, if the current electricity tariff continues, amount of construction cost difference between using the conventional Zebra and the LL-ACSR will be compensated by 2024, five years after construction.

Compare to life of conductor, about 30 years, it is beneficial to use the LL-ACSR instead of the conventional one. Thus, the Team recommends using the LL-ACSR for this T/L.

4.5.3.2. 220 kV Sampoor – Kappalturai T/L

From the Team's calculations, the annual loss reduction for this T/L will be around 6.1 MWh/km. The cost difference between the conventional Zebra and the LL-ACSR is 3.2 MLKRs/km.

In case of currently tariff continuing, amount of construction cost difference will be compensated by 2060, 41 years after construction.

Compare to life of conductor, about 30 years, it is not beneficial to use the LL-ACSR instead of the Zebra. Thus, the Team recommends using the conventional Zebra for this T/L.

Chapter 5. Facility Design of the Substations

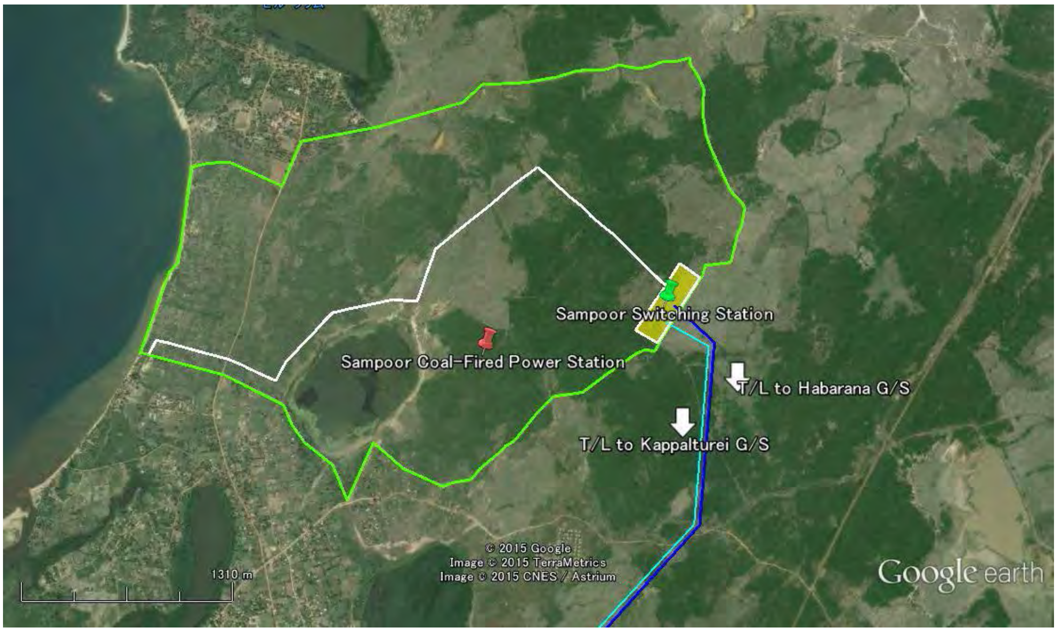
5.1. Scope of the Substations

5.1.1. Sampoor 220 kV Switching Station

5.1.1.1. Location

As shown in Figure 5.1-1, the Sampoor 220 kV switching substation (hereinafter referred to as 'Sampoor 220 kV S/S') is planned to be located at latitude 8° 28' 30.35" north and longitude 81º 18' 56.14" east in the Trincomalee District of North Central Province. The switching station will be about 14.5 km southeast of Trincomalee.

As informed by CEB, necessary land for Sampoor 220 kV S/S including future expansion to 400 kV grid substation (hereinafter referred to as 'G/S') has already been acquired approximately 500 m x 160 m next to the land for the Sampoor coal-fired power plant.



(Source: Prepared by the Team based on Google Earth Pro)

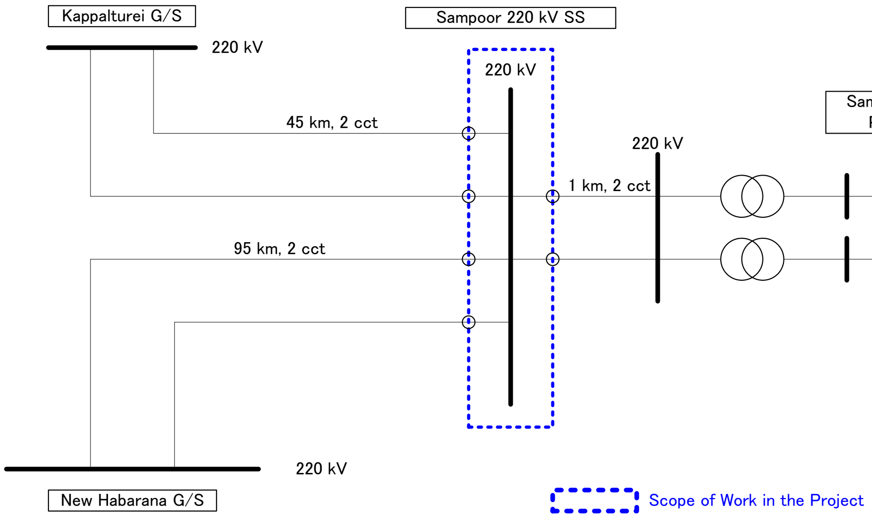
Figure 5.1-1 Location Map of the Sampoor 220 kV Switching Station

5.1.1.2. Scope of Work

The Team carried out the survey and basic design for the Sampoor 220 kV S/S. Sampoor 220 kV S/S will be constructed in order to supply the power generated at the Sampoor coal-fired power plant – with a generation output of 2 x 250 MW - to the Colombo District via the New Habarana G/S and the Kappalturai G/S. As described in section 3.2, the transmission lines from the Sampoor coal-fired power plant will be connected to Sampoor 220 kV S/S by 220 kV, and the transmission lines from the Trincomalee-2 coal-fired power plant, - this will also be constructed in the Sampoor area and shall have generation power of 4 x 300 MW - will also be connected to the Sampoor S/S. The boundary between the Sampoor 220 kV S/S and the Trincomalee-2 coal-fired power plant will be at gantry structures in the Sampoor S/S. When the Trincomalee-2 coal-fired power plant is connected to the Sampoor S/S, 400/220 kV transformers and a 400 kV GIS will also be constructed within the land acquired by CEB since the transmission line to the New

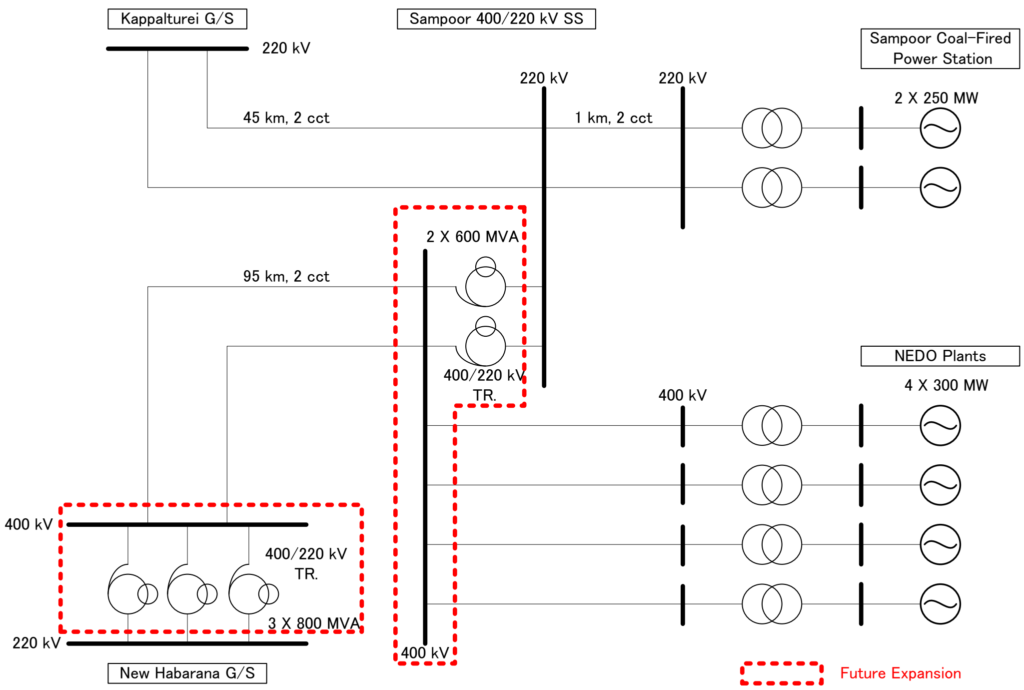
Habarana G/S will be operated at 400 kV.

Therefore, for the Project, the Team carried out the basic design for the Sampoor 220 kV S/S in consideration that its capacity will probably be expanded to 400 kV in the future.



(Source: Prepared by the Team)

Figure 5.1-2 System Configuration of the Sampoor 220 kV S/S (As at 2018)



(Source: Prepared by the Team)

Figure 5.1-3 System Configuration of the Sampoor 400/220 kV S/S (As at 2024)

5.1.1.3. Current Situation and Circumstance

At present, there is no 33 kV commercial line around the proposed Sampoor 220 kV S/S; the nearest 33 kV line is about 3 km away from the Sampoor 220 kV S/S.

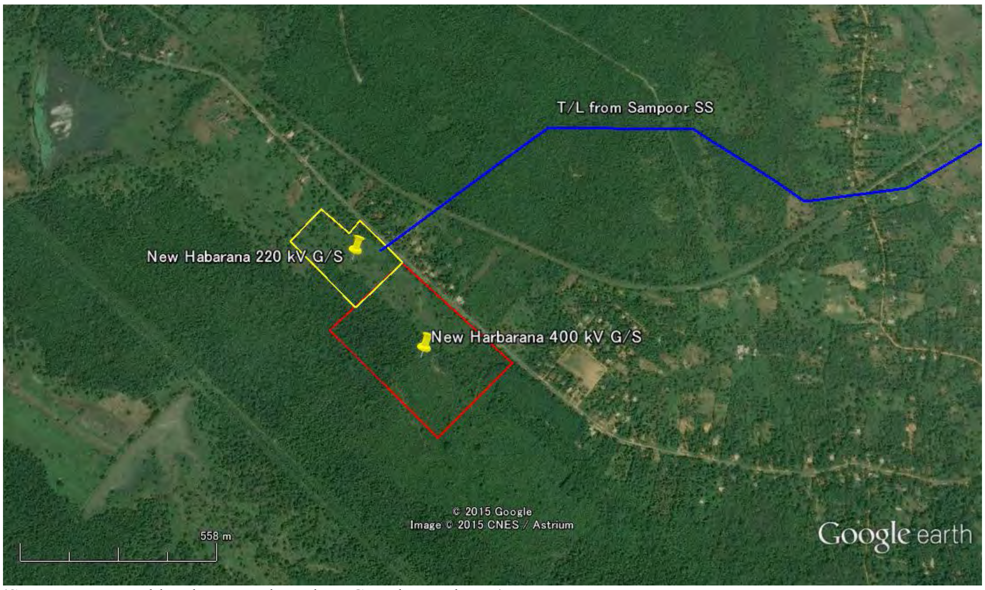
The land acquired for the Sampoor S/S is a flat and bushy area. Thus, the Team deems that is will probably not be necessary to level the land digging and filling.

Regarding the access road, the road from Trincomalee is good condition and ready for use. However, it seems like the road from Kaddaiparichchan has not been suitably maintained and is very rough, especially in rainy season.

5.1.2. New Habarana 220 kV Grid Substation

5.1.2.1. Location

As shown in Figure 5.1-4, New Habarana 220 kV G/S is planned to be located at latitude 8° 02' 59.23" north and longitude 80° 43' 34.98" east in the Anuradhapura District of North Central Province. The grid substation will be about 3.4 km east-northeast Habarana.



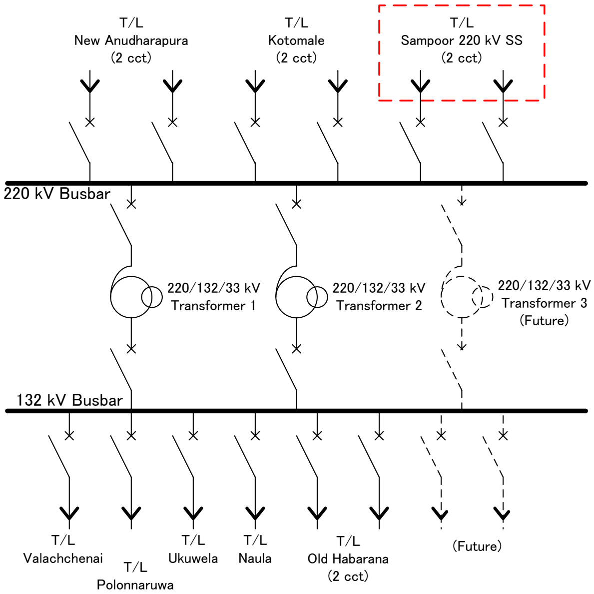
(Source: Prepared by the Team based on Google Earth Pro)

Figure 5.1-4 Location Map of the New Habarana 220 kV G/S

5.1.2.2. Scope of Work

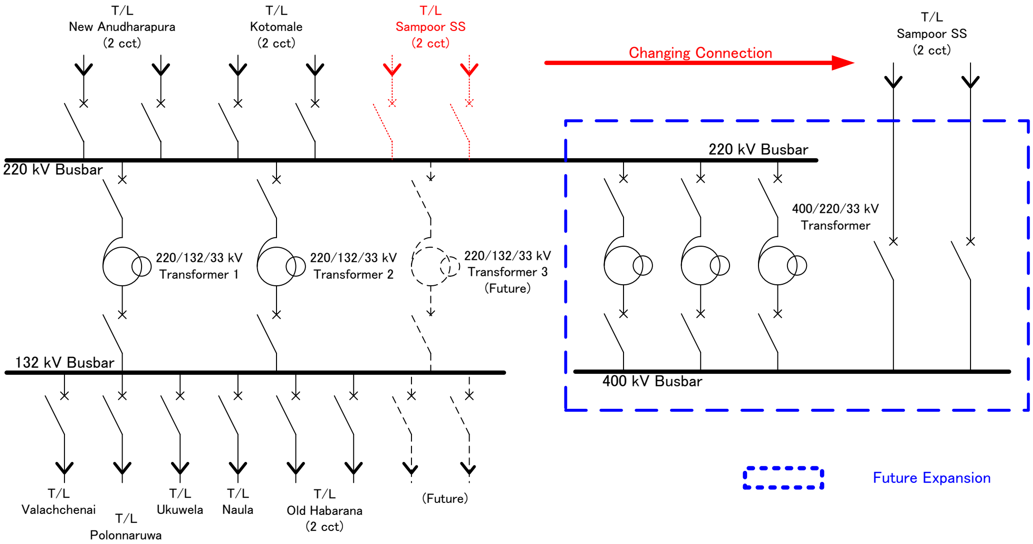
The New Habarana 220 kV G/S, as shown in Figure 5.1-5, will be constructed under other project “Habarana – Veyangoda Transmission Line Project Lot A” (hereinafter referred to as ‘Habarana T/L project’). The transmission line from the Sampoor S/S which has been designed by the Team on the Project will be connected to the gantry structures, which will be constructed as part of the Habarana T/L project, during the initial operation by 220 kV. In addition, the scope of the Project will be to connect the gantry structures in the New Habarana 220 kV G/S. The New Habarana 220 kV G/S is expected to commence operation before the construction of the transmission line – from the Sampoor S/S. Therefore, in order to reduce power outages, the optimum method to connect this transmission line to the 220 kV busbar in the New Habarana 220 kV G/S shall be considered.

Regarding 400 kV Substation in the New Habarana G/S, construction of this is not included in the scope of the Habarana T/L project, and the land for it has not yet been acquired. The Team highly recommends that the 400 kV substation shall be built in the vicinity of the New Habarana 220 kV G/S, as this will convenient for facilitating a connection to the 220 kV busbar in the G/S and for transporting and installing necessary materials and equipment.



(Source: Prepared by the Team)

Figure 5.1-5 Single Line Diagram of the New Habarana 220 kV G/S (As at 2018)



(Source: Prepared by the Team)

Figure 5.1-6 Single Line Diagram of the New Habarana 220 kV G/S (As at 2024)

5.1.2.3. Current Situation and Circumstance

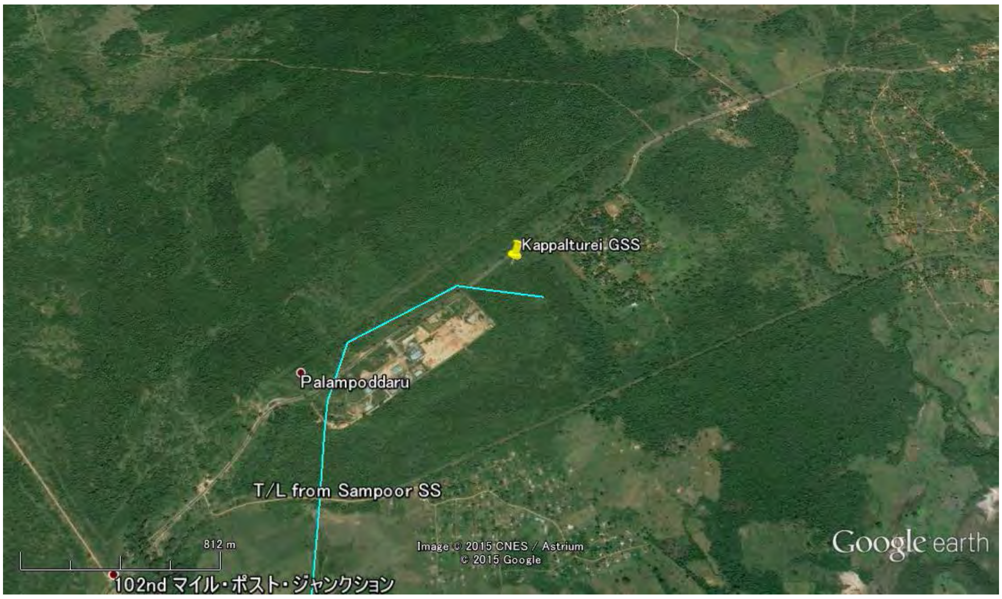
The land for the construction of the New Habarana 220 kV G/S has already been acquired in the Habarana area. The location is convenient to transport the materials and equipment to the site because the acquired land runs alongside the No.11 national road from Habarana to Palugaswewa.

The land acquired for the New Habarana 220 kV G/S is a flat and bushy area. Thus, the Team deems that is will probably not be necessary to level the land through digging and filling.

5.1.3. Kappalturai 220 kV Substation

5.1.3.1. Location

As shown in Figure 5.1-7, the Kappalturai G/S is planned to be located at latitude 8° 33’ 2.58” north and longitude 81° 07’ 46.88” east in the Trincomalee District of North Central Province. This grid substation will be about 11.7 km east of Trincomalee.



(Source: Prepared by the Team based on Google Earth Pro)

Figure 5.1-7 Location Map of the Kappalturai G/S

5.1.3.2. Scope of Work

The Team confirmed that the Kappalturai G/S will be constructed under the following project financed by an ADB loan.

1) Project Name:

Green Power Development and Energy Efficiency Improvement Investment Programme (TRANCHE 1)

Part 2 – Transmission Infrastructure Capacity Enhancement Project

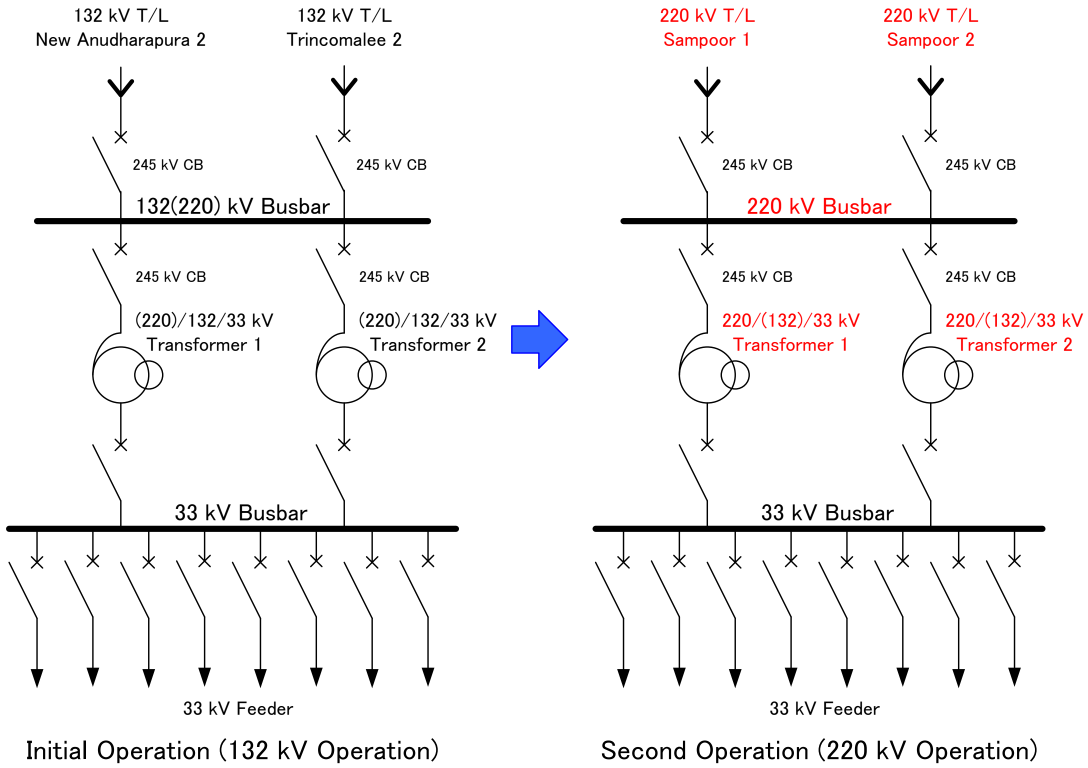
ADB Loan No. 3147/3146 (SF) - SRI

2) Project Scheme:

- ✓ Construction of 220/33 kV, Kerawarapitiya Grid Substation
- ✓ Construction of 220(132)/33 kV, Kappalturai Grid Substation
- ✓ Augmentation of 132/33 kV, Trincomalee Grid Substation
- ✓ Augmentation of 132/33 kV Katunayaka Grid Substation

3) Outline of Construction of 220(132)/33 kV Kappalturai G/S

Before the construction of the transmission line from Sampoor to Kappalturai G/S, the building of a 132/33 kV Kappalturai G/S is planned on the existing 132 kV transmission line between New Anuradhapura and Trincomalee by the pi brunch. As shown in Figure 5.1-8, it is planned that the Kappalturai G/S will initially operate as a 132/33 kV grid substation. When the transmission line from Sampoor S/S is constructed, the existing 132 kV feeder will be removed and the 220 kV line from Sampoor will be connected to gantry structures instead of the 132 kV line. It will not be necessary to replace the equipment (such as the circuit breaker, disconnector, transformer, gantry structures, and bus conductor), that is to be installed for this initial operation at 132 kV, as this is will also be suitable for handling 220 kV.



(Source: Prepared by the Team)

Figure 5.1-8 Single Line Diagram of the Kappalturai G/S

According to the above conditions, CEB and the Team confirmed and agreed that construction works for Kappalturai G/S are out of scope in the Project. In addition, the boundary between the Project and ADB project will be at the gantry structures in the Kappalturai G/S.

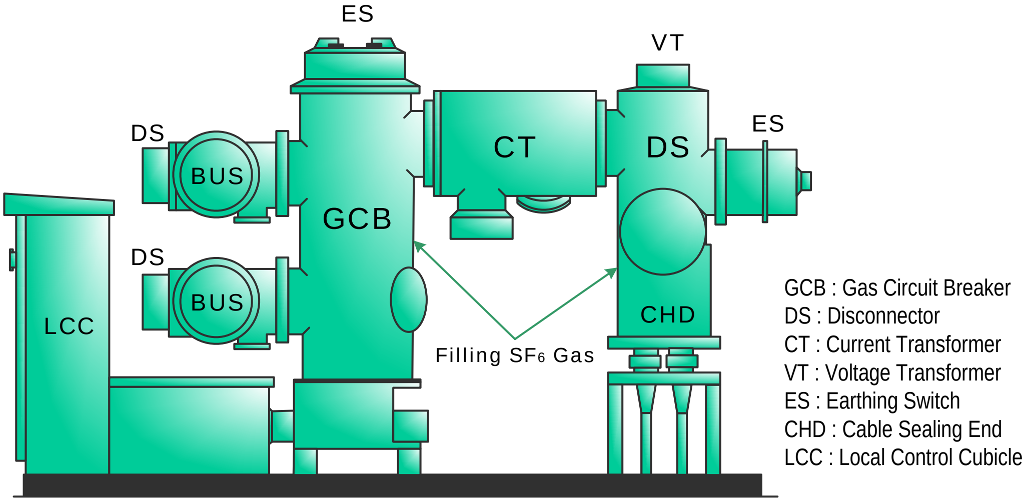
5.2. 220 kV GIS at Sampoor Switching Station

5.2.1. Features of GIS

The GIS system requires only 15 % of the space necessary for AIS system. Nevertheless, the costs of the GIS system and buildings are higher than the AIS system. The GIS system is mainly suited for areas with space constraints, such as city centers, industrial area, etc. or areas or areas with high air pollution.

5.2.2. GIS Configuration

The GIS enclosure shall be filled with sulphur hexafluoride (SF6) gas, which is used for insulating and arc-quenching medium, with appropriate gas pressure. The GIS is consist of a surge arrester (SA), disconnectors (DS), gas insulated circuit breaker (GCB), current transformer (CT), voltage transformer (VT) and cable connection module respective functions. These GIS components are housed either individually and/or shall be combined with gastight enclosures.



(Source: Prepared by the Team)

Figure 5.2-1 GIS Configuration

5.2.3. Application to the Sampoor 220 kV S/S

Regarding the Sampoor S/S, the land acquired for the construction of the switchgear, gantry structures and terminal towers is limited. Furthermore, in consideration of the proposed future extension to the 400 kV substation and the cable reconnection, the Team suggests that not too much space is used for the 220 kV. Therefore, the Team fully recommends the GIS system for the Sampoor S/S.

5.2.4. Type of GIS

The GIS has both an indoor type and an outdoor type. In the Project, as a result of discussions with CEB, the Team recommends the indoor type GIS system is recommended for the following reasons.

- ✓ Savings on construction costs for GIS building is the advantage of the outdoor type GIS system
- ✓ In coastal areas, the effects of potential damage from salt water must be considered
- ✓ There are no outdoor GIS system in Sri Lanka
- ✓ CEB's O&M staff already have the know-how and experience to operate the indoor GIS system
- ✓ The indoor GIS system will be less prone to being affected by floods

Figure 5.2-2 Indoor Type GIS in the Kerawarapitiya S/S

5.3. Preliminary Design for the Sampoor Substation

5.3.1. General

The Team has visited the site of Sampoor S/S and confirmed the availability and technical possibility of a new construction, and carried out the preliminary design for the switching stations/substations as described below.

5.3.2. Design Concepts

The following concepts are to be applied for the design of Sampoor S/S:

5.3.2.1. General Concepts

The equipment for the switching stations/substation are designed so as to maximize the functions of the substation in overall system, taking the following considerations:

- ✓ Daily O&M shall be performed in a safe and proper manners
- ✓ The connection shall be as simple as possible without affecting the proper system performance
- ✓ In case that a fault occurs in a switching station/substation, influence of the fault shall be limited to the maximum extent, and necessary switching operations for shifting loads to other substations shall be performed without delay and trouble
- ✓ Consideration must be paid to making the future process of reinforcement and/or augmentation whenever required, as easy as possible necessary
- ✓ The design must be technically viable and economically feasible

5.3.2.2. Busbar Arrangement

Almost all the substations in Sri Lanka utilize the double bus scheme. But, however, in this case the busbar arrangement was decided in consideration of the following points:

- ✓ Supply reliability and security
- ✓ Operational performance and flexibility
- ✓ Capital costs
- ✓ Maintenance and repair aspects
- ✓ Future extension
- ✓ Space requirements
- ✓ Outage rates of busbar scheme and failure rates for circuit breakers

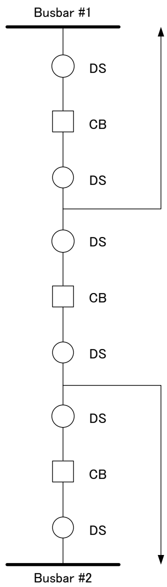


Figure 5.3-1
One-and-half CB Scheme
(Source: Prepared by the Team)

As a result of careful examination and a course of discussions with CEB, the "one-and-half circuit breaker scheme" as shown in Figure 5.3-1 shall be applied to the Sampoor 220 kV S/S due to the following reasons:

- ✓ The Sampoor S/S bear an important responsibility to supply a large amount of power to Colombo
- ✓ The large of generating power from the Trincomalee-2 coal-fired power plant in Sampoor will be connected to the Sampoor S/S
- ✓ The high reliability and flexibility of the O&M
- ✓ The higher costs will be offset by the above advantages

5.3.2.3. Power Supply to Station Service Load

In the Sampoor 220 kV S/S, there is no transformer which can supply the power to station service load from the 220 kV system, because Sampoor 220 kV S/S will be operated as the switching station until Trincomalee-2 coal-fired power plants are connected to the Sampoor S/S. Therefore, it has to be considered how to supply to station service load. The Team recommends four methods detailed below including a future extension/upgrade in order to supply the power.

1) Receiving Power from the 33 kV Commercial Line

There are no 33 kV commercial lines around the Sampoor 220 kV S/S. However, an existing 33 kV commercial line was confirmed about 3 km away from switching station, so this will be extended to near the Sampoor S/S.

2) Receiving Power from the Sampoor Coal-fired Power Plant

When the 33 kV commercial lines are tripped, there is another option to receive the power by 33 kV from the Sampoor coal-fired power plant. It has more reliability than the 33 kV commercial lines, because the power outage of the station service circuit in the Sampoor coal-fired power plant will not be permitted, and also Sampoor coal-fired power plant will be operated on a 24 hour basis as base power source in Sri Lanka. The Sampoor coal-fired power plant will be operated by TPCL not CEB. Therefore, a watt-hour meter shall be installed in the 33 kV switchgear in order to confirm the volume of electricity transaction.

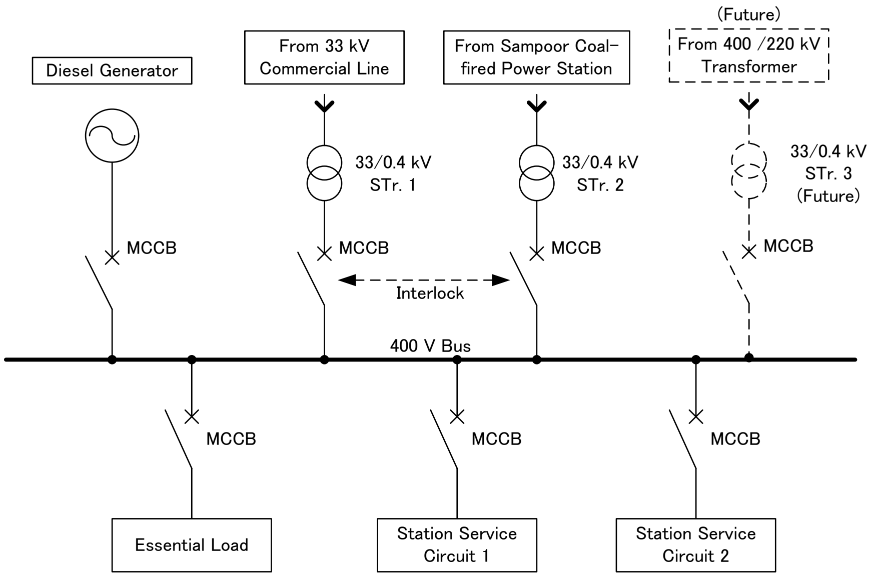
3) Emergency Diesel Generator

As well as almost all the substations in Sri Lanka, considering the case that the 33 kV commercial lines and the power from the Sampoor coal-fired power plant is tripped, an emergency diesel generator should be installed at the Sampoor 220 kV S/S.

4) Feeder for Receiving Power from Transformer in Future Extension

In the proposed future upgrade to the 400 kV system, 400/220 kV transformers will be installed at the Sampoor S/S. In order to supply the stable power to the station service system, an expansion feeder which will be able to receive power from the tertiary winding of the new transformer should be considered for 33 kV switchgear.

As considered the above four methods, the outline of the station service circuit is shown in Figure 5.3-2.



(Source: Prepared by the Team)

Figure 5.3-2 Station Service Circuit in the Sampoor 220 kV S/S

5.3.2.4. Overhead Line Protections

In CEB standard specifications, there are two methods for overhead line protection depending on the distance of the transmission line and the possibility of fiber optic link. For long transmission lines where there is no fiber optic link, two independent main protection schemes of numerical type distance relays with two different types are required to protect the whole of each overhead line circuit fault against all types of faults. On the other hand, for transmission lines where fiber optic signaling channels are available, two main protection schemes of numerical type, line differential relays are required. The line differential protection relays shall also include a distance protection function for the provision of remote back-up protection.

As back-up protection for the overhead 245 kV lines, non-directional over current and earth fault relay are recommended.

5.3.2.5. Busbar Protections / Breaker Failure Protections

In CEB standard specifications, a numerical type centralized or de-centralized busbar protection scheme to detect all inter-phase and phase-to-earth faults is required.

The busbar protection should be able to operate on current transformers having a wide range of different ratios.

Regarding the breaker failure protection, a numerical type breaker failure relay system shall be provided which shall monitor the feeder’s phase currents by detectors in each phase. The breaker failure relay shall be fed from the same main current transformer circuits as used by the busbar protection.

5.3.2.6. Substation Automation System

Substation Automation System (SAS) shall be designed according to the IEC 61850. The SAS shall include full station control, monitoring and communication functions. It shall enable local station control via industrial PC by means of a human machine interface and control software package to perform the necessary system control and data acquisition functions. Furthermore, it shall include: a communication gateway to the National Control Centre which is named as System Control Centre; a remote setting parameterisation and fault evaluation from the protection master station; an inter-bay-bus; and intelligent electronic devices for the bay control and protection as shown in Annex-5.3-4.

5.3.2.7. Auto Reclosing System

Regarding the transmission line between the Sampoor S/S and the Habarana G/S, this shall play an important role to supply the large amount of power generated at Sampoor to Colombo. Thus, it should be considered to apply a "poly-phase reclosing system" as shown in Figure 5-3.3. However, in Sri Lanka, there is no substation applied poly-phase auto reclosing system and such a system is not planned for application in the new Habarana 220 kV G/S.

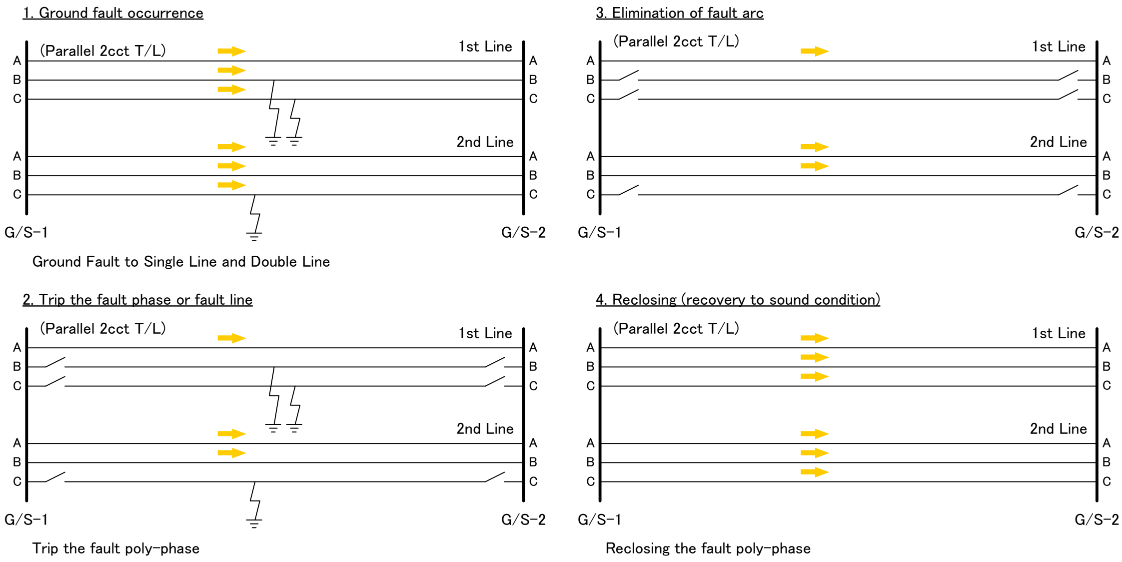
In CEB standard specifications, auto reclosing system is specified as follows:

The auto-reclosing equipment shall be programmable for all the necessary logic to provide for the following possibilities:

- ✓ *1 phase trip and high-speed auto-reclose*
- ✓ *1 + 3 phase trip and high-speed auto-reclose*
- ✓ *3 phase trip and high-speed auto-reclose*
- ✓ *3 phase trip with delayed auto-reclose*
- ✓ *3 phase definitive tripping only*

As mentioned the above, the auto reclosing system in the New Habarana 220 kV G/S will not apply poly-phase reclosing system. Therefore, in this Study, the Team recommends the same method as will be used in the New Habarana 220 kV G/S and not the poly-phase reclosing system. In this connection, the circuit breaker at the Sampoor S/S shall be a selective single-pole tripping type.

Otherwise, for the purpose of the proposed future upgrade to a 400 kV system, the Team recommends to apply the poly-phase reclosing system to 400 kV line.



Poly-Phase Auto Reclosing System

In case of transmission lines by parallel 2 circuits, it has many opportunities of 2 circuits fault by tower flashover.

For example, in case of the faults of phase B & C in first circuit and of phase C in second circuit, in ordinary protection system, all three phases in 2 circuits will be tripped by the three phase operation of short circuit relay and ground phase selector relay in each circuit and terminal. However, if faults are removed by trip of only fault phase, the system at the terminal substation will keep operating by remaining phase A in first circuit and phase A & B in second circuit. Then, it means operating is subject to interconnection more than 2 different phases against 6 lines in 2 circuits. In this system, tripped fault phase will be reclosed by high-speed. This is "Poly-phase Auto Reclosing system, and this system will increase the system atability.

(Source: Prepared by the Team)

Figure 5.3-3 Poly-Phase Auto Reclosing System

5.3.2.8. Digital Disturbance Recorder

In case some failure is occurred at transmission line, digital disturbance recorder (DDR) should be installed in order to record faults and analyze their causes.

5.3.2.9. Current Transformers Method

Althoughhere are several methods for installing the CT in one-and-half CB scheme for the busbar protection, breaker failure protection and metering, the Team recommends the 4 CT method for the Sampoor S/S (as shown in Figure 5.3-4) due to its reliability and the adaptive flexibility.

Example for the combination of CT and cores are shown in Table 5.3-1.

Table 5.3-1 Example for Combination of CT and Cores

	1-CT	2-BCT	2-ACT	3-CT
Core-1	CT secondary core is connected Buabar-1 protection	Spare	Spare	CT secondary core is connected Buabar-2 protection
Core-2	Busbar-1 Checkup Protection (Spare)	Spare	Spare	Busbar-2 Checkup Protection (Spare)
Core-3	2 CT's secondaries are connected in parallel and connected to panel meters & energy meter		2 CT's secondaries are connected in parallel and connected to panel meters & energy meter	
Core-4	2 CT's secondaries are connected in parallel and connected to main-2 protection after LBB/BFR		2 CT's secondaries are connected in parallel and connected to main-2 protection after LBB/BFR 2 CT's secondaries are connected in parallel and connected to backup protection after LBB/BFR	
Core-5	2 CT's secondaries are connected in parallel and connected to main-1 protection		2 CT's secondaries are connected in parallel and connected to main protection	

(Source: Prepared by the Team)

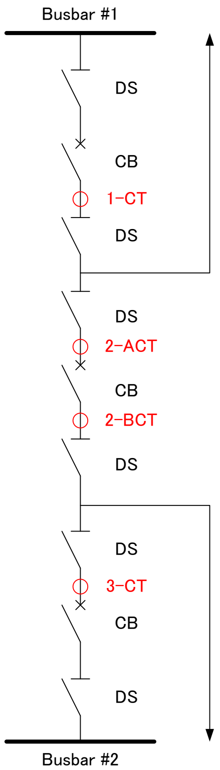


Figure 5.3-4
4 CT Method in the 1.5 CB Scheme
(Source: Prepared by the Team)

5.3.2.10. Communication System

Recently, fibre optic links which operates over the OPGW have been used as telecommunications system instead of Power Line Carrier (PLC) in Sri Lanka. The fibre optic network is based on SDH (STM-1) with a transmission capacity of 155 Mbit/s.

The fibre optic communication system provides communications channels for the following:

- ✓ The party line telephone system
- ✓ The administrative telephone system
- ✓ The Supervisory Control and Data Acquisition (SCADA) system
- ✓ The Tele-protection Signalling facilities
- ✓ Computer WAN connectivity

5.3.2.11. Other Concepts

1) Earthing System

In the switchyard of the new substation, an underground earthing system should be properly laid in the form of a meshed grid.

All equipment installed in the substation should be effectively connected to an earthing system. The resistance of the earthing system needs to be less than 1 ohm and in compliance with the guideline given in IEEE 80.

2) Countermeasure for Disasters

(i) Dust/Salt Pollution

Where a substation is constructed in an area affected by dust contamination, appropriate countermeasures need to be taken in the design based on the level of pollution. In the Sampoor S/S, damage by salt water shall be considered in the design.

(ii) Lightning

For the protection of switching station/substation equipment from lightning, appropriate measures must be provided in the design of the substation to address the required network reliability and site-specific conditions.

(iii) Flooding

In the event that the Sampoor S/S is flooded due to unavoidable circumstance, appropriate measures must be taken to keep any equipment problems to a minimum and to restore function of the station as fast as possible.

(iv) Fire

Appropriate fire fighting measures must be provided in order to protect operators and equipment from fire or explosion and, at the worst, to restrict the fire to limited area.

(v) Earthquake

In the preliminary design of the Sampoor S/S, the influence of earthquakes will be considered.

3) Consideration for Environment

(i) Noise

If there are some households around the Sampoor S/S, necessary measures for noise shall be planned to limit noise to a reasonable level.

(ii) Vibration

Necessary measures shall be planned to limit vibration levels of the Sampoor S/S to within the standard values recognized in Sri Lanka.

(iii) Harmony with Environment

Special attention shall be paid to the protection of natural environment in the surrounding areas. Consideration shall also be given to preserving the local living environment (including access to sunlight, the scenery and radio interface) and also to harmonizing with the regional community.

5.3.3. Design Criteria

5.3.3.1. Applicable Standards

The design, materials manufacture, testing, inspection and performance of all electrical and electromechanical equipment shall comply with the latest revision of the International Electrotechnical Commission Standard (IEC standards) as listed below:

IEC 60044-1	Instrument transformers – Part 1 : Current transformers
IEC 60044-5	Instrument transformers – Part 5 : Capacitor voltage transformers
IEC 60071	Insulation coordination
IEC 60099-4	Surge arresters – Part 4: Metal-oxide surge arresters without gaps for a.c. systems
IEC 60265-2	High-voltage switches – Part 2 : High-voltage switches for rated voltages of 52 kV and above
IEC 60694	Common specifications for high-voltage switchgear and controlgear standards
IEC 61850	Communication network and systems in substations
IEC 62271-100	High-voltage switchgear and controlgear – Part 100 : High-voltage alternating-current circuit-breakers
IEC 62271-102	High-voltage switchgear and controlgear – Part 102 : Alternating current disconnectors and earthing switch
IEC 62271-203	High-voltage switchgear and controlgear – Part 203 : Gas-insulated metal-enclosed switchgear for rated voltages above 52 kV

In case where IEC standards do not cover the conditions in the design, international standards will be applied such as ANSI, ASTM, BS, JIS, JEC and JEM.

5.3.3.2. Insulation Co-ordination

The insulation co-ordination for the design of 220 kV and 33 kV equipment under the Project is set out below.

Nominal system voltage	220 kV	33 kV
Rated voltage (r.m.s. value) (Highest voltage for equipment)	245 kV	36 kV
Rated frequency	50 Hz	50 Hz
Symmetrical short-circuit current at rated voltage r.m.s (ultimately)	25/40 kA	25/40 kA
Insulation levels		
Rated lightning impulse withstand Voltage (r.m.s. value)	1050 kV	170 kV
Power frequency voltage (1 min)	460 kV	70 kV
Minimum clearance of phase-to-earth	2200 mm	325 mm
Minimum clearance of phase-to-phase	2200 mm	325 mm
Standard clearance of phase-to-phase	4500 mm	2625 mm

5.3.4. Major Components of the Sampoor S/S

The following drawings in Annex 5.3-1, 5.3-2, 5.3-3, 5.3-4 and 5.3-5 show the preliminary design of the Sampoor S/S.

SL-SP SS-LY-001	Layout Drawing for the Sampoor 220 kV S/S
SL-SP SS-LY-002	Control Building Layout for the Sampoor 220 kV S/S
SL-SP SS-SD-001	Single Line Diagram for the Sampoor 220 kV S/S
SL-SP SS-SD-002	Station Service Circuit Diagram for the Sampoor 220 kV S/S
SL-SP SS-SD-003	Supervisory Control System for the Sampoor 220 kV S/S

The Sampoor S/S is to be newly constructed under the Project and will include a 220 kV indoor type GIS, two 33/0.4 station service transformers, and control cubicles.

The detailed scope of works for Sampoor S/S is as follows;

5.3.4.1. Construction of 220 kV GIS

The installation of the 220 kV one-and-half circuit breaker scheme includes two Gas Insulated Bus (GIB) and six transmission line bays.

220 kV incoming unit	2 units
220 kV feeder unit	4 units

The associated gantry structures for the above system shall be supplied and installed.

The associated steel support structures and foundations for the above equipment with all necessary connecting materials shall be supplied and installed.

The connection work between the dead-end towers, the associated gantry structures and the above equipment shall be carried out and all necessary materials for the work such as underground cross-linked polyethylene (XLPE) cables, insulator sets, fittings, post insulators, connectors, accessories, power and control cables, etc. shall be supplied and installed.

The above equipment shall be properly earthed with newly constructed underground earthing mesh and all necessary materials such as earthing conductors shall be installed.

5.3.4.2. Installation of Protection and Control Panels

The following protection and control panels with remote operation supervisory device (SCADA) shall be supplied and installed.

Protection panels	
220 kV GIS incoming protection	2 sets
220 kV GIS feeder protection	4 sets
Control panels	
220 kV GIS incoming control/synchronize	2 sets
220 kV GIS feeder control/synchronize	4 sets

Associated power and control cables with necessary accessories shall be supplied and installed.

A new protection scheme shall be coordinated with the protection schemes other substations such as the New Habarana 220 kV G/S and the Kappalturai G/S.

All necessary meters including ammeters, voltmeters, watt-hour meters shall be supplied and installed.

5.3.4.3. Installation of the Communications Equipment

The following optical fibre telecommunications equipment shall be supplied and installed:

ODF for connection of 19 inch rack / 24 core optical fibre cable
Patch cables connecting ODF with STM-1 and multiplexer
Supply STM-1 and multiplexer with multi channels of not less than 2 Mbit/s interfaces
Access STM-1 and multiplexer with multi channels (interfaces) each for 64 kbit/s to connect SCADA system and telephone subscribers
Optical fibre splicing boxes (i.e., for termination of OPGW on the transmission line towers in the Sampoor 220 kV S/S)

5.3.4.4. Miscellaneous Electrical Equipment

The following miscellaneous electrical equipment shall be supplied and installed:

Two 33/0.4 kV, 200 kVA indoor type station service transformers with associated switchgear and power cables
One indoor type 200 kVA auto start module type diesel engine generator set with associated switchgear, power cables and fuel tank
Indoor type 36 kV metal enclosed switchgear and power cables connecting from the Sampoor coal-fired power plant and 33 kV commercial line consisting of the following: 36 kV commercial line incoming feeder: 1 unit 36 kV incoming feeder (from Power Plant): 1 unit 36 kV incoming feeder (Future): 1 unit (Future)
400 V AC distribution switchboard including necessary cables and accessories
220 V DC system including two sets of 220 V battery banks, two sets of chargers, one set of distribution board
48 V DC system including two sets of 48 V battery banks, two sets of chargers, one set of distribution boards
Earthing system covering complete new S/S area including earthing rods, and conductors
Overhead substation shield wire system including shield wires and supporting structures to protect against lightning
Outdoor substation lightning system

All necessary materials for the above works such as cables, connectors, accessories shall be supplied and installed.

5.3.4.5. Civil and Building Works

The associated civil works for the above works shall be carried out as follows:

Cleaning, cutting, filling, levelling and compacting of the new switching station area
Excavation and backfilling, as required
Gravelling of the complete new switching station area
Construction of the external security fences and gate
Construction of the station service road
Construction of the gantries for 220 kV switchyards
Construction of the steel structures and equipment supports
Construction of the concrete foundation for all equipment
Construction of the drainage pit and conduit
Construction of the cable pit
Construction of a complete 220 kV GIS building with control room, 33 kV cubicle room, office, workshop, storage room, battery room, toilet and other facilities
Construction of the guard house beside the main gate
Supply and installation of air conditioning and ventilation equipment for the switching station building
Supply and installation of lighting and power system for the switching statin control building including distribution boards, and socket outlet
Supply and installation of a water well, storage facility and a wastewater and septic tank facility
Supply and installation of firefighting equipment associated with the air conditioning system for the control building

All necessary materials for the above works such as concrete, aggregate, reinforcement, accessories shall be supplied and constructed.

5.3.4.6. Other Works

The following works for the above new equipment shall be carried out:

Spare parts for at least five years of operation
Tool and erection accessories as required
Complete documentation for the O&M
Training for CEB staff at the manufacturer’s factory and at the site

5.3.5. Specifications of the Major Equipment

5.3.5.1. 220 kV Gas Insulated Switchgear

1) Type

The GIS shall be a metal-enclosed, three-phase busbar and switchgear type, for indoor use, and filled with SF6 insulation gas.

2) Circuit Breakers

Rated voltage	245 kV
Rated busbar normal current	not less than 3,150 A
Rated feeder normal current	2,000 A
Rated frequency	50 Hz
Rated short-circuit breaking current	40 kA, 1 sec.
Rated interrupting time	less than or equal to 3 cycle
Rated operating sequence	O - 0.3 sec. - CO - 3 min. - CO
Rated closing operation voltage	220 V DC
Rated control voltage	220 V DC
Rated insulation level	
a) Rated short-duration power-frequency withstand voltage (r.m.s. value)	460 kV
b) Rated lightning impulse withstand voltage (peak value)	1050 kV

The circuit breakers shall be suitable for selective single-pole tripping and rapid auto-reclosing provided with a motor-operated spring mechanism and shall comply with the related IEC standards/recommendations.

The circuit breakers shall be equipped with a motor-charged spring operated mechanism for 220 V DC and the mechanism shall ensure uniform and positive closing and opening.

3) Disconnectors and Earthing Switches

Rated voltage	245 kV
Rated normal current	2,000 A
Rated frequency	50 Hz
Rated short-circuit withstand current	40 kA, 1 sec.
Rated control voltage	220 V DC
Rated insulation level	
a) Rated short-duration power-frequency withstand voltage (r.m.s. value)	460 kV
b) Rated lightning impulse withstand voltage (peak value)	1050 kV

The disconnectors and earthing switch shall both be motor-operated and provided with a manual operating mechanism with a hand crank.

The motor-operated disconnectors and earthing switch shall be designed with a three-pole operation and the motor shall be operated on 220 V DC.

Where specified, the disconnectors shall be fitted with approved three-phase line earthing devices, mechanically coupled or interlocked with the main disconnector so that the earthing device and main disconnector cannot be closed at the same time.

4) Current Transformers

Highest system voltage	245 kV
Rated frequency	50 Hz
Rated insulation level a) Rated short-duration power-frequency withstand voltage (r.m.s. value) b) Rated lightning impulse withstand voltage (peak value)	 460 kV 1050 kV
Rated current ratio	as specified in single line diagram of Sampoor S/S
Accuracy classes	5P20 for protection, Class 0.5 for metering

5) Voltage Transformers (inductive type)

Highest system voltage	245 kV
Rated frequency	50 Hz
Voltage ratio	$\frac{220\,kV}{\sqrt{3}} : \frac{110\,V}{\sqrt{3}} : \frac{110\,V}{3}$
Accuracy classes	0.5
Rated insulation level a) Rated short-duration power-frequency withstand voltage (r.m.s. value) b) Rated lightning impulse withstand voltage (peak value)	 460 kV 1050 kV

5.3.5.2. Outdoor Switchgear

1) Surge Arresters

The 192 kV arrester shall be a gapless, metal-oxide, outdoor and heavy duty type. These arresters shall be designed in accordance with IEC 60099-4.

Rated voltage (r.m.s. value)	192 kV
Rated frequency	50 Hz
Nominal discharge current	10 kA
Long-duration discharge class	Class 3 (Table-5, IEC 60099-4)
Pressure-relief current	40 kA
Rated insulation levels for insulators a) Rated short-duration power-frequency withstand voltage (r.m.s. value) b) Rated lightning impulse withstand voltage (peak value)	 460 kV 1050 kV

5.3.5.3. Indoor Switchgear Cubicles

1) Type

The 36 kV switchgear cubicle shall be an indoor, three-phase, and metal-enclosed type.

2) Ratings

Rated voltage	36 kV
Rated normal current	1,250 A
Rated frequency	50 Hz
Rated short-circuit withstand current	25 kA, 1 sec.
Rated control voltage	220 V DC
Rated insulation level	
a) Rated short-duration power-frequency withstand voltage (r.m.s. value)	70 kV
b) Rated lightning impulse withstand voltage (peak value)	170 kV

3) Necessary Equipment and Operating Mechanism

The following equipment and operating mechanism shall be used:

CB, CT, VT, DS, ES and SA
Remote control module with Micro-SCADA
Protection relays such as over-current, over-current grounding, under-voltage, over-voltage shall be equipped and front-side mounted
All necessary metering instruments including ammeters, voltmeters, watt-hour meters shall be front-side mounted with front side
ES shall be equipped with CB and DS (both with interlock mechanisms)

5.3.5.4. Protection and Control Equipment

Protection and control equipment for the 220 kV system shall be mounted in the cubicles and installed in totally air conditioned substation control rooms. Control panels shall incorporate all necessary control and indication devices for the operation of equipment at the Sampoor S/S.

The new equipment shall be operated independently of each other, applying decentralized modules for alarm (monitoring) and tripping functions.

The remote operation supervisory devices (Micro-SCADA) shall incorporate all necessary control and indication devices for the operation of equipment at the Sampoor S/S. The Micro-SCADA system shall be equipped with a desktop PC and shall be installed in totally air conditioned substation control rooms.

1) Protection Relays

The following protection relays shall be supplied:

(i) 220 kV Transmission Line Protections

Differential Relay including distance relay function (main protection)
Non directional over-current and earth fault relay (back up protection)
Auto-reclosing relay
Breaker failure relay
Synchro check relay

(ii) 220 kV Busbar Protections

Ratio differential relay

2) Digital Disturbance Recorder

(i) General

For recording the faults and analysing their causes in the substation and transmission line, a Digital Disturbance Recorder (DDR) shall be installed in the Sampoor S/S.

The DDR shall be a microprocessor based system. In addition, the DDR system shall be a complete modular designed standalone system to monitor maximum grouping of eight to nine (8/9) analogue input channels and sixteen (16) digital input channels it is also predicted that these shall be upgraded to at least hundred and ninety two (192) analogue input channels and three hundreds and eighty four (384) digital input channels. The DDR system shall be capable of simultaneous monitoring for at least in two different sampling/scanning for the required input channels. Furthermore, the DDR system shall be integrated into the overall SAS.

The DDR shall be a complete automatic digital recording system capable of sensing, acquiring, storing and recording the data, printing and transmitting disturbance records to the analysis units (Local Station Computer & Remote Master Analysis Station).

(ii) Remote Master Analysis Station (RMAS)

The Remote Master Analysis Station (RMAS) shall be installed in the Protection Developments and O &M branches. If it is compatible with the existing system, it will be proposed to add the necessary hardware and software to the existing master station.

The RMAS shall facilitate the retrieval of data records from the installed DDR location either manually or automatically.

3) Control Equipment

The control panels to be installed shall include all devices necessary for the safe and effective control of the equipment.

The control panels shall include control and indication function for all the 220 kV circuit breakers and disconnectors. The control switches for the circuit breakers and disconnectors shall be flash mounted on the front of the control panels.

The front panel shall include a mimic diagram reflecting the actual layout of the 220 kV. The mimic diagram shall have different colours for different voltages.

All control and indicator circuit shall be designed for 220 V DC. Fuses for various DC circuits, including for control, protection relay, and indication shall be mounted on separate board. Each circuit shall be supervised by voltage relays giving alarm in case of a voltage failure or fuse trip.

Position indication signals of switches and breakers for transmission by the supervisory control scheme shall be derived from separate, normally open and closed auxiliary contacts that are provided and connected up to terminal blocks in the associated control panels.

5.3.5.5. Optical Fibre Communication System

The OPGW will be with 24 optical fibres (single mode).

To achieve the necessary availability for the overall telecommunication network, redundancy shall be established by means of main and backup links for most fibre optic links by installation of a fibre-optic ring. Additionally, as shown in Annex 5.3-4, the ethernet switch shall be redundant in the proposed future extension to the 400 kV system. This is because the control system in the Sampoor S/S will be a double ring system.

The fibre optic telecommunication systems shall be supervised and controlled by the CEB communication branch.

Optical fibres shall be used to establish the telecommunication channels with all the required functions for SCADA, telephones, teleprotection and other data transmission as described below.

1) Party Line Telephone System

This system is a dedicated non-switched telephone system, which is exclusively used for system control purposes. The system comprises of master station equipment at the system control centre and terminal equipment at all power station and grid substations.

2) Administrative Telephone System

The administrative telephone system provides voice communications between any other substation and generating stations connected to the Sri Lanka HV transmission system.

3) Teleprotection System

The teleprotection system is provided for satisfactory operation of the grid substations. Fibre optic teleprotection equipment will be used to provide, with maximum security, the rapid, two-way transmission of a trip command between adjacent substations connected by OPGW line.

4) Overall SCADA System

The existing SCADA system in Sri Lanka includes the master station hardware at the National Control Centre of CEB and Remote Terminal Units (RTU) and/or SAS gateways at power stations and grid substations.

The SCADA system will be used for monitoring and controlling of the power generation and transmission network in CEB

5.3.5.6. 220kV Power Cables in the Sampoor S/S

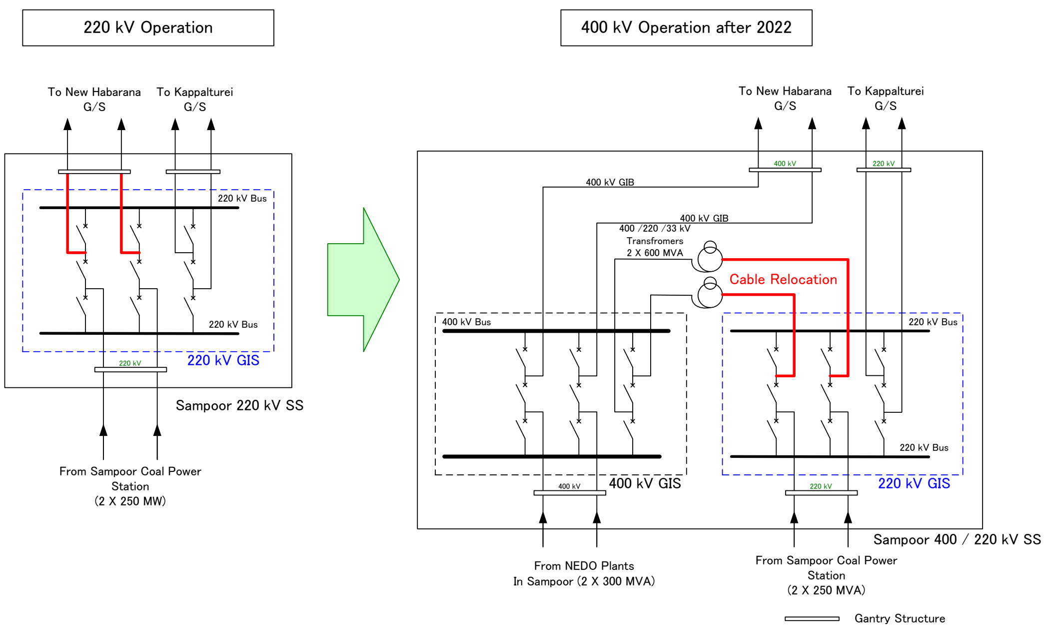
1) 220 kV Power Cable Section

In order to connect the transmission line and the 220 kV GIS, power cable size between the following sections should be considered.

- ✓ 220 kV GIS – gantry structure of T/L to New Habarana 220 kV G/S : 2 cct
- ✓ 220 kV GIS – gantry structure of T/L to Kappalturai G/S : 2 cct
- ✓ 220 kV GIS – gantry structure of T/L to Sampoor Coal-fired Plant : 2 cct

2) Cable Configuration

The 220 kV feeder in the GIS for the transmission line to the New Habarana 220 kV G/S will have its connection changed to the 400/220 kV transformers when the proposed future upgrade to the 400 kV system occurs. Then, in order to reduce the costs for purchasing new cables to the 400/220 kV transformers, cables from the 220 kV GIS to the gantry structure for the T/L to the New Habarana 220 kV G/S shall be reused for the transformer through a cable relocation as shown in Figure 5.3-5.



(Source: Prepared by the Team)

Figure 5.3-5 Cable Relocation at the Sampoor S/S

As shown in Figure 5.3-5, cables which are connected to the gantry structure of the T/L to the Kappalturai GS will be outgoing from same bay in the 220 kV GIS in order to reduce the number of bay and construction cost. These cables will be connected to GIS through cable room under GIS floor. In this case, the reliability for operation of circuit breaker by tapping at same bay will not be changed in accordance with feature of one and half circuit breaker scheme. This method will be also applied to the 400 kV GIS when the 400 / 220 kV transformers are installed and connected to the 400 kV GIS.

In this method, it has the possibility to trip all circuit breakers in the same bay when the breaker failure protection is occurred in circuit breaker between feeders after detecting some ground faults or short circuit fault in the transmission line. It means both feeders for transmission line connected to same G/S and for transformers are tripped. However, frequency for operation of breaker failure protection will be far less than some troubles in transmission lines.

3) Maximum Current in each Cable Section

According to the system analysis described in Clause 3.5, the maximum current in each section under N-1 condition will be calculated as shown in Table 5.3-2.

Table 5.3-2 Maximum Current for the Power Cable in the Sampoor S/S

Section	As at 2020	As at 2022	As at 2024
To New Habarana G/S	1019.8 A	1003.0 A	1003.0 A
(To 400/220 kV Tr. after 2022)	(388.6 MVA)	(382.2 MVA)	(382.2 MVA)
To Kappalturai G/S	206.3 A	231.5 A	299.7 A
	(78.6 MVA)	(88.2 MVA)	(114.2 MVA)
To Sampoor Coal-fired Plant	1191.4 A	1191.4 A	1191.4 A
	(454.0 MVA)	(454.0 MVA)	(454.0 MVA)

(Source: Prepared by the Team)

To select the cable size, the maximum current shall be considered to have a margin of 10 % as follows,

- ✓ 220 kV GIS – gantry structure of T/L to New Habarana 220 kV G/S

  1019.8 A × 110 % = 1121.8 A

- ✓ 220 kV GIS – gantry structure of T/L to Kappalturai G/S : 2 cct

  299.7 A × 110 % = 329.7 A

- ✓ 220 kV GIS – gantry structure of T/L to Sampoor Coal-fired Plant : 2 cct

  1191.4 A × 110 % = 1310.5 A

4) Cable Size

Cross-linked polyethylene cable (XLPE cable) is widely used for the power cables in substations and switching stations. In this Project, the following cable size is recommended in connection with the using current.

Table 5.3-2 Specifications for 220 kV XLPE Cables

Cable Size	800 mm^2	1000 mm^2	1200 mm^2	1600 mm^2	2000 mm^2
Overall diameter	117 mm	122 mm	126 mm	133 mm	139 mm
Continuous current carrying (laid direct at 1.2 m depth, S=600 mm)	898 A	1005 A	1088 A	1249 A	1379 A

(Source: J-Power systems)

5) Cable Selection

Considering the maximum current in each cable section and allowable continuous current as mentioned above, the cable size in the Sampoor S/S is recommended as follow,

- ✓ 220 kV GIS – gantry structure of T/L to New Habarana 220 kV G/S : 1600 mm^2
- ✓ 220 kV GIS – gantry structure of T/L to Kappalturai G/S : 800 mm^2
- ✓ 220 kV GIS – gantry structure of T/L to Sampoor Coal-fired Plant : 2000 mm^2

5.3.6. Particular Construction Method for the Sampoor 220 kV S/S

The Team have determined that there are no particular construction methods for the Sampoor 220 kV S/S. This is because the Sampoor 220 kV S/S is to be newly constructed without any outside coordination in the acquired land. Furthermore, CEB has an experience in the construction of 220 kV GIS S/S such as the Kerawarapitiya S/S.

However, with regard to the proposed future upgrade to the 400 kV system and related construction work not only for the Sampoor S/S but also the New Habarana 400 kV G/S - particular care must be given to the reconfiguration for the existing 220 kV GIS and cable relocation (in consideration of the changing-over methods as mentioned in section 5.4.1).

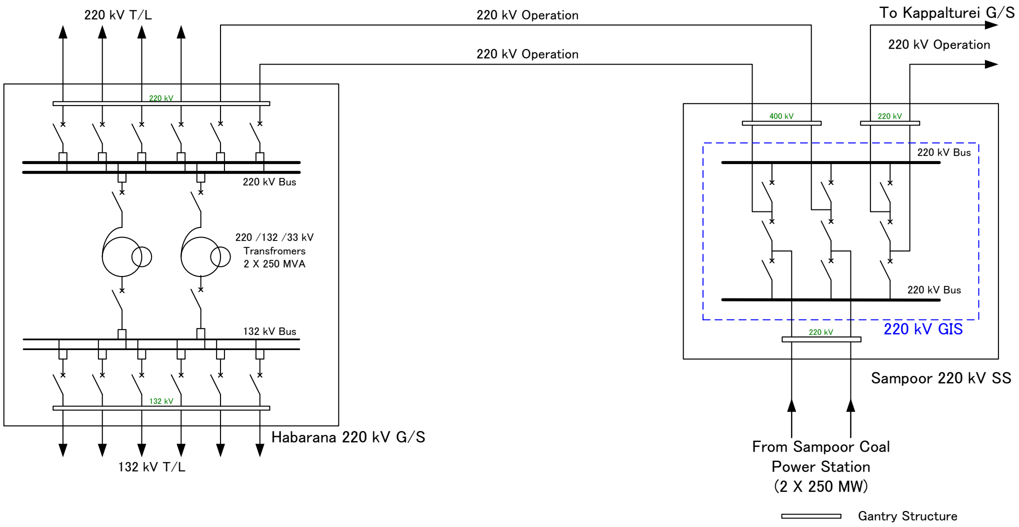
5.4. Study Team Recommendations

5.4.1. Changing-over Method from the 220 kV System to the 400 kV System

When the 400 kV transmission line from the Trincomalee-2 coal-fired power plant connected to the Sampoor S/S, the operating voltage of the Sampoor S/S shall be raised from 220 kV to 400 kV, and the transmission line between the Sampoor S/S and the New Habarana 400 kV G/S shall be operated as a 400 kV line. The Team considers that a change-over from 220 kV to 400 kV would be the best way to reduce the potential power outages while having a minimal impact on the operation of the overall system. Therefore, the change-over from 400 kV to 220 kV should be carried on a step-by-step per circuit basis.

5.4.1.1. Phase-1: 220 kV System Operation

During the period after the construction on the Project is completed until the Trincomalee-2 coal-fired power plant is connected to the Sampoor 220 kV S/S in 2022, the system between the Sampoor S/S and the New Habarana 220 kV G/S will be operated at 220 kV as shown in Figure 5.4-1.



(Source: Prepared by the Team)

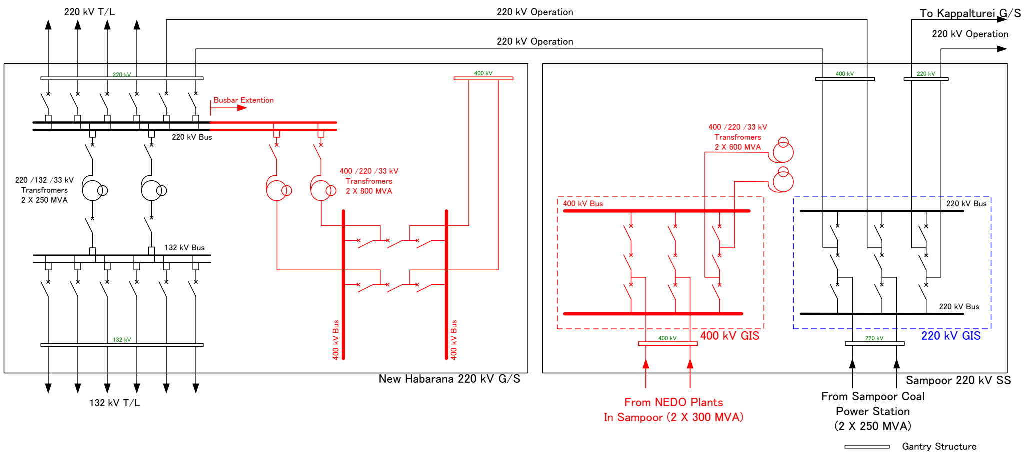
Figure 5.4-1 System Configuration for the Changing-Over Method (Phase 1)

5.4.1.2. Phase-2: Preceding Construction for the 400 kV System

As shown in Figure 5.4-2, in order to reduce time in the changing-over of the system from 220 kV to 400 kV, essential equipment such as the 400/220 kV transformers, the 400 kV GIS, the gantry structures and the associated buildings, shall be constructed.

In the Sampoor 220 kV S/S, the switchgear for the 400 kV system will also be GIS in consideration of the limited space and cable reconnection from the 220 kV GIS to 400/220 kV transformers. In preceding the changing-over to 400 kV, the following facilities shall be installed: a 400 kV GIS including its building, two 400/220 kV 600 MVA transformers, gantry structures for the Trincomalee-2 coal-fired power plant and cables (which are interconnected between the 400 kV GIS and the 400/220 kV transformers; and the 400 kV GIS and gantry structures).

In relation to the New Habarana G/S, as with the Sampoor 220 kV S/S, the following facilities shall be installed: a 400 kV switchgear, two 400/220 kV 800 MVA transformers, gantry structures and necessary conductors (which are interconnected between the 220 kV busbar and the 400/220 kV transformers, the 400 kV switchgear and the 400/220 kV transformers, and the 400 kV switchgear and the gantry structures). It must be noted that the 220 kV busbar in the New Habarana G/S shall be extended so as to connect to the 400/220 kV transformers. Regarding the switchgear for the 400 kV system in the New Habarana G/S, the Team recommends AIS because there is enough space to construct the 400 kV substation next to the 220 kV G/S.



(Source: Prepared by the Team)

Figure 5.4-2 System Configuration for the Changing-Over Method (Phase 2)

5.4.1.3. Phase-3: Difference in Voltage Operation of the Transmission Line

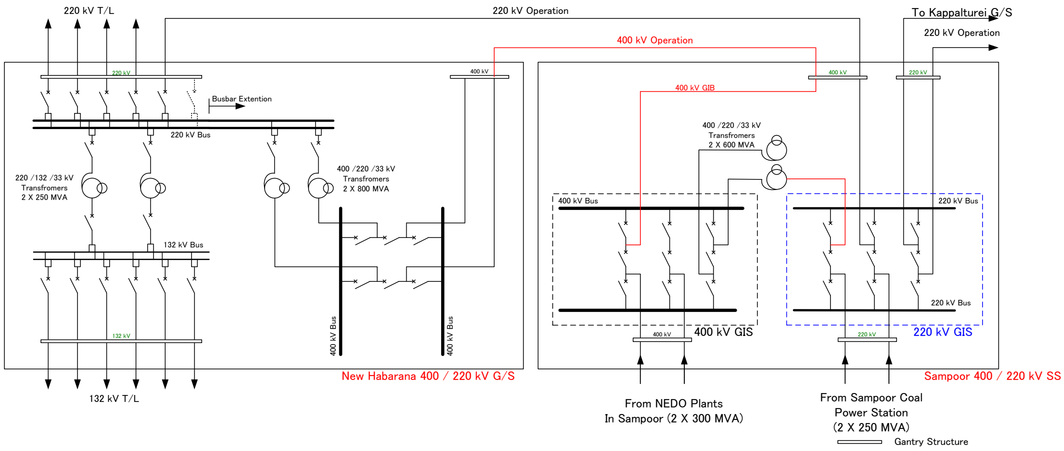
In order to reduce the changing-over time, following the completion of preceding construction for the 400 kV system, the 220 kV transmission lines shall be changed-over to 400 kV on a per circuit basis.

As shown in Figure 5.4-3, the connection change in both substations shall be carried out at the same time.

In the Sampoor 220 kV S/S, the connection of underground cable between the 220 kV GIS to the gantry structure shall be changed to the 400/220 kV transformer, then it will be possible to reuse the existing cable, which was used during the 220 kV operation without removal. The Team recommends a Gas Insulated Bus (GIB) for the conductor from the 400 kV GIS to the gantry structure, since the maximum current of this circuit in the future will be reached at about 2,600 A. Basically, if XLPE cables are applied to the conductor, the cable size will be too large or there will be too many cables; thus, it would be difficult to lay cables underground. The GIB has a large capacity and is able to connect to the GIS directly. In this case, the Team recommends applying the GIB as the conductor from the 400 kV GIS to the gantry structures.

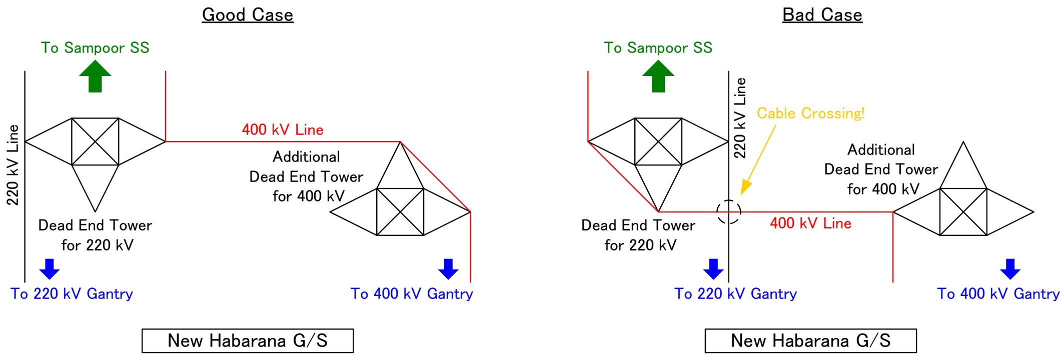
As is the case with the Sampoor S/S, in the New Habarana G/S, the construction of an additional dead-end tower shall facilitate the change-over in connection of the transmission line from 220 kV to 400 kV gantry structures. Here, as shown in Figure 5.4-4, in order to avoid a potential crossing into another circuit, the Team strongly recommends that serious consideration is given as to which circuit the change-over will first take place.

After completing the connection of one circuit, the transmission line from the Sampoor S/S to the New Habarana G/S will be operated as both 220 kV and 400 kV



(Source: Prepared by the Team)

Figure 5.4-3 System Configuration for the Changing-Over Method (Phase 3)



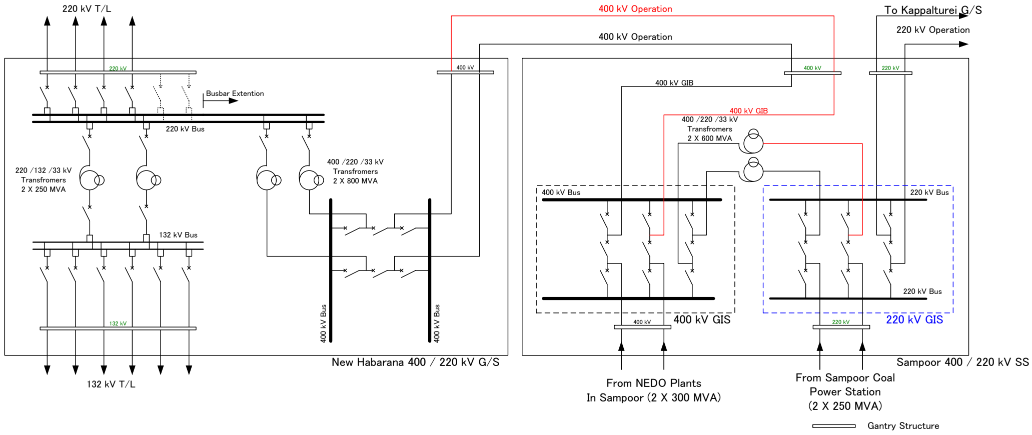
(Source: Prepared by the Team)

Figure 5.4-4 Careful Point for Selecting the Changing Circuit

5.4.1.4. Phase-4: 400 kV System Operation

As shown in Figure 5.4-5, the connection of the remaining 220 kV circuit shall be changed from 220 kV to 400 kV. The method for changing-over to 400 kV is as well as the preceding circuit which was changed in phase 3.

After completing the connection works in each substation, the transmission line from the Sampoor S/S to the New Habarana G/S will be operated as a 400 kV system.



(Source: Prepared by the Team)

Figure 5.4-5 System Configuration for the Changing-Over Method (Phase 4)

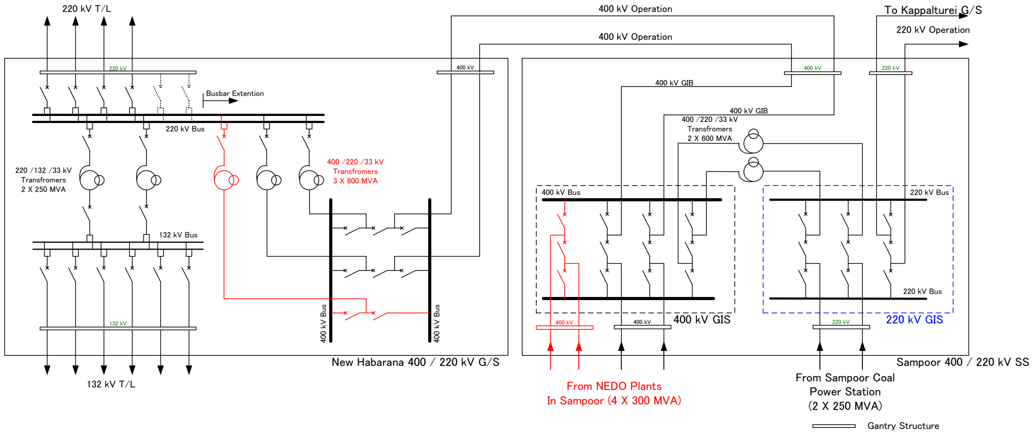
5.4.1.5. Phase-5: Future Extension for Additional Power Plants

Additional units in the Trincomalee-2 coal-fired power plant are planned by CEB. As shown in Figure 5.4-6, when the generating power from the additional units of the Trincomalee-2 coal-fired power plant are connected to the Sampoor 400/220 kV G/S, the 400 kV system in each substation shall be augmented.

In the Sampoor 400/220 kV G/S, an additional bay in the 400 kV GIS shall be added. In this context, the 400 kV gantry structure and related equipment such as the XLPE conductors from the gantry structures to the 400 kV GIS shall be installed.

In the New Habarana G/S, an additional 400/220 kV transformers shall be installed in consideration of the N-1 conditions because the capacity of the transmission line will be increased up to 1,802 MVA under the N-1 conditions after connecting the generating power from the additional units in the Trincomalee-2 coal-fired power plant.

Furthermore, an additional bay in the 400 kV AIS shall be installed so as to connect the additional 400/220 kV transformer to the system. Therefore, additional installation space for the 400 kV AIS shall be considered in the layout for the New Habarana G/S.



(Source: Prepared by the Team)

Figure 5.4-6 System Configurations for the Changing-Over Method (Phase 5)

5.4.1.6. Layout Drawing for the Future Expansion to 400 kV (For Reference)

The layout drawings for the future expansion to 400 kV in consideration of each construction phase are shown in Annex 5.4-1, 5.4-2, 5.4-3, 5.4-4 and 5.4-5. These drawings for future expansion shall be treated as “for reference” because there may be fluctuations in the future power development planning.

5.4.2. Necessary Land Area for the New Habarana 400 kV Grid Substation

As described in section 5.1.2, the land for constructing the New Habarana 400 kV substation has not yet been acquired, and the necessary dimensions for this land have not been determined. Therefore, The Team prepared and proposed the tentative layout drawing for the New Habarana 400 kV G/S in order to calculate the necessary dimension the construction as shown in Annexes 5.4-6, 5.4-7, 5.4-8 and 5.4-9.

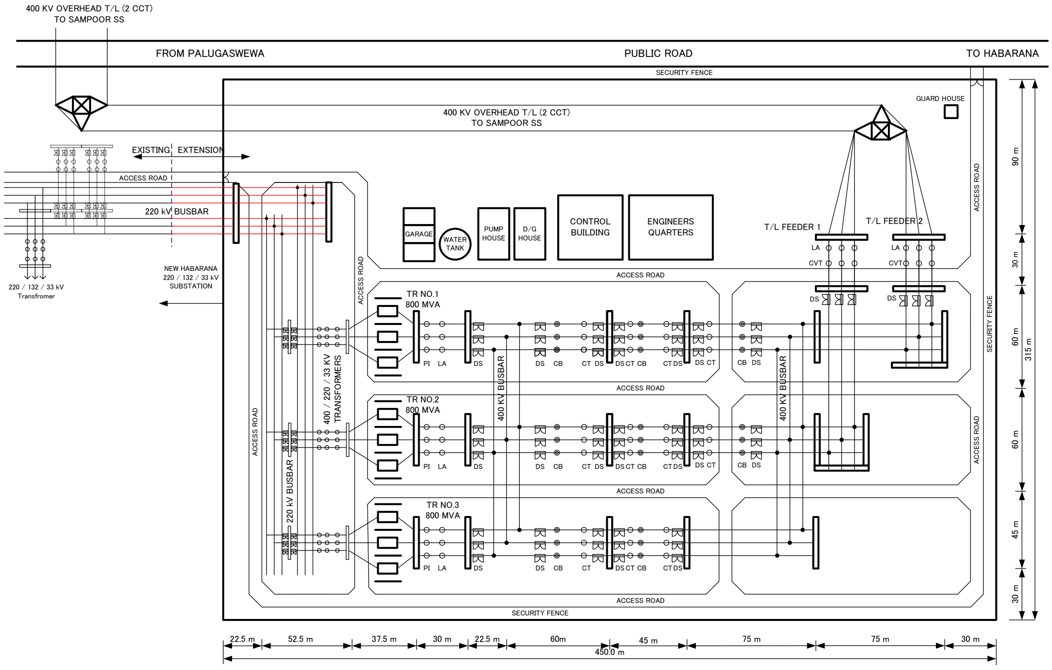
The Team recommends that the New Habarana 400 kV substation is constructed near to the New Habarana 220 kV G/S - planned to be built before 2018 under the “Habarana T/L project” – due to the connection to the 220 kV busbar and the convenience of being able to transport the materials on national roads.

Regarding the busbar arrangement for the New Habarana 400 kV G/S, this should be in conformity with that of the Sampoor S/S (i.e. one-and-half circuit breaker scheme). This is because the transmission line between the Sampoor S/S to the New Habarana G/S is of major significance in that it shall supply the Colombo area with power generated in the Sampoor area. Furthermore, the dimension of the one-and-half CB system is usually bigger than that of the double bus scheme. This means, if the land is acquired by considering a one-and-half scheme, it shall be possible to rearrange this to double bus scheme.

As a result of drawing the tentative layout for the New Habarana 400 kV G/S, approximately 315 m x 450 m at the maximum dimension will be required to construct the 400 kV G/S through the one-and-half CB scheme. Consideration was also given to reducing the amount of wasted space in terms of connecting the existing 220 kV busbar and the arrangements for the dead-end tower.

In case that the New Habarana 400 kV G/S is constructed nearby 220 kV by approximately

315 m x 450 m, the image of necessary land for 400 kV substation is shown in Figure 5.4-7.



(Source: Prepared by the Team)

Figure 5.4-7 Outline of Layout Drawing for the New Habarana 400 kV Substation

5.4.3. Increasing the Current Capacity of the 220 kV Busbar in the New Habarana G/S

In the current design under the "Habarana T/L project", the current capacity of the 220 kV busbar is designed to be 4,000 A. In considering the future connection of the generating power from the Trincomalee-2 coal-fired power plant, it is predicted that the incoming capacity at the New Habarana 400 kV G/S will be 1,803 MVA under the N-1 conditions. In this case, the current rating of the 220 kV busbar in the New Habarana 220 kV G/S will be calculated as follow;

$$\mathrm{I(A)} = \frac{1803\ (MVA) \times 1000}{220\ (kV) \times \sqrt{3}} = 4731(A)$$

According to the above calculation, it is judged that the current design of 220 kV busbar will not be enough. Therefore, the Team recommends that the current capacity of the 220 kV busbar should be increased to 5,000 A in accordance with the IEC standard 62271-100.

Chapter 6. Project Packages and Contract Conditions

6.1. Project Packages

The Team discussed with CEB about the project package, and it was confirmed that the Project shall be divided as below into transmission and substation packages.

1) Package 1: Construction of the Transmission Lines

- ✓ The construction of 4 x LL-ACSR Zebra equivalent, 400 kV, 95 km, double circuit transmission line between Sampoor and New Habarana
- ✓ The construction of 2 x Zebra, 220 kV, 45km, double circuit transmission line between Sampoor and Kappalturai
- ✓ The supply of transmission line tools and equipment as follows;
    - UV camera to detect corona discharge of the insulator
    - Total station (sag measurement instrument: reflector less laser technology)
    - Coating thickness gauges
    - Hotline tool sets (bare hand including sticks for the 400 kV T/L)
    - Live line OPGW stringing traction robot with all accessories
    - OPGW cum-along clamps
    - Distance measuring scope (minimum 0.5 m measurement)
- ✓ The provision of training as follows;
    - Live line maintenance training for the 400 kV T/L
    - Low loss conductor maintenance training

2) Package 2: Construction of the Switching Station

- ✓ The construction of the Sampoor 220 kV switching station (including the one-and-half circuit breaker line bay 220 kV for the GIS, common items for the GIS, substation automation for the GIS, spare parts)
- ✓ The supply of substation tool and equipment as follows;
    - Micro ohm tester
    - SF6 leak detector (flow rate detector type)
    - SF6 percentage meter (zero emission type)
    - Thermal image camera

- Capacitor tester
- Power quality analyzer
- Single phase current injector

✓ The provision of training as follows;

- SAS
- Protection for the electrical power systems
- Protection for the transmission lines
- Protection for the busbars, circuit breakers and power transformers
- O&M of the GIS

6.2. Contract Conditions

Preparation of the Bidding Documents of the Project is included in the 45th Japanese ODA loan, and it is confirmed that its general conditions of contract is "Standard Bidding Documents under Japanese ODA Loans, Procurement of Electrical and Mechanical Plant, and for Building and Engineering Works, Designed by the Contractor, July 2015" (Design Build) published by JICA, which is conformed with "Conditions of Contract for Plant and Design Built for Electrical and Mechanical Plant, and for Building and Engineering Works, Designed by the Contractor, 1999 (Yellow Book)" published by FIDIC,.

Chapter 7. Implementation Schedule

7.1. Transmission Lines

The following work items shall be considered for the construction of transmission lines.

- ✓ Surveys and soil tests
- ✓ The clearing of Right of Way, and the construction of access road
- ✓ Design and approval
- ✓ Manufacturing and factory tests
- ✓ Transportation
- ✓ Foundation work
- ✓ Tower Erection work
- ✓ Stringing work
- ✓ Test and commissioning

The area around the Mahaweli River is almost always flooded during rainy season. Therefore, the Team recommends that in consideration of the technical and safety issues, some work items, such as the surveys, foundation work, and tower erection should be carried out during the dry season around the Mahaweli River.

As a result, it is assumed that the construction of 400 kV Sampoor – New Habarana transmission line and 220 kV Sampoor – Kappalturai transmission line will take 24 months and 22 months, respectively, with reference to the similar projects.

7.2. Switching Station

The following work items shall be considered for the construction of the switching station.

- ✓ Surveys and soil test
- ✓ Facility design and approvals
- ✓ Manufacturing and factory tests
- ✓ Transportation
- ✓ Civil and building work
- ✓ Erection and installation work
- ✓ Tests and commissioning

In making reference to similar projects, the Team assumes that the construction of the 220 kV Sampoor switching station will take around 24 months.

7.3. Overall Implementation Schedule

Overall implementation schedule is shown in Figure 7.3-1, and detailed construction schedule is shown in Figure 7.3-2. Construction period is assumed to be 36 months including 12 months warranty/ defect liability period after commissioning.

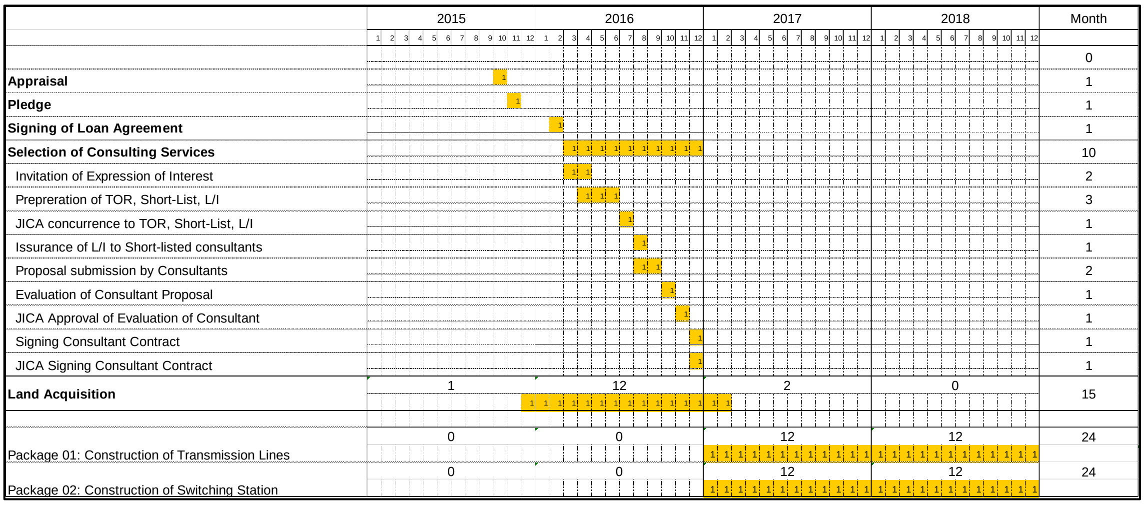


Figure 7.3-1 Overall Implementation Schedule

	2017												2018												Month
		1	2	3	4	5	6	7	8	9	10	11	12		1	2	3	4	5	6	7	8	9	10	11	12	
Construction period	12	1	1	1	1	1	1	1	1	1	1	1	1	12	1	1	1	1	1	1	1	1	1	1	1	1	24
Package 01: Construction of Transmission Lines	0													0													0
1.1 Construction of 400 kV Sampoor - New Habarana TL	12	1	1	1	1	1	1	1	1	1	1	1	1	12	1	1	1	1	1	1	1	1	1	1	1	1	24
1.1.1 (1) Survey and Soil Test excluding Mahaweli Area	6	1	1	1	1	1	1							0													6
1.1.1 (2) Survey and Soil Test for Mahaweli Area	2							1	1					0													2
1.1.2 Clearing of Right of Way, Construction of Access Road	7			1	1	1	1	1	1	1				0													7
1.1.3 Facility Design and Approval	9	1	1	1	1	1	1	1	1	1				0													9
1.1.4 Manufacturing and Factory Tests	10			1	1	1	1	1	1	1	1	1	1	2	1	1											12
1.1.5 Transportation	8					1	1	1	1	1	1	1	1	4	1	1	1	1									12
1.1.6 (1) Foundation Work excluding Mahaweli Area	7						1	1	1	1	1	1	1	6	1	1	1	1			1	1					13
1.1.6 (2) Foundation Work for Mahaweli Area	0													2					1	1							2
1.1.7 (1) Tower Erection Work excluding Mahaweli Area	3										1	1	1	7	1	1	1	1	1	1			1				10
1.1.7 (2) Tower Erection Work for Mahaweli Area	0													2							1	1					2
1.1.8 (1) Stringing Work excluding Mahaweli Area	0													9		1	1	1	1	1	1	1		1	1		9
1.1.8 (2) Stringing Work for Mahaweli Area	0													1									1				1
1.1.9 Test and Commissioning	0													1												1	1
1.2 Construction of 220kV Sampoor - Kappalturai TL	12	1	1	1	1	1	1	1	1	1	1	1	1	10	1	1	1	1	1	1	1	1	1	1			22
1.2.1 (1) Survey and Soil Test excluding Mahaweli Area	3	1	1	1										0													3
1.2.1 (2) Survey and Soil Test for Mahaweli Area	2							1	1					0													2
1.2.2 Clearing of Right of Way, Construction of Access Road	7			1	1	1	1	1	1	1				0													7
1.2.3 Facility Design and Approval	9	1	1	1	1	1	1	1	1	1				0													9
1.2.4 Manufacturing and Factory Tests	9			1	1	1	1	1	1	1	1	1		0													9
1.2.5 Transportation	8					1	1	1	1	1	1	1	1	1	1												9
1.2.6 (1) Foundation Work excluding Mahaweli Area	7						1	1	1	1	1	1	1	1	1												8
1.2.6 (2) Foundation Work for Mahaweli Area	0													2					1	1							2
1.2.7 (1) Tower Erection Work excluding Mahaweli Area	3										1	1	1	3	1	1	1										6
1.2.7 (2) Tower Erection Work for Mahaweli Area	0													2							1	1					2
1.2.8 (1) Stringing Work excluding Mahaweli Area	0													4		1	1	1	1								4
1.2.8 (2) Stringing Work for Mahaweli Area	0													1									1				1
1.2.9 Test and Commissioning	0													1										1			1
	0													0													0
Package 02: Construction of Switching Station	12	1	1	1	1	1	1	1	1	1	1	1	1	12	1	1	1	1	1	1	1	1	1	1	1	1	24
2.1 Construction of 220 kV Sampoor SS	12	1	1	1	1	1	1	1	1	1	1	1	1	12	1	1	1	1	1	1	1	1	1	1	1	1	24
2.1.1 Survey and Soil Test	3	1	1	1										0													3
2.1.2 Facility Design and Approval	8		1	1	1	1	1	1	1	1				0													8
2.1.3 Manufacturing and Factory Tests	8					1	1	1	1	1	1	1	1	4	1	1	1	1									12
2.1.4 Transportation	6							1	1	1	1	1	1	6	1	1	1	1	1	1							12
2.1.5 Civil and Building Work	8					1	1	1	1	1	1	1	1	2	1	1											10
2.1.6 Erection and Installation Work	1												1	10	1	1	1	1	1	1	1	1	1	1			11
2.1.7 Test and Commissioning	0													5								1	1	1	1	1	5
	0													0													0
Warranty / Defect Liability Period	0													0													0
	0													0													0

Figure 7.3-2 Detailed Construction Schedule

Chapter 8. Implementation Plan

8.1. Project Management Unit

8.1.1. Organization of the Project Management Unit

Project Management Unit (PMU) was set up within CEB to manage the overall Project implementation. PMU is headed by the project director, under which there is one Project Manager, three electrical engineers, one civil engineer and other supporting staffs. PMU organization chart is shown in Figure 8.1-1.

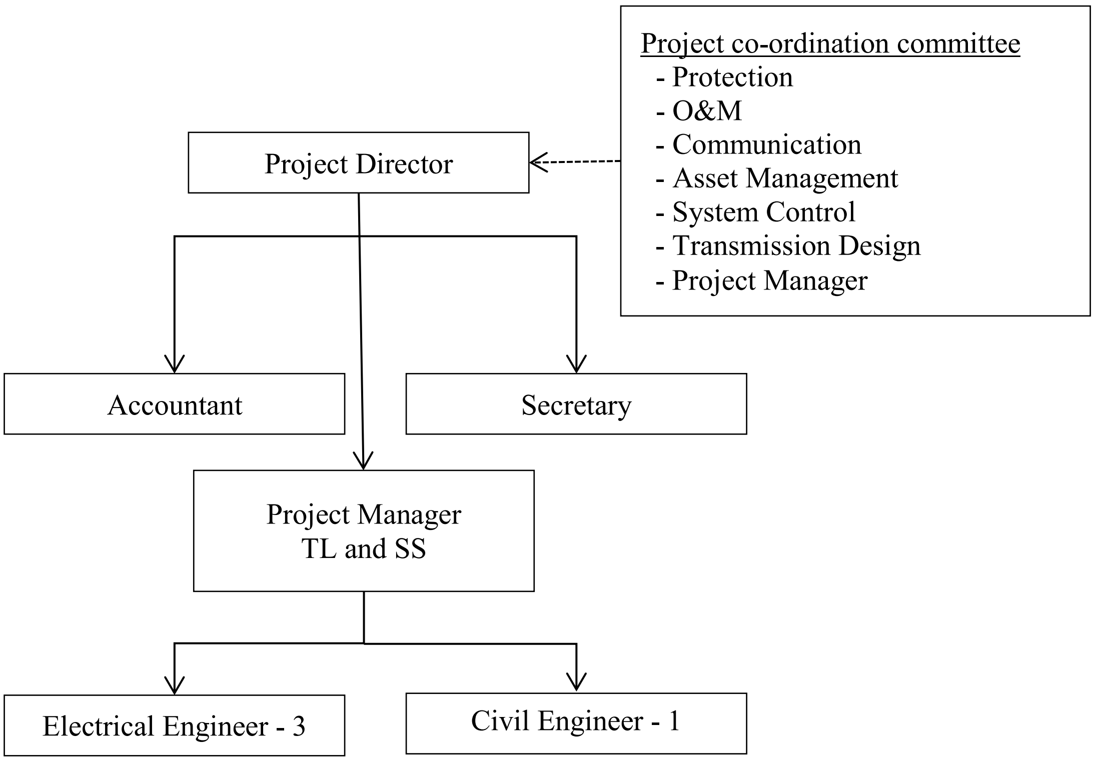


Figure 8.1-1 Organization Chart for the Project Management Unit

The Project co-ordination committee not only covers the Project but also the other projects.as the committee covers the followings (including the Project);

- ✓ The 400 kV transmission line from Sampoor to New Habarana
- ✓ The 220 kV transmission line from New Habarana to Veyangoda
- ✓ The 220 kV transmission line from Sampoor to Kappalturai
- ✓ The switching stations at Veyangoda, New Habarana, and Sampoor
- ✓ The interconnection with the coal plant

8.1.2. Employment Plan

CEB personnel including electrical engineers, civil engineer, technical offices shall be selected for the project financed by the 45th Japanese ODA loan, and those engineers and officers will be in charge of not only the pre-construction stage but also the construction stage.

CEB considers that they have enough number of those engineers and officers for the Project. In case that it is necessary to add some more engineers and officers, it will be arranged internally in CEB, because other personnel may be available from other projects that have been completed before the Project commences (including the "Clean Energy & Network Efficiency Improvement Projects" funded by ADB).

8.1.3. Training Plan

The differences between the 400 kV transmission line and the 220 kV transmission line are as follows;

- ✓ The scale of towers and foundations
- ✓ The number of conductors per phase

The design documents and bidding documents shall be prepared in consideration of above-mentioned special characteristics of the 400 kV transmission line, and shall be supported by the consultant hired by the 45th Japanese ODA loan.

The construction methodology for the 400 kV transmission line is similar to that of the 220 kV transmission line. CEB also has much experience of supervising the construction of 220 kV transmission lines.

Therefore, it is considered that on-the-job-training by the consultant and/or the contractor shall be sufficient for the CEB staff, and that it is not necessary to carry out any special training for construction supervision.

8.2. Operation and Maintenance

8.2.1. Organization for the Operation and Maintenance

When all the testing and final commissioning for the Project is completed, the responsibility of operation and maintenance of the Project will take over by O&M branch headed by Deputy General Manager (DGM). The substation O&M is implemented by each region, Colombo Region, Kandy Region, Anuradhapura Region and Galle Region Branch office. And transmission line O&M is implemented by two branches. HTM-1 maintains southern part and HTM-2 maintains northern part. The transmission lines constructed in this project are taken by HTM-2. Each HTM branches have five teams called 'gang' headed by Electrical Superintendent (ES). The gang has ten workers. After completion of construction, CEB plans to add one gang to HTM-2 along with increasing of facility. The existing organization chart for the O&M is shown in Figure 8.2-1, and the existing organization chart for the hot line maintenance unit is shown in Figure 8.2-2.

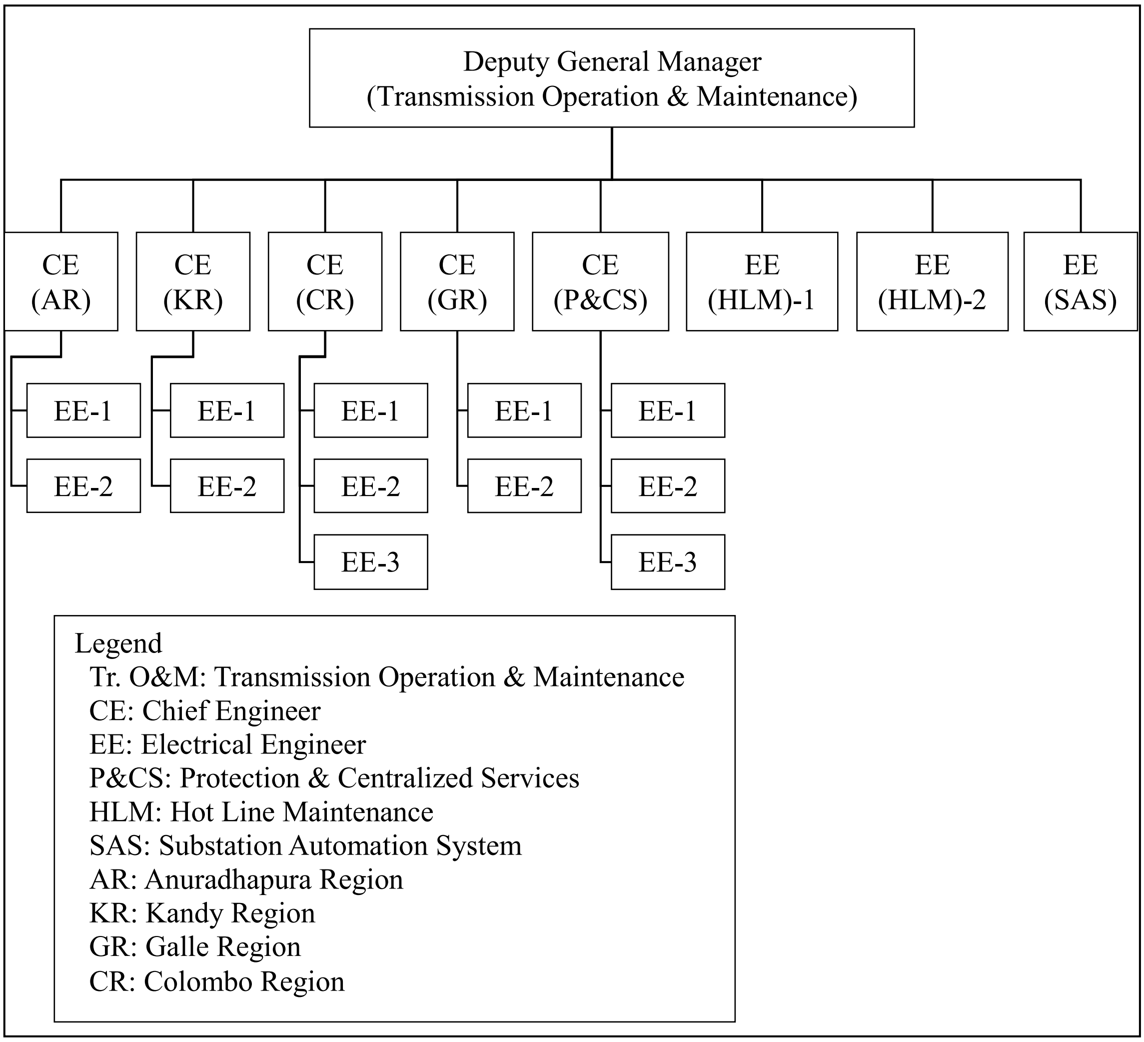


Figure 8.2-1 Existing Organization Chart for the Operation and Maintenance

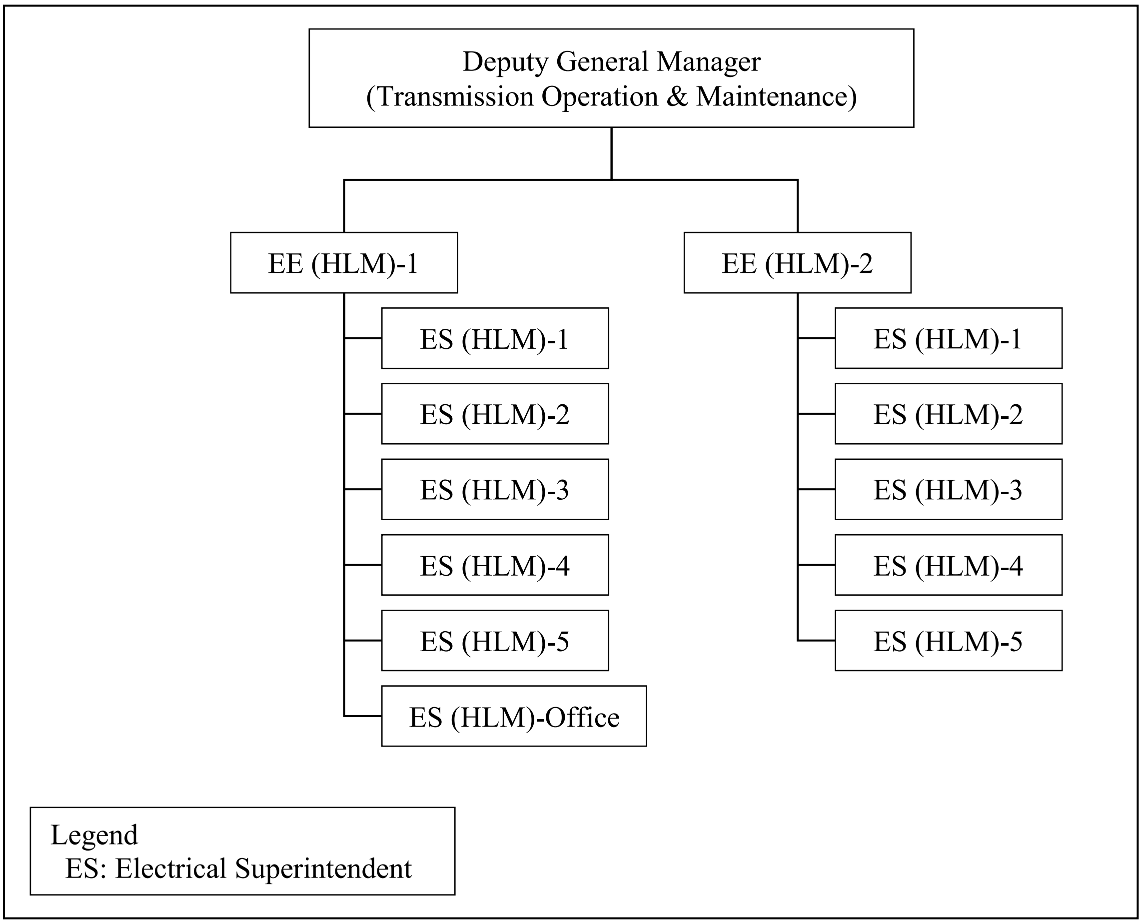


Figure 8.2-2 Existing Organization Chart for the Hot Line Maintenance Unit

The maintenance group has their periodic maintenance policies and check-lists for high voltage transmission line and grid substation equipment. Basic frequency of the periodic inspection will be 3 years for high voltage cables, 6 months for primary substation equipment, and 1 year for secondary equipment.

The transmission facilities will be increased after the completion of the Project. Accordingly, the man-power for the inspection shall be raised. In addition, as periodic maintenance of the transmission facilities is also required. CEB is considering adding one more hot line maintenance unit to HLM-2.

8.2.2. Training Plan

1) Transmission Line

As mentioned in Chapter 6, it is necessary to have following trainings;

(i) Live Line Maintenance Training for the 400 kV T/L

This is the first 400 kV transmission line for CEB. Therefore, it is necessary to have live line maintenance training provided by hot line training licensing authorities/institutes. This training should cover bare hand techniques for changing the suspension and the tension insulator strings.

In addition, the conductor approaching methods, such as the ladder approach methods shall be included in the training.

This training shall be arranged by the contractor.

(ii) Low Loss Conductor Maintenance Training

Low loss conductor will be applied for the Project. Therefore, it is necessary to have a training provided by contractor(s) for the maintenance related to this conductor, such as the creation of mid-span joints, repair sleeves, dead end clamps, and jumper wire.

2) Switching Station

This is also the first time that the CIB shall build a GIS by one-and-half circuit breaker scheme. Thus, as mentioned in Chapter 6, it is intended that the contractor(s) shall provide training for the SAS, protection relays, protection schemes, and O&M of the GIS.

Chapter 9. Terms of Reference for the Consulting Services

9.1. Necessity of Consulting Services

The 45th and 46th Japanese ODA loan project contains first time 400 kV T/L installation in this country. The 400 kV T/L design is different from other lower voltages, therefore the consultant is needed for preparation of the Project. Preparation of project design documents, preparation of pre-qualification document and bidding documents, and evaluation of proposals submitted from the Contractor will be performed by the Consultant selected by the 45th Japanese ODA loan project during pre-construction stage. Therefore, the remaining works is supervision of the construction, such as the foundation work, the tower erection work, and the conductor stringing work.

As for the supervision of transmission construction, CEB has enough experience and capability. As a result, there is not any consultant for transmission and distribution project funded by ADB, and no crucial problems occurred until now.

As for the supervision of 400 kV T/L construction, the Team evaluated that CEB also has capability of supervision of construction because 400 kV T/L has same structure as lower voltage T/L.

Nevertheless, this Project is the first time that CEB has managed such a large scale transmission line construction. For instance, the size of the 400 kV line transmission towers is much larger than those of 220 kV transmission line, and here four bundle conductors shall also be applied. In addition, this is the first time that CEB shall deal with a GIS by one-and-half circuit breaker scheme.

Therefore, in light of this, CEB intends to hire small scale of the consultant/advisor for supervising of the 400 kV transmission line and 220 kV GIS switching station.

9.2. Scope of the Consulting Services

Based on the above-mentioned situation, it is considered that scope of consulting/advisory services may be minimized. The draft scope of the consulting/advisory services is proposed as follows and the draft terms of reference for supervision consultant are attached as Annex 9.2-1;

- ✓ To assist in reviewing the detailed design documents for the 400 kV transmission line and the 220 kV GIS that are prepared by the contractors.
- ✓ To assist in carrying out the construction supervision for the 400 kV transmission line and the 220 kV GIS in view of quality control and scheduling control.
- ✓ To assist in the on-site inspection of the manufacturing and fabrications for the 400 kV transmission line and the 220 kV GIS.
- ✓ To assist in the reviewing and approvals for the testing procedures prepared by the contractors.
- ✓ To witness the testing and commissioning at site as well as the factory acceptance tests.
- ✓ To check the as-built drawings and O&M manuals prepared by the contractors.

- ✓ To assist CEB to maintain proper co-ordination and communication between CEB/JICA and CEB/contractors

9.3. Staffing

It is assumed that two of professional (A) consultants will be required over the Project period of 24 months, for a total of 40 man-months. The manning schedule for these consulting services is attached as Annex 9.3-1.

The required qualifications for Professional (A) consultants are shown in Table 9.3-1.

Table 9.3-1 Qualifications of the Professional (A) Consultants

Designation	Qualification
Transmission Engineer	Education: Graduate of Electrical Engineering
	Experience: In the power transmission system related field: 15 years or more In design and/or construction supervision for transmission line projects: 10 years or more In design and/or supervision of installation work for transmission projects: two projects or more
Substation Engineer	Education: Graduate of Electrical Engineering
	Experience: In the power transmission system related field: 15 years or more In design and/or construction supervision for substation (including GIS) projects: 10 years or more In design and/or supervision of installation work for substation projects: two projects or more

Chapter 10. Estimate of the Project Costs

10.1. Condition for the Calculations

The preconditions for the estimate of the Project costs are based on the data below from JICA:

Items	Contents	Notes
Base year for cost estimation:	November/2014	
Exchange rate		
JPY/USD:	107.10	
LKR/USD:	130.20	
LKR/JPY:	0.823	
Price escalation		
Annual average of foreign currency:	2.0%	
Annual average of local currency:	3.8%	
Physical contingency		
Construction:	5%	
Consultant:	5%	
Rate of tax		
VAT:	12%	
Import tax:	7.0%	Port and Airport Development Levy (PAL): 5% Nation Building Tax (NBT): 2%
Rate of administration costs:	5%	
Rate of interest during construction		
Construction:	0.30%	
Consultant:	0.01%	
Rate of front end fee:	0.2%	
Compensation and land acquisition costs:	3%	

10.2. Construction Costs of the Transmission Lines

The cost estimates for the transmission lines prepared by CEB were reviewed as follows;

- ✓ The unit price for the 400 kV Sampoor – New Habarana T/L is modified based on assumed the 400 kV T/L design (Annex 10.2-1) instead of that prepared by CEB which is estimated considering India and other country's construction price obtained from internet.

- ✓ The conductor costs for the 400 kV T/L was modified from the conventional Zebra to the LL-ACSR.

- ✓ The costs for the crossing of the 132 kV T/L and 400 kV T/L were estimated using of the TDT towers.

- ✓ The unit price for the 220 kV Sampoor – Kappalturai T/L prepared by CEB was based on the 2013 price but modified for 2015.

- ✓ The costs for the dispute board have been considered, and the breakdown for these is attached as Annex 10.2-2

The Construction costs of the transmission lines are shown in Table 10.2-1.

Table 10.2-1 Construction Costs of the Transmission Lines (Package 01)

Item	Unit	Qty	Unit Price		Cost		Total
			Foreign	Local	Foreign	Local	
			JPY	LKR	JPY	LKR	JPY
400 kV Sampoor - New Habarana T/L							
400 kV 2cct T/L (4xLow Loss Zebra-equivalent)	km	95	63,786,600	32,470,000	6,059,727,000	3,084,650,000	8,598,393,950
220kV Sampoor - Kappalturai T/L							
220kV 2cct T/L (2xZebra)	km	45	33,479,300	16,937,400	1,506,568,500	762,183,000	2,133,845,109
Tool and Equipment for Transmission Line							
UV Camera to detect Corona Discharge of Insulator	sets	2	9,110,000	0	18,220,000	0	18,220,000
Total Station (Sag Measurement Instrument: reflector less laser technology)	sets	3	3,000,000	0	9,000,000	0	9,000,000
Coating Thickness Gauges	sets	9	100,000	0	900,000	0	900,000
Hotline Tool Sets (Bare hand including sticks for 400 kV T/L)	sets	1	37,035,000	0	37,035,000	0	37,035,000
Live Line OPGW Stringing Traction Robot with All Accessories	sets	2	15,000,000	0	30,000,000	0	30,000,000
OPGW Cum-along Clamps	sets	6	200,000	0	1,200,000	0	1,200,000
Distance Measuring Scope (minimum 0.5 m measurement)	sets	2	40,000	0	80,000	0	80,000
Training							
Live Line Maintenance Training for 400 kV T/L	lot	1	8,230,000	0	8,230,000	0	8,230,000
Low Loss Conductor Maintenance Training	lot	1	823,000	0	823,000	0	823,000
Dispute Board Fee							
Dispute Board Fee (Standing)	set	3	25,061,400	0	75,184,200	0	75,184,200
Total					7,746,967,700	3,846,833,000	10,912,911,259

10.3. Construction Costs of the Switching Station

The cost estimates for the switching station prepared by CEB were reviewed as follows;

- ✓ The unit price prepared by CEB was based on the 2013 price but modified for 2015
- ✓ The "one-and-half breaker bus coupler bay 220 kV" item was deleted
- ✓ The unit price for the one-and-half circuit breaker line bay 220 kV for the GIS was modified based on information from manufacturers
- ✓ The unit price for the "common items for the GIS" was modified based on the estimated length of the "cable and sealing end"
- ✓ Cost breakdown for 220 kV GIS and common items are indicated in Annex 10.3-1
- ✓ Cost for dispute board is considered, and its breakdown is attached as Annex 10.2-2

The construction costs of the switching station are shown in Table 10.3-1.

Table 10.3-1 Construction Costs of the Switching Station (Package 02)

Item	Unit	Qty	Unit Price		Cost		Total
			Foreign	Local	Foreign	Local	
			JPY	LKR	JPY	LKR	JPY
220 kV Sampoor S/S							
One-and-half circuit breaker line bay 220 kV for GIS	sets	3	250,000,000	12,980,000	750,000,000	38,940,000	782,047,620
Common items for GIS	lot	1	229,610,000	234,040,000	229,610,000	234,040,000	422,224,920
Substation automation for GIS	lot	1	47,616,000	592,600	47,616,000	592,600	48,103,710
Spare Parts	lot	1	36,905,800	17,332,900	36,905,800	17,332,900	51,170,777
Tool and Equipment for Substation							
Micro Ohm Tester	unit	5	408,000	0	2,040,000	0	2,040,000
SF6 Leak Detector (Flow rate detector type)	sets	2	536,000	0	1,072,000	0	1,072,000
SF6 Percentage Meter (Zero emission type)	sets	3	1,071,000	0	3,213,000	0	3,213,000
Thermal Image Camera	sets	3	161,000	0	483,000	0	483,000
Capacitor Tester	sets	2	5,000	0	10,000	0	10,000
Power Quality Analyzer	sets	2	375,000	0	750,000	0	750,000
Single Phase Current Injector	sets	1	2,500,000	0	2,500,000	0	2,500,000
Training							
Substation Automation System	lot	1	3,591,000	0	3,591,000	0	3,591,000
Protection for electrical Power Systems	lot	1	3,591,000	0	3,591,000	0	3,591,000
Protection for Transmission Lines	lot	1	3,591,000	0	3,591,000	0	3,591,000
Protection for Busbars, Circuit Breakers and Power Transformers	lot	1	3,591,000	0	3,591,000	0	3,591,000
Gas Insulated Switchgear Operation & Maintenance	lot	1	6,569,000	0	6,569,000	0	6,569,000
Dispute Board Fee							
Dispute Board Fee (Ad hoc)	set	1	4,498,200	0	4,498,200	0	4,498,200
Total					**1,099,631,000**	**290,905,500**	**1,339,046,227**

10.4. Consulting Service Costs

Based on the reasons mentioned in Chapter 9, the Team recommends hiring the consultant/advisor to supervise the construction of the 400 kV transmission line and the 220 kV GIS switching station.

Its total cost is estimated to be approximately 144 million JPY as foreign currency and 15 million LKR as local currency including direct cost including international airfare, accommodation allowance, and vehicle rental. The cost breakdown for this is attached as Annex 10.4-1.

10.5. Total Project Costs

The result of total project costs is shown in Table 10.5-1, and annual fund requirement is attached as Annex 10.5-1.

Table 10.5-1 Total Project Costs

Item		Foreign	Local	Total
		Mil. JPY	Mil. LKR	Mil. JPY
A. ELIGIBLE PORTION				
I)	Procurement/Construction	9,761	4,770	13,687
	Package 01: Construction of Transmission Lines	7,747	3,847	10,913
	Package 02: Construction of Switching Station	1,100	291	1,339
	Base cost for JICA financing	8,847	4,138	12,252
	Price escalation	449	405	783
	Physical contingency	465	227	652
II)	Consulting services	159	17	173
	Base cost	144	15	156
	Price escalation	7	1	9
	Physical contingency	8	1	8
Total (I + II)		9,920	4,787	13,859
B. NON ELIGIBLE PORTION				
a	Procurement / Construction	0	0	0
	Package 01: Construction of Transmission Lines	0	0	0
	Package 02: Construction of Switching Station	0	0	0
	Base cost for Borrower financing	0	0	0
	Price escalation	0	0	0
	Physical contingency	0	0	0
b	Land Acquisition	0	428	352
	Base cost	0	391	322
	Price escalation	0	16	13
	Physical contingency	0	20	17
c	Administration cost	0	863	711
d	VAT	0	2,021	1,663
e	Import Tax	0	844	694
Total (a + b + c + d + e)		0	4,155	3,420
TOTAL (A+B)		9,920	8,942	17,279
C. Interest during Construction		61	0	61
	Interest during Construction(Const.)	61	0	61
	Interest during Construction (Consul.)	0	0	0
D. Front End Fee		28	0	28
GRAND TOTAL (A+B+C+D)		10,009	8,942	17,368

Chapter 11. Environmental and Social Considerations for Transmission Lines and Substations

11.1. Legislation relating to Environmental and Social Considerations

11.1.1. Laws and Regulations relevant to Environmental and Social Considerations

Major laws and regulations relevant to environmental and social considerations are shown in Table 11.1-1.

Table 11.1-1 Laws and Regulations relevant to Environmental and Social Considerations

Laws and regulations	General Outline	Key Agencies
Environmental Conservation		
National Environmental Act No. 47 of 1980 (as amended by Acts No. 56 of 1988 and No. 53 of 2000) and the Regulations under the Act	Establishes the Central Environmental Authority (CEA) and defines its powers, functions and duties. Provides overall environmental protection legislation, including licensing procedures, environmental standards and project approval procedures.	Central Environmental Authority (CEA)
Fauna and Flora Protection (Amendment) Act No. 22 of 2009	Protection, conservation, prevention of commercial and other misuse of the fauna and flora and their habitats, and conservation of the biodiversity.	Department of Wildlife Conservation Forest Department
Plant Protection Act No. 35 of 1999	Provides for the prevention of wild plants, weeds and plant diseases, and controls the introduction of new plant species.	Department of Agriculture
Forest Ordinance No. 16 of 1907 (as amended) and the Rules and Regulations under the Ordinance	Consolidates the laws relating to management of forests (including the felling and transportation of timber) and plant protection. Empowers the Minister to declare any area of State and as a Reserved Forest, Conservation Forest or a Village Forest.	Forest Department
Felling of Trees (Control) Act No. 9 of 1951 (as amended No. 1 of 2000)	Provides for the prohibition, regulation and control of the felling of specified tree species, including cultivated tree species such as Jak.	Forest Department Development of Agriculture
Water Hyacinth Ordinance No. 4 of 1909	Provides for preventing the importation, introduction into and dissemination in Sri Lanka of the plant known as Water Hyacinth	Department of Agriculture Sri Lanka Customs
Coconut Development Act No. 46 of 1971 * This Act is applied when compensation for loss of coconut trees occur.	Development and regulation of the coconut industry and the utilization of land in and for coconut plantations; to provide for the management and acquisition of coconut plantations.	Coconut Development Authority Coconut Cultivation Board
Fisheries and Aquatic Resources Act No. 2 of 1996 (as amended)	Makes provision to protect and conserve fisheries and aquatic biodiversity in marine and freshwater areas for the declaration of fisheries reserves, and imposes licensing and registration requirements with regard to fishing. Defines the term ‘Sri Lankan Waters’.	Ministry of Fisheries and Aquatic Resources Director of Fisheries and Aquatic Resource
Soil Conservation (Amendment) Act No. 57 of 1996	To provide for the enhancement and sustenance of productive capacity of the soil, to restore degraded land for the prevention and mitigation of soil erosion for the conservation of soil resources, and protection of land against damage by floods, salinity, alkalinity of water, logging, and drought.	Department of Agriculture Forest Department
Coast Conservation Act No. 57 of 1981 (as amended)	Identifies Coastal Zones, regulates and control development activities within coastal zones.	Coast Conservation Department Ministry of Fisheries and Aquatic Ocean Resources
National Heritage Wilderness Areas Act No. 3 of 1988	Provides for the declaration, protection and preservation of any area of State land with unique ecosystems, genetic Resources or outstanding natural features As National Heritage Wilderness Areas.	Forest Department, Department of Agriculture Department of Cultural Affairs
The Antiquities Ordinance (gazette of DSRSL, Extraordinary No. 1152/14, 4th October, 2000 as amended by Act no. 24 of 1988)	Regulates to protect and maintain archaeological, historical, cultural, and religious heritages and monuments which the nations have designated, and to control the development in those areas	Ministry of National heritage Ministry of Cultural and Arts
Mahaweli Authority of Sri Lanka Act No. 23of 1979 (as amended) and the Regulations under the Act	Established the Mahaweli Authority of Sri Lanka which is the authority responsible for the implementation of the Mahaweli Ganga Development Schemes. -for the conservation and maintenance of the physical	Mahaweli Authority

Laws and regulations	General Outline	Key Agencies
	environment of Mahaweli Areas, including water shed management, soil erosion and the protection of Reservation areas. -for the construction and operation of reservoirs, irrigation distribution systems and installations for the generation and supply of electrical energy.	
Irrigation Ordinance (An Ordinance to amend and consolidate the law relating to irrigation) Date of original text (1946), consolidation/reprint: 1973	The Irrigation Ordinance deals with environmental aspects of water and land use in irrigated agriculture.	Irrigation Department
Agrarian Development Act No. 46 of 2011	This act deals with implementation of the national agricultural policy.	Department of Agriculture
Mines and Minerals Act No. 33 of 1992	Regulates mining, exploitation, processing, trading and export of minerals.	Geological Surveys and Mines Bureau
Sri Lanka Electricity Act (Act No. 20 of 2009)	This act depicts regulations applicable to the generation, transmission, distribution, supply and use of electricity in Sri Lanka.	Ministry of Power and Energy Divisional Secretariat Office
Crown Lands Ordinance (1840)	The British declared the prevention of encroachments upon this Ordinance. All lands are crown lands if people could not prove their ownership to such lands. Their ownership to lands they were suing from generation to generation was not considered. For proving ownership of lands the British expected the public to produce deeds, grants and such other documentary evidence.	Department of Land Settlement
Botanic Gardens Ordinance (16th Nov. 1928)	An ordinance to provide for the management, administration and control of Botanic Gardens	Department of National Botanic Gardens
EIA		
Guideline for implementing the Environmental Impact Assessment (EIA) Process (1993, 1999, 2000)	Prescribed Projects for which EIA are necessary. Project Approving Agencies (PAA) and their responsibilities, procedures for compliance with regulations and EIA contents and application format etc.	Central Environmental Authority (CEA)
Land Acquisition and Involuntary Resettlement		
Land Acquisition Act (LAA) No. 9 of 1950 This act has several amendments and the latest being the version of 1986 is the most important legal provision pertaining to the land acquisition process in Sri Lanka.	Governing acquisition of land for public purposes is explained in this act. It provides compensation for acquisition of land, structures and crops only. Therefore, acquisition of lands and properties and any resettlement as part of the project will have to follow this law.	Ministry of Land and Land Development Divisional Secretariat
National Involuntary Resettlement Policy (NIRP) of 2001 * There is still no legal provision for resettlement.	To minimize and mitigate negative impacts of involuntary resettlements required for implementation of nationally important projects by facilitating the re-establishment of PAPs (Project Affected Persons) on a productive and self-sustaining basis. The policy also facilitates the development of the PAPs while ensuring that PAPs are fully and promptly compensated and successfully resettled. The livelihoods of any displaced persons should also be re–established and their standard of living improved. To provide guidelines for the project proponents to develop and execute a comprehensive resettlement implementation and compensation plan.	Ministry of Land and Land Development Divisional Secretariat Project Proponents
Environmental Standards		
National Environmental (Noise Control) Regulations, No. 1of 1996	Noise standards in residential, business and industrial area.	Central Environmental Authority (CEA)
National Environmental Act (Vibration Control) of 1966	Vibration Standards in residential, business and industrial area.	Central Environmental Authority (CEA)
National Environmental (Ambient Air Quality standards (Gazette extraordinary No. 850/4 dated 20th December 1994)	Sulphur dioxide (SO2) , Nitrogen dioxide (NO2), Carbon monoxide (CO) and Particular matter (PM10) etc.	Central Environmental Authority (CEA)
National Environment Act, No. 47 of 1980. National Environmental (Protection and Quality) Regulations, No. 1 of 1990	General standards for discharge of effluents into inland surface waters.	Central Environmental Authority (CEA)
Drinking Water Quality Standards (SLS 614,1983)	Bacteriological and chemicals of health significance (inorganic constituents, organic constituents) and substances and parameters that may give rise to complaints from consumers.	Ministry of Water Supply and Drainage
Public Nuisance Act (1979)	Regulates penal code on public nuisance (dumping of	Ministry of Health

Laws and regulations	General Outline	Key Agencies
	excavating soil and solid waste etc.)	CEA

(Source: Survey by the Team)

11.1.2. Laws and Regulations relevant to Environmental Impact Assessment

11.1.2.1. National Environmental (Amendment) Act (NEA)

In the new constitution of Sri Lanka (enacted in 1978), environmental conservation was enacted in Article 18, which states that "It is the duty of every person in Sri Lanka to protect nature and conserve its riches", and also in Article 27, which states that "The state shall protect, preserve and improve the environment for the benefit of the community".

Based on these constitution articles, the National Environmental Act (NEA) was enacted in1980 (Act No. 47) which was later amended in 1988 (Act No. 56) and in 2000 (Act No. 53) to serve as the main legislation for environmental protection.

The Central Environmental Authority (CEA) was established in August 1981 under the provisions of NEA. NEA introduced EIAs as part of a strategy to achieve sustainable development for the entire country. CEA was assigned the regulatory functions.

In 1984, the Sri Lankan Parliament decided to expand the requirement for EIAs to all development projects in Sri Lanka, regardless of whether the proponent is a private organization or a state agency.

Detailed procedures of the EIA were subsequently specified in 1988.

Thereafter in 1990, the Ministry of Environment was established for the formulation of environmental policies.

11.1.2.2. Institutional Arrangement for IEE/EIA

The projects that need to be subject to the IEE/EIA requirement are referred to as 'prescribed projects' and are specified in the list. In addition, 'prescribed projects' in 'environmentally sensitive areas' are required to undergo an EIA, irrespective of their magnitude. The environmentally sensitive areas are also listed. Prescribed projects are divided into two groups (Part I and Part II). Part I of the Schedule of prescribed projects located wholly or partly outside the coastal zone as defined by Coast Conservation Act, No. 57 of 1981. These projects are 31 large-scale development projects (items 1 to 31) that are likely to have significant impacts on the environment.

"Transmission lines" project is included in Part I of the Schedule (Item No. 10) and the IEE/EIA requirement condition is stipulated as follows.

> Installation of overhead transmission lines of length exceeding 10 kilometers and voltage above 50 kilovolts is being classified as 'prescribed project'.

The construction of individual facilities such as switching stations, grid substations and primary substations were not listed as a prescribed project, which is needed to undertake IEE/EIA.

Part II of the Schedule of prescribed projects includes 21 industries (items 33 to 52). Item 32 is described as, 'All projects and undertakings listed in Part I irrespective of their magnitudes and irrespective of whether they are located in the coastal zone or not, if located wholly or partly within the areas specified in Part III of the Schedule'. The industries included as items 33 to 52 are not described by magnitude and are subject to the approval process only if located within the environmental sensitive areas mentioned in Part III of the Schedule.

Table 11.1-2 shows the projects subject to the EIA requirement (Part III).

Table 11.1-2 The Projects subject to the EIA Requirement (Part III)

1.	Within 100 metres from the boundaries of or within any area declared under the National Heritage Wilderness Act No. 3 of 1988 Within 100 metres from the boundaries of or within any area declared under the Forest Ordinance (Chapter 451) of 1981 ; whether or not such areas are wholly or partly within the Coastal Zone as defined in the Coast Conservation Act, No. 57 of 1981
2.	Within the following areas whether or not the areas are wholly or partly within the Coastal Zone: Any erodible area declared under the Soil Conservation Act (Chapter 450) Any Flood Area declared under the Flood Protection Ordinance (Chapter 449) Any flood protection area declared under the Sri Lanka Land Reclamation and Development Corporation Act, No. 15 of 1968 as amended by the Act, No. 52 of 1982. 60 metres from the bank of a public stream as defined in the Crown Lands Ordinance (Chapter 454) and having a width of more than 25 metres at any point of its course. Any reservation beyond the full supply level of a reservoir. Any archaeological reserve, ancient or protected monument as defined or declared under the Antiquities Ordinance (Chapter 188) Any area declared under the Botanic Gardens Ordinance (Chapter 446) Within 100 metres from the boundaries of, or within, any area declared as a Sanctuary under the Fauna and Flora Protection Ordinance (Chapter 469). Within 100 metres form the high flood level contour of, or within, a public lake as defined in the Crown Lands Ordinance (Chapter 454) including those declared under section 71 of the said Ordinance. In these regulations unless the context otherwise requires: 'Hazardous waste' means any waste that has toxic, corrosive, flammable, reactive, radioactive or infectious characteristics. 'Reservoir' means an expanse of water resulting from man made constructions across a river or a stream to store or regulate water. Its 'environs' will include that area extending up to a distance of 100 metres from full supply level of the reservoir of all islands falling within the reservoir.

(Source: CEA. 2006. Guidance for Implementing the EIA Process, No. 1: A General Guide for Project Approving Agencies.)

11.1.2.3. Procedures of IEE/EIA Approval

1) IEE/EIA by the Project Approving Agency (PAA)

Responsibility for the review of environmental impacts is delegated to various government bodies depending on the nature of the project. Such government agencies are referred to as the Project Approving Agency (PAA). At present, 23 government agencies have been designated as PAA.

A single PAA is designated as responsible for administrating the IEE/EIA process for a particular project.

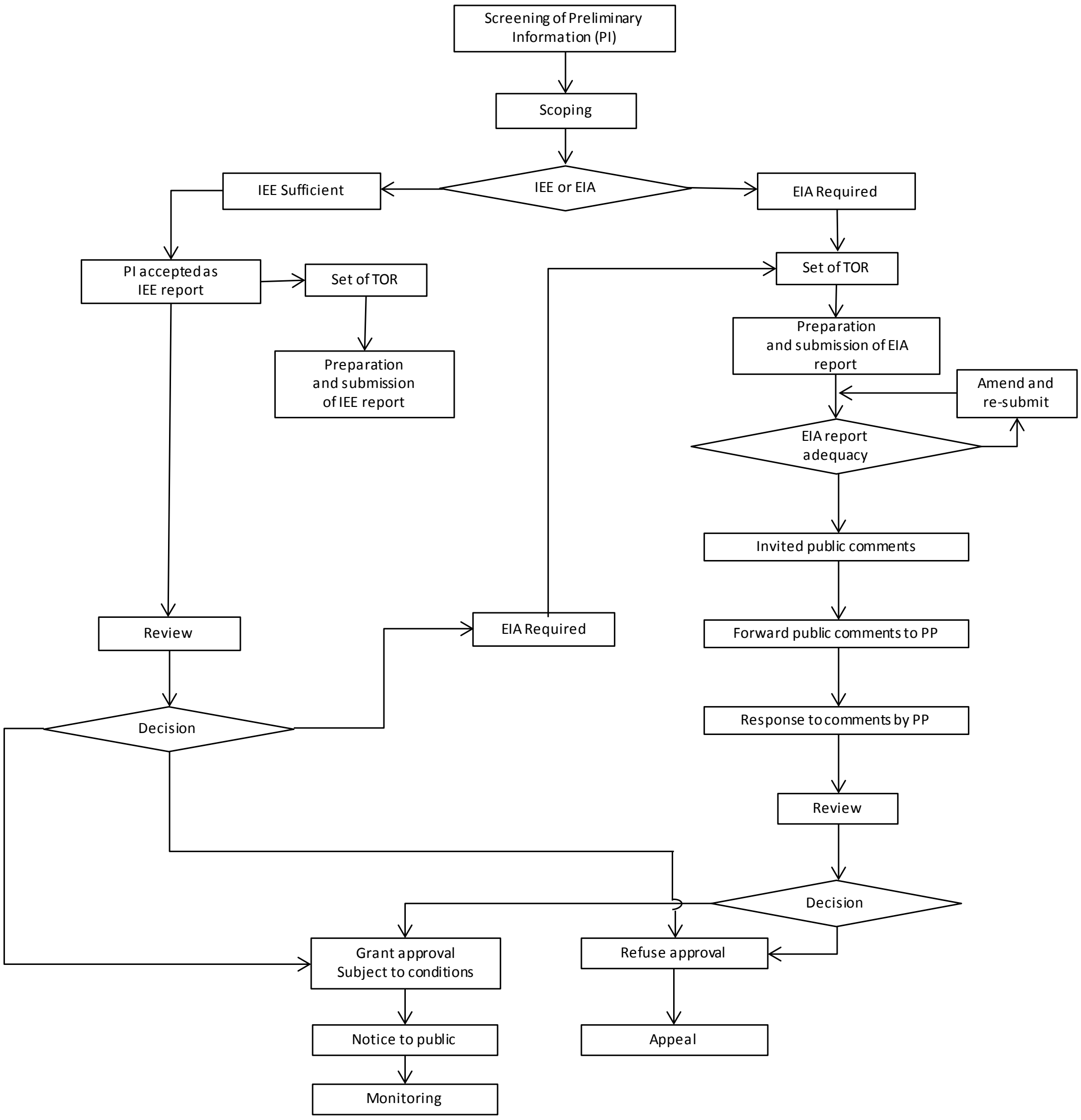
The PAA is designated according to the following unranked criteria, with the PAA either

- ✓ having jurisdiction over the largest area, or
- ✓ having jurisdiction over diverse or unique ecosystems, or
- ✓ having jurisdiction over areas where the environmental impacts (resource depletion) are likely to be the greatest, or
- ✓ having statutory authority to license or otherwise approve the prescribed project.

It is considered based on the above criteria which agency is best suited to serve as the PAA of a proposed project. Finally, the PAA is determined by ordinance of the Department of Environment. If more than one agency is involved, based on agreement between the ministries that are candidates for PAA, one of them is elected as the PAA.

2) Flow of IEE/EIA Procedure

Figure 11.1-1 shows the Flowchart of IEE/EIA procedure.



(Source: Prepared by the Team referring to information by CEA and CEB)

Figure 11.1-1 Flowchart of the IEE/EIA Process

Once a project is started by a private or state agency, there are several stages in an IEE/EIA. They are as follows:

✓ The project proponent provides preliminary information to the PAA.

✓ Scoping is conducted by the PAA.

✓ PAAs should prepare the Terms of Reference (TOR).

✓ EIA or IEE report is prepared and submitted by the project proponent.

- ✓ The PAA and the CEA review the IEE/EIA report.
- ✓ PAA may request the project proponent for clarifications and further details.
- ✓ The PAA decides whether a project is to be approved or not.
- ✓ If the project is rejected, an appeal by the project proponent is allowed.
- ✓ If the project is approved, the project proponent and the PAA should monitor the affected environmental characteristics.

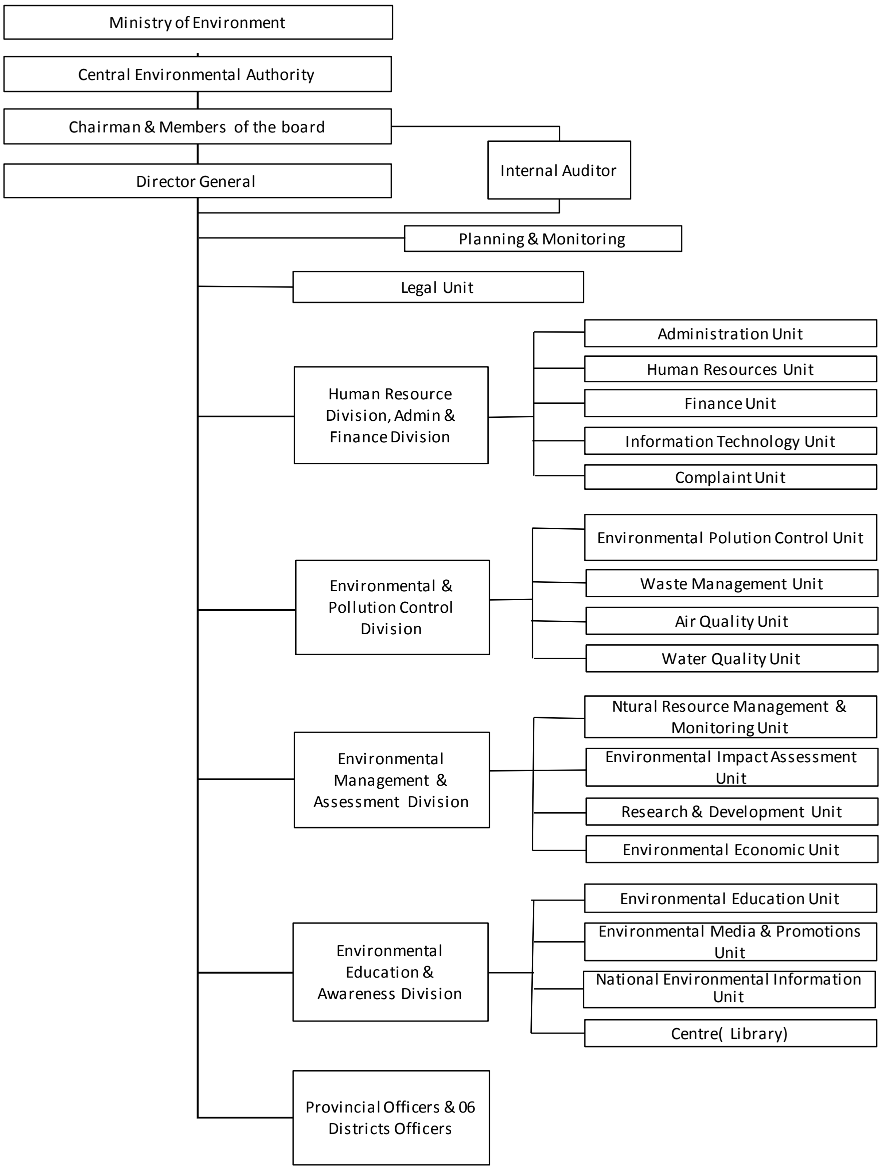
3) EIA by the Coast Conservation Department (CCD)

The Coast Conservation Act stipulates that development projects in the Coastal Zone should be reviewed and monitored by the Coast Conservation Department. The basic process is similar to which the PAA conducts.

11.1.2.4. Institutional Framework for IEE/EIA

Figure 11.1-2 shows organization chart of Central Environmental Authority (CEA).

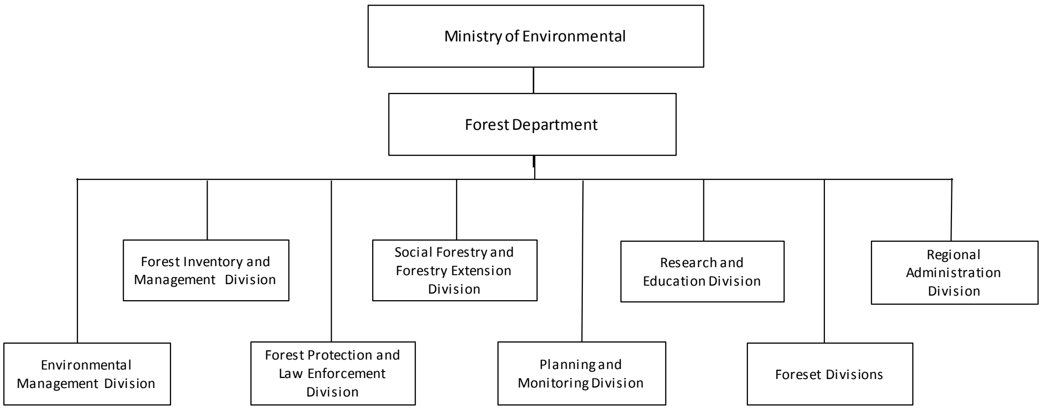
In the CEA, Environmental Impact Assessment Unit of Environmental Management and Assessment Division are in charge of IEE/EIA.



(Source: Prepared by the Team based on CEA Homepage and CEA Annual Report 2012)

Figure 11.1-2 Organization Chart of Central Environmental Authority (CEA)

Figure 11.1-3 shows organization chart of Forest Department (FD).



(Source: Prepared by the Team Tea based on FD Homepage)

Figure 11.1-3 Organization Chart of Forest Department (FD)

11.1.2.5. Requirement of IEE for the Project

The Project installs overhead transmission lines as follows.

- ✓ 400 kV Sampoor – New Habarana T/L : length : 95 km
- ✓ 220 kV Sampoor – Kappalturai T/L : length : 37.4 km

Both of T/L is exceeding 10 km and above 50 kV. Accordingly, the Project is classified as 'prescribed project'. It is necessary to submit IEE or EIA report and the report must be approved. In addition, since the Project area doesn't include 'environmentally sensitive areas', IEE is required to be implemented.

CEA will decide an appropriate PAA (according to the prescription in 'Guidance for implementing the Environmental Impact Assessment (EIA) Process'). The Ministry of Power and Energy (MOPE) was decided as the PAA for the Project.

From 2012, PAA of all projects implemented by CEB have been CEB. However, since the PAA deciding process was in transient period, MOPE became PAA for the Project. Final IEE report was submitted by CEB November 2014. The approval document of the Project was issued by PAA on 10th December 2014.

11.1.2.6. IEE/EIA Approval Procedure in Detail

1) Preliminary Information (PI)

It is the responsibility of the PAA to obtain from the project proponent at the earliest practical stage information regarding the nature, location and potential impacts of a proposed project that requires an IEE or an EIA. The CEA has already compiled checklists and a questionnaire in order to help collect preliminary information (PI). The PAA may use them for obtaining PI from the project proponent.

The PAA may obtain help on PI forms and questionnaires from the CEA and other PAAs. Once the PAA is satisfied that adequate PI has been received, the PAA should acknowledge its receipt in writing within six days. If any documents are found to be inadequate, the PAA should tell the project proponent as early as possible (CEA 2006).

2) Scoping

The process of determining the scope of issues to be addressed and for identifying the significant issues related to a proposed action is termed "scoping".

As part of the scoping process, the PAA should

- ✓ invite the formal and informal participation of all concerned agencies, the project proponent and other interested persons;
- ✓ determine whether the project proponent should be asked to prepare an IEE or EIA, unless an adequate IEE has already been presented;
- ✓ determine the scope and significant issues to be analyzed in depth in the IEE/EIA;
- ✓ determine reasonable alternatives that should be addressed in the IEE/EIA;
- ✓ set schedules and time periods as needed,

Detailed guidelines on the scoping process have already been issued as "Guidance for Implementing the Environmental Impact Assessment (EIA) Process", No. 2: A General Guide for Conducting Environmental Scoping by the CEA for assistance to PAA.

PAA should determine whether an IEE or EIA is required for a proposed project based on an assessment of the likely significance of the impacts of the proposed project to the environment.

If the environmental impacts of the project are not very significant then the project proponent may be asked to do an IEE, which is a relatively short and simple study. However, if the potential impacts appear to be more significant, the project proponent may be asked to do an EIA which is a more detailed and comprehensive study of environmental impacts.

3) Terms of Reference (TOR)

Effective and efficient compliance with the NEA will require that IEE undergo the simplest possible preparation process consistent with their basic purpose. Guidance on TOR preparation can be obtained from the CEA.

PAA should prepare the TOR before assessing the EIA report created by the project proponent in order to achieve the following objectives:

- ✓ EIA should be analytic, rather than encyclopedic.
- ✓ EIA should discuss impacts in proportion to their significance. There should be only brief discussion of anything other than significant issues.
- ✓ EIA should be concise and should be not longer than needed to comply with the NEA and its regulations.
- ✓ EIA should serve as the means to assess the environmental impacts of the proposed prescribed project and reasonable alternatives, rather than to justify decisions already made (CEA 2006).

The TOR should be concise and should follow a regular format to facilitate compliance by proponents, consulting entities, and efficient IEE/EIA review by the PAA. The TOR should ensure that EIAs are prepared to meet the EIA requirements and format. The PAA shall convey in writing to the project proponent the TOR within 14 days in case of IEE or 30 days in case of EIA from the date of acknowledging the receipt of preliminary information.

The TOR should ensure that IEE or EIA are prepared to meet the IEE/EIA requirements and format.

The issuance of the TOR for IEE requests for the simplest possible process as compared to that of EIA.

4) Timing of the EIA Process

A project proponent should start the IEE/EIA process as close as possible to the time when it develops the proposal. By ensuring that project proponents do this, the PAA can ensure that the IEE/EIA should be prepared early enough so that it can contribute practically to the decision-making process and to ensure that it will not be used to rationalize or justify decisions already made (CEA 2006).

For projects directly undertaken by public entities, the IEE/EIA should be prepared at the feasibility ('go'/'no-go') stage. The EIA may be supplemented at a later stage if needed.

5) Preparation of EIA or IEE Report

The IEE/EIA report should be prepared in any of the national languages by the project proponent, and then submitted to the PAA for evaluation. If there is a request from the public, these reports are translated to any of the other two national languages.

The PAA is required to announce in national newspapers of all three languages that the particular EIA is available for inspection by the public.

(i) EIA

The following standard format for an EIA should be followed unless the agency determines that there is compelling reason to do otherwise (CEA 2006).

The Structure of an EIA Report (Source: CEA, Guidance for Implementing the EIA Process, 2006)
Inside Cover Sheet The inside cover sheet should not exceed one page. It should include: the title of the proposed action that is the subject of the assessment. the list of preparers, including the consulting company or companies, if any, responsible for the preparation of the EIA report. The original document should be authenticated by the preparers or by a responsible individual or individuals form the consulting company (if any). the name, address and telephone number of the responsible person at the agency who can supply further information on the document. a paragraph abstract of the EIA (for use in public notices of EIA availability).
Table of Contents
Executive Summary Each EIA should contain an adequate and accurate executive summary. It should emphasize the major choices to be made, major conclusions, topics of controversy (including issues raised by agencies and the public in the scoping process) and the issues to be resolved (including the choices among alternatives). Summaries should not normally exceed five pages.
Proposed Action's Purpose, Need and Legal Requirements The EIA should briefly specify the underlying purpose and need to which preparers are responding in proposing the alternatives including the proposed action. This section should include a concise description of the legal steps required and actions that must be taken (and findings that must be made) by specified government agencies in order to approve the project. In this way, the EIA can serve as a project-management tool to identify all information needed to meet various legal requirements for project approval.
Proposed Action and Reasonable Alternatives This section describes the proposed action and reasonable alternatives, which should include those agreed upon in the scoping process. If subsequently determined to be unreasonable, the reasons should be discussed in this section. may include reasonable alternatives not discussed at the scoping stage. may be more restricted for private proposals than for government proposals, because realistic options may be more restricted. should always include the "no action" alternative, meaning one based on current practices without approval of the proposed project. should always state clear reasons for rejecting the alternatives in preference to the one recommended.
Affected Environment The EIA should succinctly describe the environment(s) of the area(s) to be affected by the proposed project. Descriptions should be no longer than is needed to understand the effect(s). Data and analyses in an assessment should be commensurate with the importance of the impact. Less-significant material should be summarized, consolidated or simply referenced. Preparers should avoid useless bulk in assessments and should concentrate their efforts and attention on important issues. Verbose descriptions of the affected environment are themselves no measure of the adequacy of an EIA.
Environmental Consequences of Proposed Action This important section provides the scientific and analytic basis for identifying and evaluating the environmental impacts of the proposed action. Impacts include: Direct and indirect effects and their significance, and indirect including biological/ecological, health, historic or cultural resource impacts. Natural or depletable resource requirements of the project including irreversible or irretrievable commitments of resources affected if the proposal is implemented. Adverse environmental effects that cannot be avoided if the proposal is implemented. A statement evaluating the significance of impacts Direct, indirect and cumulative impacts, irreversible and irretrievable commitments of resources together with an analysis on the significance of impacts.
Mitigation Measures Feasible and implementable mitigation measures should be submitted. Extended Cost-benefit Analysis Include, if the project proponent has prepared one.
Proposed Monitoring Plan This section should include followings: Parameters to be monitored Institutional responsibility and procedures for reporting
Appendices If an agency prepares an appendix to the EIA, it should: Consist of material prepared for an EIA (as distinct from material not prepared for the EIA and incorporated for reference). Normally consist of material that substantiates any analysis fundamental to the impact assessment. Normally be analytic and relevant to the decision to be made. Be circulated with the EIA or be readily available on request.
Preparation of TOR for IEE

(ii) IEE

IEEs are intended to be brief documents, which aims at helping decision makers to ensure that projects are implemented with appropriate mitigation measures to avoid significant impacts.

PAAs may wish to establish page limits, checklists or other guides for project proponents to meet IEE requirement effectively and efficiently.

An IEE report should contain following sections and items in general.

The Structure of an IEE Report (Source: CEA, Guidance for Implementing the EIA Process, 2006)
Summary (one page)
Proposed Action's Purpose, Needs and Legal Requirements
Legal actions required by the government to approve action
Proposed Action
Brief description of the proposed action, including any mitigation measures designated to reduce environmental impacts

The IEEs may need to contain description of reasonable alternatives.

- Affected Environment
- Environmental Consequences of the Proposed Action
- Mitigation and Monitoring Plan
- Appendixes (List of IEE prepares, reference, backup data and analysis)

6) Public Participation at the "Scoping" Stage

The public can participate at the "scoping" stage, review the EIA for 30 working days, request clarifications from the Project Proponent through the PAA and may, at the discretion of the PAA, participate at a public hearing.

PAAs should establish procedures for making the EIA readily available to the public for reading in Colombo and in the district or division in which the project is proposed. PAAs should establish an efficient process to allow copies of EIAs to be made for the public upon request and upon payment of the full reproduction costs by the requesting party or parties. PAAs should forward all comments received to the project proponent for review and response. Upon receipt of the project proponent's written response to comments, the PAA should evaluate the responses before making a decision (CEA 2006).

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

- ✓ Whether the proposed prescribed project is highly controversial.
- ✓ Whether more expressions of public views are essential to making a decision.
- ✓ Whether the proposed prescribed project might cause unusual national or regional impacts.

- ✓ Whether it might threaten nationally important, environmentally sensitive areas.
- ✓ Whether a formal request for a public hearing has been requested by any stakeholder, including the general public (CEA 2006).

If it is decided to hold a public hearing, the hearing should be held immediately after the expiration of the 30-working-day public-comment period and before the project proponent is formally asked to comment on public and agency comments (CEA 2006).

The project proponent should assess and consider comments by the public, agencies and the PAA and should respond by one or more of the means listed below, stating its response in the final assessment.

7) Review the IEE/EIA Report by PAA and CEA

The PAA and CEA will review the EIA report.

Queries can be directed to the project proponent through the PAA. If there are any public comments on the EIA report, the public is allowed to submit queries and observations for 30 working days. These will be sent to the project proponent for response and it must respond to their queries within six days.

PAA may request the project proponent for clarifications and further details.

On review of the public comments the PAA may request the project proponent for clarifications and further details.

8) Public Participation and Comment by Cooperating Agencies

On receipt of the IEE/EIA, the PAA should make a preliminary assessment of its adequacy as per the expectations set out in the TOR. If found adequate on prima facie review, the EIA document should be made available for public scrutiny for a period of 30 working days, and its availability must be announced by gazette and in one newspaper each in English, Sinhala and Tamil. The commenting period of 30 working days will begin on the day that the notice is published. The period of 30 days will be calculated excluding public holidays and Sundays (CEA 2006).

Cooperating agencies with either jurisdiction by law or special expertise with respect to any IEE/EIA, as well as agencies that are authorized to develop and enforce environmental standards, should comment on assessments within their jurisdiction, expertise or authority and within the time period specified for comment (CEA 2006).

9) Information Disclosure of the Result of the Environmental Impact Assessment

The results of the EIA reports have to be disclosed to receive public comment. If the PAA refuses to approve a prescribed project, the project proponent has the right to appeal to the Secretary of the Ministry of Environment. On the contrary, once the PAA approved a project, affected people by the project do not enjoy that right under the NEA.

10) Decision of Approval

Subsequent to the public participation period, the PAA will appoint a “technical evaluation committee (TEC)” to evaluate the IEE/EIA report and make its recommendations.

Based on the recommendations of the TEC, the PAA will make its decision on whether to grant approval for a project within 21 days in case of IEE, or 30 days in case of EIA.

The PAA, in concurrence with the CEA, decides whether a project is to be approved or not.

If approved, the conditions under which it can be allowed should be decided.

If the project is rejected, an appeal by the project proponent is allowed.

If the project is approved, the project proponent and the PAA should monitor the affected environmental characteristics.

If the project is approved, the project proponent and the PAA should monitor the affected environmental characteristics as set out in the EIA.

11) Timing of Each Step in the IEE/EIA Process

Table 11.1-3 Timing of Each Step in the IEE/EIA Process

Step	Timing		Law Background
	EIA	IEE	
Acknowledgement of the preliminary information	6 days	6 days	Regulations Article 6-(i) of gazette no. 772/22,18 June 1993
Producing of the TOR	30 days	14 days	Regulations Article 6-(iii) of gazette no. 772/22, 18 June 1993
Public commenting	30 days	-**	Regulations Article 11-(i) of gazette no. 772/22, 18 June 1993
Sending of public comments to the project proponents	6 days	-**	Regulations Article 12 of gazette no. 772/22, 18 June 1993
Approval (after receiving the comments of the Project Proponent	30 days	21 days*	Regulations Article 13 of gazette no. 772/22,18 June 1993 *Regulations Article 8 of gazette no. 1159/22, 21 November 2000

Note: -** article on disclosure of IEE was repealed on November 2000

(Source: Prepared by the Team referring to the contents described above section)

12) Requirements for an Environmental Management Plan (EMP)

To date, there is no act or ordinance that stipulates the necessity of an Environmental Management Plan (EMP). However, consideration for impact mitigation should be in the EIA process. In the case of large-scale development, the proponent is sometimes requested to submit a list of specific mitigation measures, although this is not a legally binding requirement. According to an interview with an expert in the field in Sri Lanka, there seems to be some movement forward to institutionalize the process of preparing and submitting an EMP.

11.1.2.7. Monitoring

1) Legal Framework and Procedures

The PAA must make a plan to monitor the project and must submit the plan to CEA with the report provided by the proponent. Usually, the PAA commissions other bodies to carry out the monitoring of the project. The result of the monitoring is disclosed only when requested. Other monitoring processes (e.g., by the project proponent) are not mandated.

Mitigation and other conditions established in the IEE/EIA during its review and committed to as part of the decision should be implemented by the project proponent and monitored by the PAA. The PAA should:

- ✓ Include appropriate mitigation conditions in grants, permits or other approvals.
- ✓ Condition funding of government actions upon mitigation by the proponent.
- ✓ Establish monitoring processes and assign monitoring responsibilities to public or private entities.
- ✓ Establish a means for providing government compensation for monitoring costs through fees, bonds or other measures.
- ✓ Upon request, inform commenting agencies on progress in carrying out proposed mitigation measures adopted by the decision-making agency.
- ✓ Upon request, make available to the public the results of relevant monitoring (CEA 2006).

The PAA should follow the schedule requirements set forth in the EIA regulations. These time requirements are important to achieve the goals of the EIA process as an efficient management tool. Two other requirements are also critical:

- ✓ No decision on the proposed action should be made or recorded by a PAA during the 30-working-day public-review period.
- ✓ No action by the PAA on the proposed action should be taken until the project proponent has responded to comments received on the EIA (CEA 2006).

2) Information Disclosure of Monitoring Results

According to the Guidance for Implementing the Environmental Impact Assessment (EIA) Process, No. 1: A General Guide for Project Approving Agencies, information disclosure of monitoring results should be conducted by the PAA, as mentioned above.

3) Prescription and Procedure to Address Issues Found in the Monitoring Process

To date, laws that specify penalties for the violation of EIA procedures do not exist in Sri Lanka. In cases of emergency (e.g., landslides or floods), in keeping with legal guidelines, the agency taking action should consult with the CEA about alternative arrangements (CEA 2006).

11.1.3. Environmental Standard

11.1.3.1. Air Quality Standards

Air Quality (Ambient Air Quality, AQ) standards specify the quality of the surrounding air as opposed to emission standards which specify the standard at the point of emission. Thus AQ standards reflect the cumulative impact of the individual emission sources both stationary and mobile.

Table 11.1-4 shows the National Environmental (Air Quality) Regulations of 1994 as amended in 2008 specify the maximum permissible amount in the ambient air of pollutants (Referring to CEA WEB page Acts & Regulations, 02 September 2013), with

WHO Guidelines.

The Sri Lanka national AQ standards are more tolerant than those of WHO guidelines for almost all pollutants.

Table 11.1-4 Sri Lanka National Air Quality Standards vs. WHO Guideline

Pollutant	Averaging Time	Maximum Permissible Level		WHO Guidelines
		μg/m³	ppm	μg/m³
PM_{10}	Annual	50	–	20
	24 hrs.	100	–	50
$PM_{2.5}$	Annual	25	–	10
	24 hrs.	50	–	25
NO_2	Annual	–	–	40
	24 hrs.	100	0.05	–
	8 hrs.	150	0.08	–
	1 hr.	250	0.13	200
SO_2	24 hrs.	80	0.03	20
	8 hrs.	120	0.05	–
	1 hr.	200	0.08	–
	10 mins.	–	–	500
O_3	8 hrs.	–	–	100
	1 hr.	200	0.10	–
CO	8 hrs.	10,000	9.00	10,000
	1 hr.	30,000	26.00	30,000
	Anytime	58,000	50.00	–

(Source: The Gazette of the Democratic Socialist Republic of Sri Lanka No. 1562/22 (2008.08.15), WHO, 2000. Air Quality Guidelines for Europe, 2nd ed., WHO, 2006. Air Quality Guidelines for Particulate Matter, Ozone, Nitrogen Dioxide and Sulfur Dioxide)

11.1.3.2. Ambient Noise (Noise) Control Regulations (Noise Standards)

The following tables show environmental standards of noise (maximum permissible noise level in L_{Aeq} at the land on which the noise source is located).

These regulations are cited as the National Environmental (Noise Control) Regulation No. 1 of 1996.

Table 11.1-5 Noise Regulation Schedule I

Area	L_{Aeq} T	
	Day Time (6:00 a.m. to 6:00 p.m.)	Night Time (6:00 p.m. to 6:00 a.m.)
Low Noise areas (within Pradeshiya sabhas)	55 dB(A)	45 dB(A)
Medium Noise areas (within Municipal Councils or Urban Councils)	63* dB(A)	50 dB(A)
High Noise areas (within Export Processing Zones or Industrial Estates)	70 dB(A)	60 dB(A)
Silent zones (100 meters from the boundary of a courthouse, hospital, public library, school. Zoo, sacred area and areas set apart for recreation or environment)	50 dB(A)	45 dB(A)

* Provided that the noise level should not exceed 60 dB (A) inside existing houses, during day time.
Note: L_{Aeq} means the equivalent, continuous, A-weighted sound pressure determined over a time interval (T) in dB.

Following noise levels will be allowed where the background noise level exceeds or is marginal to the given levels in Schedule I.

Table 11.1-6 Noise Regulation Schedule II

(a)	For low noise areas in which the background noise level exceeds or is marginal to the given level	Measured Background Noise level +3 dB(A)
(b)	For medium noise areas in which the background noise level exceeds or is marginal to the given level	Measured Background Noise Level +3 dB(A)
(c)	For silent zone in which the background noise level exceeds or is marginal to the given level	Measured Background Noise Level +3dB(A)
(d)	For high noise areas in which the background noise level exceeds or is marginal to the given level	(i) For day time Measured Background Noise level +5dB(A) (ii) For night time Measured Background Noise level +3dB(A)

Note 1: "Daytime" means from 6:00 a.m. to 6:00 p.m., except for the purposes of construction activities, where it means 6:00 a.m. to 9:00 p.m. "Nighttime" means from 6:00 p.m. to 6:00 a.m., except for the purposes of construction activities, where it means 9:00 p.m. to 6:00 a.m.

Note 2: Noise generated from machinery and processes should be controlled at the source as far as possible by one or more of the following methods: (a) vibration isolation, (b) noise insulation, (c) noise absorption, and/or (d) damping.

Table11.1-7 shows maximum permissible noise levels (in L_{Aeq} T) at the boundaries of the land on which the source of noise is located for construction activities.

Table 11.1-7 Noise Regulation Schedule III (Permissible Noise Levels of Construction Activities)

L_{Aeq} T	
Day time (6:00 a.m. to 9:00 p.m.)	Night time (9:00 p.m. to 6:00 a.m.)
75 dB(A)	50 dB(A)

Table11.1-8 shows maximum permissible noise levels at the boundaries in L_{Aeq} T, for industrial activities.

Table 11.1-8 Noise Regulation Schedule IV (Permissible Noise Levels for Industrial Activities)

Area	L_{Aeq} T	
	Day Time (6:00 a.m. to 6:00 p.m.)	Night Time (6:00 p.m. to 6:00 a.m.)
Rural residential area	55 dB(A)	45 dB(A)
Urban residential area	60 dB(A)	50 dB(A)
Noise sensitive area	50 dB(A)	45 dB(A)
Mixed residential	65 dB(A)	55 dB(A)
Commercial area	60 dB(A)	55 dB(A)
Industrial Area	70 dB(A)	60 dB(A)

Noise levels shown in Table 11.1-9 will be allowed where the background noise level exceeds or is marginal to the given levels in Schedule I.

Table 11.1-9 Noise Regulation Schedule V

(a)	For rural residential areas in which the background noise level exceeds or is marginal to the given level l	Measured Background Noise level +3 dB(A)
(b)	For noise sensitive areas in which the background noise level exceeds or is marginal to the given level	Measured Background Noise Level +3 dB(A)
(c)	For noise sensitive areas in which the background noise level exceeds or is marginal to the given level	Measured Background Noise Level +3dB(A)
(d)	For mixed residential or commercial areas in which the background noise level exceed or is marginal to the given level	(i) For day time Measured Background Noise level +5dB(A) (ii) For night time Measured Background Noise level +3dB(A)
(e)	For industrial areas in which the background noise level exceeds or is marginal to the given level	(i) For day time Measured Background Noise level +5dB(A) (ii) For night time Measured Background Noise level +3dB(A)

Table 11.1-10 shows maximum permissible noise levels in Industrial/ Commercial area and Urban/ Rural/ Mixed Residential area.

Table 11.1-10 Noise Regulation Schedule VI

Area	L_{Aeq} T	
	Day Time	Night Time
Industrial / Commercial	75 dB(A)	60 dB(A)
Urban / Rural / Mixed Residential	65 dB(A)	56 dB(A)

11.1.3.3. Vibration Standards (Air-Blast Over Pressure and Ground Vibration Standards)

(Source: "Amended interim ABOP and vibration standards (CEA , 4th Dec. 2008))

Building that have been built-up in Sri Lanka could be categorized into the following categories in accordance with the ISO 4866:1990 (E) standards. The following categorization of buildings has been adopted in introducing the vibration standards for all cases. However, it is noteworthy to mention here that even though the classification of buildings given by the International Standards are almost the same, the same categories have been divided into sub categories to suit the Sri Lankan situation.

1) Building Classification

Table 11.1-11 Categorization of Structures according to the Type of Building (from ISO-4966: 1990E)

Category of the structure of the building		Description
Resistance to the vibration decreasing	Type 1	Multi storey buildings of reinforced concrete or structural steel, with in filling panels of block work, brick work or precast units not designed to resist earthquakes.
	Type 2	Two-storey domestic houses & buildings constructed of reinforced block work, precast units, and with reinforced floor & roof construction, or wholly of reinforced concepts or similar, not designed to resist earthquakes.
	Type 3	Single and two-storey houses & buildings made of lighter construction, using lightweight materials such as bricks, cement blocks etc., not designed to resist earthquakes.
	Type 4	Structures that, because of their sensitivity to vibration, do not correspond to those listed above 1, 2 & 3, & declared as archeologically preserved structures by the Department of Archaeology.

2) Interim Standards for Vibration Control

Table 11.1-12 Interim Standards for Vibration of the Operation of Machinery, Construction, Activities and Vehicle Movements Traffic

Category of the structure as given in Table 11.1-11	Type of Vibration	Frequency of Vibration (Hz)	Vibration in PPV (mm/Sec.)
Type 1	Continuous	0 –10	5.0
		10-50	7.5
		Over 50	15.0
	Intermittent	0 –10	10.0
		10-50	15.0
		Over 50	30.0
Type 2	Continuous	0 –10	2.0
		10-50	4.0
		Over 50	8.0
	Intermittent	0 –10	4.0
		10-50	8.0
		Over 50	16.0
Type 3	Continuous	0 –10	1.0
		10-50	2.0
		Over 50	4.0
	Intermittent	0 –10	2.0
		10-50	4.0
		Over 50	8.0
Type 4	Continuous	0 –10	0.25
		10-50	0.5
		Over 50	1.0
	Intermittent	0 –10	0.5
		10-50	1.0
		Over 50	2.0

Note: 1. Please see separate measurement methods.
Note: 2. The values given above are in such a way that minor damage is unlikely as the nearby house/building.

Table 11.1-13 Interim Standards on Air Blast Over Pressure and Ground Vibration for Blasting Activities

Category of the structure as given in Table 11.1-11	Type of Vibration	Type of Blasting	Ground Vibration in PPV (mm/sec.)	Air blast over Pressure (dB (L))
Type 1	Impulsive	Single bore hole	8.0	105
		Multi bore hole with delay detonators	10.0	115
Type 2	Impulsive	Single bore hole	6.0	105
		Multi bore hole with delay detonators	7.0	115
Type 3	Impulsive	Single bore hole	4.0	115
		Multi bore hole with delay detonators	5.0	120
Type 4	Impulsive	Single bore hole	0.5	95
		Multi bore hole with delay detonators	0.75	100

Note: 1. Please see separate measurement methods.
Note: 2. The values given above are in such a way that minor damage is unlikely as the nearby house/building.

11.1.3.4. Standards for the Inconvenience of the Occupants in Buildings

The frequency response of vibration of the human body is complex. However, approximate response curves (basic curve) for Z axis are given in BS 6472: 1992. These are given in terms of base curves, which may be close to the threshold of perception for majority of people.

Table 11.1-14 Base Curve in relation to Preparing of Interim Vibration for the Inconvenience of the Occupants in Building taken from BS 6472: 1992 (BS: British Standard)

Frequency Hz	PPV (mm/sec)
1	2.25
1.25	1.61
1.6	1.11
2.0	0.296
2.5	0.569
3.15	0.402
4.00	0.281
5.00	0.225
6.30	0.179
8.00	-
10.00	-
12.50	-
16.00	-
20.00	-
25.00	-
31.00	-
40.00	-
50.00	-
63.00	-

Table 11.1-15 Multiplying Factors use to Specify Magnitudes of Building Vibration with respect to Human Resource using the Base Curve in Table 11.1-13

Place	Time	Multiplying factors		
		Continuous vibration (day time and night time)*	Impulsive vibration (max. of three occurrence per day	Intermittent vibration
Critical working areas (e.g. hospital operating theatres, precision laboratories	Day	1	1	1
	Night	1	1	1
Residential	Day	6	40	20
	Night	2	10	5
Office	Day	6	80	30
	Night	6	80	30
Workshop	Day	8	100	50
	Night	8	100	50

Note: * “day time”: from 0600h to 1800h, “night time”: from 1800h to 0600h

Table 11.1-16 Interim Standards on Vibration for the Inconvenience of the Occupants in Buildings

Place	Time	Multiplying factors		
		Continuous vibration (day time and night time)*	Impulsive vibration (max. of three occurrence per day	Intermittent vibration
Critical working areas	Day & Night	0.141	0.141	0.141
Residential	Day	0.705	5.640	2.820
	Night	0.282	1.410	0.705
Office	Day & Night	0.846	11.280	4.230
Workshop	Day & Night	1.41	1.41	7.05

Note: * “day time”: from 0600h to 1800h, “night time”: from 1800h to 0600h

All values are frequency weighted to vertical axis.

11.1.3.5. Water Quality Standards

1) Standards of Water Quality of Discharge of Industrial Waste Water

Table 11.1-17 Tolerance Limits for the Discharge of Industrial Waste Water into Inland Surface Waters

No.	Parameter	Unit, Type of limit	Tolerance Limit Value
01.	Total suspended solids	mg/l, max.	50
02.	Particle size of the total suspended solids (a) Floatable solids (b) Settable solids	 μm, less than μm, less than	 3 850
03.	pH at ambient temperature	-	6.0-8.5
04.	Biochemical Oxygen Demand (BOD_5 in five days at 20 deg C or BOD_3 in three days at 27 deg C)	mg/l, max.	30
05.	Temperature of discharge	deg C, max.	Shall not exceed 40 deg C in any section of the stream within 15 m down stream from the effluent outlet.
06.	Oils and greases	mg/l, max.	10
07.	Phenolic compounds (as phenolic OH)	mg/l, max.	1
08.	Chemical Oxygen Demand (COD)	mg/l, max.	250
09.	Colour	Wave length range 436nm (Yellow range) 525 (Red range) 620 (Blue range)	Maximum spectral absorption coefficient $7m^{-1}$ $5m^{-1}$ $3m^{-1}$
10.	Dissolved phosphates (as P)	mg/l, max.	5
11.	Total Kjeldahl nitrogen (as N)	mg/l, max.	150
12.	Ammonical nitrogen (as N)	mg/l, max.	50
13.	Cyanide (as CN^-)	mg/l, max.	0.2
14.	Total residual chlorine	mg/l, max.	1.0
15.	Fluorides (as F^-)	mg/l, max.	2.0
16.	Sulphides (as S^{2-})	mg/l, max.	2.0
17.	Arsenic (as As)	mg/l, max.	0.2
18.	Cadmium (as Cd)	mg/l, max.	0.1
19.	Chromium, total (as Cr)	mg/l, max.	0.5
20.	Chromium, Hexavalent (as Cr^{6+})	mg/l, max.	0.1
21.	Copper (as Cu)	mg/l, max.	3.0
22.	Iron (as Fe)	mg/l, max.	3.0
23.	Lead (as Pb)	mg/l, max.	0.1
24.	Mercury (as Hg)	mg/l, max.	0.0005
25.	Nickel (as Ni)	mg/l, max.	3.0
26.	Selenium (as Se)	mg/l, max.	0.05
27.	Zinc (as Zn)	mg/l, max.	2.0
28.	Pesticides	mg/l, max.	0.005
29.	Detergents/surfactants	mg/l, max.	5
30.	Faecal Coliform	MPN/100 ml, max	40
31.	Radio Active Material: (a) Alpha emitters (b) Beta emitters	 micro curie/ml, max micro curie/ml, max	 10^{-8} 10^{-7}

Note 1: All efforts should be made to remove unpleasant odour as far as possible.
Note 2: These values are based on dilution of effluents by at least 8 volumes of clean receiving water. If the dilution is below 8 times, the tolerance limits are multiplied by the 1/8 of the actual dilution.
Note 3: The above mentioned general standards shall cease to apply with regard to a particular industry when industry specific standards are notified for that industry.
Note 4: Pesticides as per World Health Organization (WHO) and Food and Agriculture Organization (FAO) requirements.
(Source: GAZETTE EXTRAORDINARY OF THE DEMOCRATIC SOCIALIST REPUBLIC OF SRI LANKA- 01.02.2008)

Table 11.1-18 Tolerance Limits for Industrial Waste Water Discharged on Land for Irrigation Purpose

No.	Parameter	Unit, Type of limit	Tolerance Limit Value
01.	Total dissolved solids	mg/l, max.	2100
02.	pH at ambient temperature	-	5.5-9.0
03.	Biochemical Oxygen Demand (BOD_5 in five days at 20 deg C or BOD_3 in three days at 27 deg C)	mg/l, max.	250
04.	Oils and greases	mg/l, max.	10
05.	Chemical Oxygen Demand (COD)	mg/l, max.	400
06.	Chlorides (as Cl^-)	mg/l, max.	600
07.	Sulphates (as SO_4^{2-})	mg/l, max.	1000
08.	Boron (as B)	mg/l, max.	2.0
09.	Arsenic (as As)	mg/l, max.	0.2
10.	Cadmium (as Cd)	mg/l, max.	2.0
11.	Chromium, total (as Cr)	mg/l, max.	1.0
12.	Lead (as Pb)	mg/l, max.	1.0
13.	Mercury (as Hg)	mg/l, max.	0.01
14.	Sodium Adsorption Ration (SAR)	-	10-15
15.	Residual Sodium Carbonate (RSC)	mol/l, max.	2.5
16.	Electrical conductivity	µs/cm, max.	2250
17.	Faecal Coliform	MPN/100ml, max.	40
18.	Copper (as Cu)	mg/l, max.	1.0
19.	Cyanide (as CN^-)	mg/l, max.	0.2
20.	Radio Active Material: (a) Alpha emitters (b) Beta emitters	 micro curie/ml max micro	0.1 10^{-9} 10^{-8}

(Source: GAZETTE EXTRAORDINARY OF THE DEMOCRATIC SOCIALIST REPUBLIC OF SRI LANKA- 01.02.2008)

Table 11.1-19 Hydraulic Loading Applicable for Different Soils

	Soil Texture Class	Recommended dosage settled Industrial Effluents (m^3/hectare, day)
1.	Sandy	225 - 280
2.	Sandy loam	170 – 225
3.	Loam	110 – 170
4.	Clay loam	55 – 110
5.	Clay	35 - 55

Table 11.1-20 Tolerance Limits for Industrial and Domestic Waste Discharged into Marine Coastal Areas

No.	Parameter	Unit, Type of limit	Tolerance Limit Value
01.	Total suspended solids	mg/l, max.	150
02.	Particle size of the total suspended solids (a) Floatable solids (b) Settable solids	 mm, max. μm, max	 3 850
03.	pH at ambient temperature	-	5.5-9.00
04.	Biochemical Oxygen Demand (BOD_5 in five days at 20 deg C or BOD_3 in three days at 27 deg C)	mg/l, max.	100
05.	Temperature of discharge	deg C, max.	45 deg C at the point of discharge
06.	Oils and greases	mg/l, max.	20
07.	Phenolic compounds (as phenolic OH)	mg/l, max.	5
08.	Chemical Oxygen Demand (COD)	mg/l, max.	250
09.	Total residual	mg/l, max.	1.0
10.	Ammonical nitrogen (as N)	mg/l, max.	50
11.	Cyanide (as CN^-)	mg/l, max.	0.2
12.	Sulphides (as S^{2-})	mg/l, max.	5.0
13.	Fluorides (as F)	mg/l, max.	15
14.	Arsenic (as As)	mg/l, max.	0.2
15.	Cadmium (as Cd)	mg/l, max.	2.0
16.	Chromium, total (as Cr)	mg/l, max.	2.0
17.	Chromium, Hexavalent (as Cr^{6+})	mg/l, max.	1.0
18.	Copper (as Cu)	mg/l, max.	3.0
19.	Lead (as Pb)	mg/l, max.	1.0
20.	Mercury (as Hg)	mg/l, max.	0.01
21.	Nickel (as Ni)	mg/l, max.	5.0
22.	Selenium (as Se)	mg/l, max.	0.1
23.	Zinc (as Zn)	mg/l, max.	5.0
24.	Pesticides	mg/l, max.	0.005
25.	Organo-Phosphorus compounds	mg/l, max.	1.0
26.	Chlorinated hydrocarbons (as C1)	mg/l, max.	0.02
27.	Faecal Coliform	MPN/100 ml, max	60
28.	Radio Active Material: (a) Alpha emitters (b) Beta emitters	 micro curie/ml, max micro curie/ml, max	 10^{-8} 10^{-7}

Note 1: All efforts should be made to remove unpleasant odor and color as far as practicable.
Note 2: These values are based on dilution of effluents by at least 8 volumes of clean receiving water. If the dilution is below 8 times, the permissible limits are multiplied by the 1/8 of the actual dilution.

2) Drinking-Water Quality Standards

Table 11.1-21 Sri Lanka Drinking-Water Standards vs. WHO Guideline

No.	Parameter	Unit type of limit	Highest Desirable Level	Maximum Permissible Level	WHO
1.	Electrical conductivity at 25°C	μS/cm	750	3500	N/A
2.	Total solids	mg/l	500	2000	600
3.	Color	Hazen	5	30	N/A
4.	Taste	–	Unobjectionable	–	
5.	Odor		Unobjectionable		
6.	Turbidity	NTU	2	8	0.1 (A)
7.	Chloride (Cl^-)	mg/l, max	200	1200	
8.	Fluoride (F^-)	mg/l, max.	–	1.5	1.5
9.	Iron (Fe)	Mg/l, max.	0.3	1	0.3 (A)
10.	Manganese (Mn)	mg/l, max.	0.05	0.5	0.4 (C)
11.	Copper (Cu)	mg/l, max.	0.05	1.5	2.0
12.	Zinc (Zn)	mg/l, max.	5	15	4.0 (A)
13.	Calcium (Ca)	mg/l, max.	100	240	N/A
14.	Magnesium (Mg)	mg/l, max.	30	150	N/A
15.	Total phosphates$_4$ (PO_4^{3-})	mg/l, max.	–	2.0	N/A
16.	Sulphate (SO_4^{2-})	mg/l, max.	200	400	N/A
17.	Total alkalinity (as $CaCO_3$)	mg/l, max.	200	400	N/A
18.	Total hardness (as $CaCO_3$)	mg/l, max.	250	600	300 (A)
19.	Free ammonia (asNH_3)	mg/l, max.	–	0.06	N/A
20.	Nitrate (NO_3^-)	mg/l, max.	–	45	N/A
21.	Nitrite (NO_2^-)	mg/l, max.	–	0.01	N/A
22.	pH		7.0–8.5	6.5–9.0	6.5–8.0 (A)
23.	Arsenic (As)	mg/l, max.	–	0.05	0.01 (P)
24.	Cadmium (Cd)	mg/l, max.	–	0.005	0.003
25.	Chromium (Cr)	mg/l, max.	–	0.05	0.05 (P)
26.	Cyanide (CN^-)	mg/l, max.	–	0.05	0.07
27.	Lead (Pb)	mg/l, max.	–	0.05	0.01
28.	Mercury (Hg)	mg/l, max.	–	0.001	0.006
29.	Selenium (Se)	mg/l, max.	–	0.01	0.01
30.	Free residual chlorin (as chlorine)	mg/l, max.	–	0.2	5
31.	Polynuclear aromatic hydrocarbons	mg/l, max.	–	0.0002	
32.	Phenolic compounds (as phenolic OH)	mg/l, max.	0.001	0.002	
33.	Greases and oil	mg/l, max.	–	1.0	
34.	COD (Chemical Oxygen Demand)	mg/l, max.	–	10	
35.	Radioactive materials Gross alpha radioactivity Gross beta radioactivity	pC/l	–	3	0.5 (Bq/l)
36.	Total coliforms	per/100ml	Absent in 95 % of samples in a year and in any two consecutive samples	10	
37.	E. Coli	per/100 ml	absent	absent	absent

(Source: National Environmental (Protection and Quality) Regulations, No. 1 of 2008)

11.2. Environmental and Social Considerations for 400 kV Sampoor- New Habarana T/L

11.2.1. Project components having possibility of environmental and social impacts

The components of the Project are shown below.

Transmission Line	1) Construction of 400 kV Sampoor – New Habarana T/L (Initially operate at 220 kV)
	2) Construction of 220 kV Sampoor – Kappalturai T/L
Substation	3) Construction of Sampoor Switching Subtation with 220 kV indoor GIS

1) 400 kV Sampoor – New Habarana T/L

The T/L length will be approximately 95 km with a capacity of around 2,110 MVA. The T/L's operating voltage will initially be 220 kV, and this will be increased to 400 kV before the installation of the Trincomalee-2 coal-fired power plant. The facilities for this T/L will be constructed on a 400 kV scale.

In general the proposed transmission line runs through a flat terrain with short stretches of hilly terrain in the sections near to Hatares Kotuwa and Morakanda. A dry undulating topography dominates the Project area.

At the present time, the land has not been recurred for the transmission line. CEB doesn't have a plan to acquire land for T/L. However, there will be restrictions such as land use restriction for tower footings / temporally access road, tree cutting / removing under / beside of T/L for safety. CEB plans to pay compensation for these restrictions.

The proposed route for the 400 kV Sampoor – New Habarana T/L is shown in Figure 11.2-1.

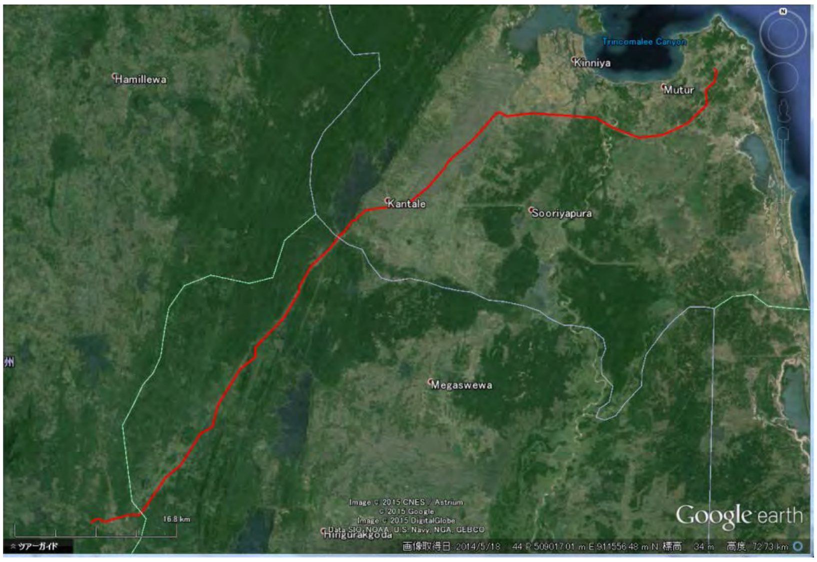


Figure 11.2-1 400 kV Sampoor – New Habarana Transmission Line Route

2) 220 kV Sampoor – Kappalturai T/L

Environmental and social considerations is described in 11.3.

3) Sampoor Switching Subtation with 220 kV indoor GIS

Environmental and social considerations is included in this 11.2.

Consideration for Environment

(i) Noise and Vibration

There is no household near around the Sampoor S/S and S/S is indoor type, there may be no environmental impact by noise and vibration.

(ii) Land Acquisition and Involuntary Resettlement

CEB already got the land for S/S in 2013. Land acquisition and involuntary resettlement are unnecessary.

11.2.2. Existing Conditions of the Project Area

11.2.2.1. Natural Environment

1) Geographic Features

Sri Lanka is a tropical island located in the Indian Ocean off the southern tip of peninsular India, between latitudes 5° 55' and 9° 51' North and longitudes 79° 41' and 81° 54' East. The island is 65,610 km^2 in area and consists of three peneplains: lowlands (up to 300 m above sea level), uplands (300 to 900 m above sea level) and highlands (more than 900 m above sea level).

The island also contains three distinct mountain ranges: the Central hill massif, the Rakwana range towards the Southwest and the Knuckles range towards the north of the Central massif (IUCN 2007).

The physiographic regions the study area belongs to include the Elehera Ridge and Coastal Plain I types. The altitude of the study area is between 150-30 m inland and 30-0 m towards the coastal plains.

2) Geology and Soils

The geological formations in the project areas vary from Sampoor (coastal zone) to Habarana (dry inland areas). The coastal areas consist of charnockites and quartzites, along with more recent alluvium. The hilly areas from Agbopura to Morakanda consist mainly of rocky areas with charnockites and quartzites. Very often bands and lenses of basis charnockite of variable thickness are found in the hilly areas.

Soils in the coastal areas are mostly sandy regosols and recent beach and dune sands, with areas of riverine alluvial soils. Reddish brown earth dominates the entire area from Agobopura to Habarana with varying degrees of granites and charnokites in the hilly slopes. Low humic glay soils dominate the paddy cultivation areas from Sampoor to Agbopura which is more than one third of the length of the proposed power line.

3) Climate and Weather

According to the distribution of rainfall, three major climatic zones are recognized in the island: a dry zone (with an annual rainfall less than 1900 mm), wet zone (annual rainfall more than 2500 mm) and intermediate zone (annual rainfall 1900 to 2500 mm).

Climate of Sri Lanka can be divided into four seasons namely, the first inter-monsoon (March-April), the South West Monsoon (May-September), the second inter-monsoon (October-November) and the North East Monsoon (December -February) according to the rainfall and the wind pattern along Sri Lanka. The highest total areal rainfall is received during the South West Monsoon and second Inter-monsoon periods. About 60 % of the total rainfall is received during these two monsoon periods. The lowest rainfall is received during the first inter-monsoon. Total annual average rainfall in Sri Lanka is 1,861 mm and it is equivalent to122 km^3 by volume.

The entire project area is located within the dry zone, which has a hot and humid tropical climate. The distinctive feature is the 8-9 month long dry period (February to October) and 3-4 months rainy season (November to January). However, there are inter-monsoonal rains during the dry period. The mean annual temperature is 28.5 deg C although typically this ranges from 18 deg C during cooler nights of the rainy season to 39 deg C during the day in the drier months. The Eastern Province receives an average rainfall ranging 1,000 mm to 2,000 mm per annum, primarily about 60 % from the North East Monsoon during October to February. Rainfall in the North Central Province is similar but its average is higher than that of the Eastern Province.

4) Biota and Ecology

(i) Ecological Resources

Biogeographically, the proposed project area lies within the low country Dry Zone. Floristically it is under Dry and Arid Lowlands Floristic Zone and Coastal and Marine Belt Floristic Zone. Tropical Dry Mixed Evergreen Forests {Manilkara Community, Mixed community (Chloroxylon – Vitex – Berrya –S chleichera series)}, Tropical Thorn Forests (Manilkara – Chloroxylon – Salvadora - Randia series), Damana and Villu Grasslands, Flood-plain Wetlands, Riverine and Gallery Forests are typical natural vegetation formations in the Dry and Arid Lowlands Floristic Zone and Mangroves, Salt Marshes, Sand Dunes and Strand Vegetation are typical natural vegetation formations in the Coastal and Marine Belt Floristic Zone.

Except Salt Marshes, Sand Dunes and Strand Vegetation, all other typical natural vegetation formations in the Dry and Arid Lowlands Floristic Zone and Coastal and Marine Belt Floristic Zone are exists in and around the proposed transmission line. In addition, several non-natural habitats and vegetations such as abandoned lands, forest plantations, agricultural lands, home gardens, tanks etc. exist in and around the proposed transmission line.

(ii) Flora of the Project Area

A total of 186 predominant flora species were recorded from the site surveyed (July, 2014) by CEB in IEE study. These included 7 species of endemic plants. In addition, 29 species of introduced plants were also recorded from the study site indicating that it is under human interference. Further, *Diospyros ebenum* (Kaluwara) which is an endangered species (EN) according to IUCN Red List 2012 criteria was recorded. Vulnerable species (VU) of *Haldina cordifolia* (Kolon) and *Mitragyna parvifolia* (Helamba) according to IUCN Red List 2012 criteria were also recorded within the study area (Table 11.2-1).

Table 11.2-1 Summary of Recorded Flora

Family	Species	Local Name	HA	TS	CS
Asteraceae	*Vernonia zeylanica*	Pupulu	C	E	
Ebenaceae	*Diospyros ebenum*	Kaluwara	T	N	EN
Ebenaceae	*Diospyros nummulariifolia*		T	E	
Erythroxylaceae	*Erythroxylum zeylanicum*		T	E	
Euphorbiaceae	*Drypetes gardneri*	Gal Wira	T	E	
Fabaceae	*Derris parviflora*	Kala Wel	C	E	
Rubiaceae	*Haldina cordifolia*	Kolon	T	N	VU
Rubiaceae	*Mitragyna parvifolia*	Helamba	T	N	VU
Sapindaceae	*Glenniea unijuga*	Wal Mora	T	E	
Tiliaceae	*Diplodiscus verrucosus*	Dik Wenna	T	E	
Fabaceae	*Dichrostachys cinerea*	Andara	S	N	
Rubiaceae	*Catunaregam spinosa*	Kukuruman	S	N	
Euphorbiaceae	*Phyllanthus polyphyllus*	Kuratiya	S	N	E
Rubiaceae	*Ixora pavetta*	Maha Ratabala	S	N	
Annonaceae	*Polyalthia korinti*	Ulkenda	S	N	

Note: <HA> Habit: T – Tree, S – Shrub, C – Climber or Creeper
According to National Red List 2012 of Sri Lanka
Diospyros ebenum (Kaluwara) : Endangered Species (EN),
Haldina cordifolia (Kolon) : LC (Least Concern)
Mitragyna parvifolia (Helamba) : LC (Least Concern)
<TS> Taxonomic Status: N – Native, E – Endemic
<CS> Conservation Status: (according to IUCN Red List 2012 criteria): EN – Endangered, VU –Vulnerable
(Source: CEB)

(iii) Fauna of the Project Area

A total of 142 faunal species were recorded from the Project site during the survey (July, 2014) including 68 bird species, 8 amphibian species, 22 reptile species, 11 mammal species and 33 butterfly species. Among the species observed 9 are endemic to the island. However, none of these species is restricted to the study area.

There is evidence of the presence of *Elephas maximus* (Elephant) within several sections of proposed line route. In some area elephants cross railway lines as shown with warning sign in Figure 11.2-2. It is endangered (EN) mammal.

(Source: CEB)

Figure 11.2-2 Elephant Crossing Areas

No significant impact is anticipated since the transmission towers and the conductors will be placed with a height, which has no effect on elephants. However, to avoid any unnecessary disturbances to their wildlife, following care will be exercised during the construction period. The mitigation measures are shown in “11.2.5.4 Impact on Terrestrial Fauna”.

(iv) Protected Area

The transmission line route does not traverse through any of environmentally sensitive areas, such as strict natural reserves, national parks and nature reserves, in the route alignment of the proposed transmission line.

There are no important archaeological, historical, cultural, and biological sites, such as World Heritage sites along the route alignment.

However, the line route does run through a few Forest Reserves but for as minimum a length as possible. Figure 11.2-3 shows Map of Transmission Line and Forest Reserves/ Conservation Forest Reserve. As shown in the Figure, the transmission line crosses small portions of reserves namely Gal Oya, Chundankadu and Kanthalai Forest Reserves and the Anaolendewa Conservation Forest Reserve. Table 11.2-2 shows Area of Forest Reserves and Conservation Forest Reserve traversed by transmission line.

However, the area for land clearance and/or tree cutting/removal in natural forest is much lower than the area within 52 m buffer of corridor shown in Table 11.1-23. For example, corridor opened with Gal Oya F.R. (50.57 ha of total area) consists only 4.85 ha of good quality forest and 34.5 ha of degraded/scattered forest, and 10.3 ha of shrub with scattered tall trees. In addition, the corridor opened with Analolondewa C.F.R. (29.20 ha of total area) consists of 10.4 ha of degraded/scattered forest, and 12.5 ha of shrub with scattered tall trees.

Table 11.2-2 Area of Forest Reserves and Conservation Forest Reserve Traversed by Transmission Line (52 m Width Buffer Corridor)

Name of Reserve	Area within 52 m Buffer of Corridor (ha)
Anaolondewa C.F.R.	29.20
Gal Oya F.R.	50.57
Kanthalai F.R.	8.54
Chundankadu F.R.	15.65

Note: C.F.R: Conservation Forest Reserve, F.R: Forest Reserve
(Source: CEB)

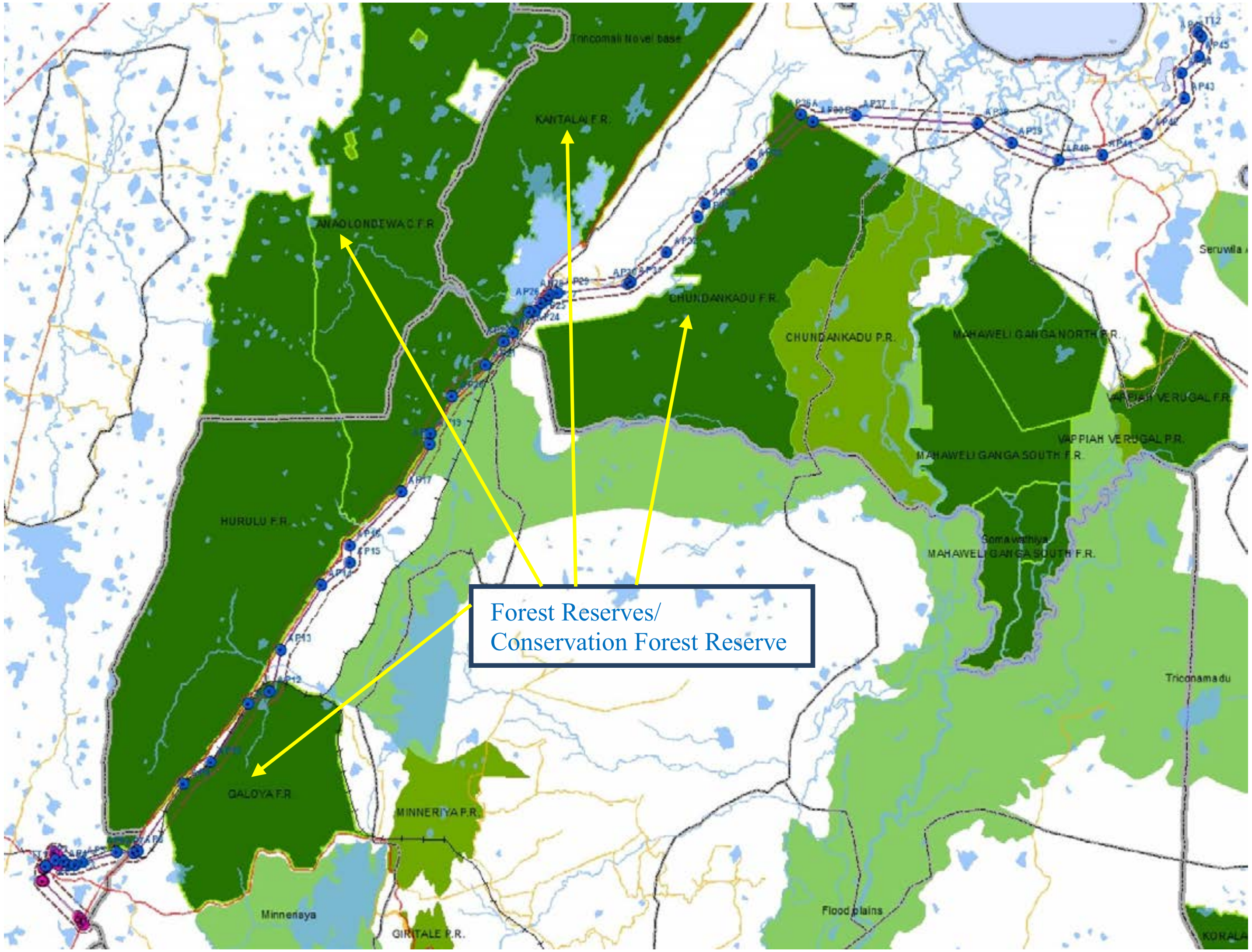
Regulations for activities in Forest Reserve and Conservation Forest Reserve are as follows.

- Forest Reserve: No activities other than research and visitations are allowed.

- Conservation Forest Reserve: Activities confined to non-extractive uses are allowed.

However, concerning to the Project, all activities done by CEB are controlled by FD, and Reforestation/afforestation program for cutting/removal of trees in forest will be planned and conducted by FD using suitable indigenous species (taking into consideration habitat types) with financial assistance from the CEB. An arboretum will be established at Habarana or at a suitable area as decided by the FD to fulfill this requirement.

Under the condition shown above, use of the land of Forest Reserve and Conservation Forest Reserve will be approved by FD.



(Source: CEB)

Figure 11.2-3 Map of Transmission Line and Forest Reserves/ Conservation Forest Reserve

11.2.2.2. Social Environment

1) Administrative Districts

Figure 11.2-4 shows administrative district where the project site exists.

The proposed transmission line will pass through three administrative districts namely Trincomalee, Polonnaruwa and Anuradhapura.

In these three Districts, transmission line will pass through following seven Divisional Secretaries.

1. Trincomalee

(1) Muttur

(2) Seruvila

(3) Kinniya

(4) Tambalagamuwa

(5) Kantalai

2. Polonnaruwa

(6) Hingurakgoda

3 Anuradhapura

(7) Palugaswewa

T/L will pass through
In these three Districts

Figure 11.2-4 Administrative District where the Project Site Exists

2) Demographic conditions

(i) Population, Household

Table 11.2-3 shows population of relevant Divisional Secretaries. The population ratio of female to male in the project area is slightly smaller than the national level.

Table 11.2-3 Population of Relevant Divisional Secretaries

Gender	National Total	In Trincomalee District						In Polonnaruwa District	In Anuradhapura District
		1 Muttur DS	2 Seruvila DS	3 Kinniya DS	4 Tambalagamuwa DS	5 Kantalai DS	1-5 Total In Trincomalee District	6 Hingurakgoda DS	7 Palugaswewa DS
Male	9,856,634	32,690	7,359	35,581	15,580	25,453	116,654	31,574	7,802
Female	10,502,805	32,690	8,011	34,781	15,754	27,022	118,258	32,715	7,780
Male :Female	1:1.066						1:1.014	1:036	1:0.997
Total	20,359,439	65,380	15,370	70,362	31,334	52,475	234,912	64,289	15,582

(Source: Census of Population and Housing of Sri Lanka, 2012 (Department of Census and Statistics))

Table 11.2-4 shows population of classified ages of relevant Divisional Secretaries. Population ratio of 20-64 age group (maturity age) in National total is 59 %. Population ratios of 20-64 age group (maturity age) in Hingurakgoda and Palugaswewa DS are 62 %, 61 % respectively. The ratio of five DS total in Trincomalee District is 50 %.

Table 11.2-4 Population of Classified Ages of Relevant Divisional Secretaries

Gender	National Total	In Trincomalee District						In Polonnaruwa District	In Anuradhapura District
		1 Muttur DS	2 Seruvila DS	3 Kinniya DS	4 Tambalagamuwa DS	5 Kantalai DS	1-5 Total In Trincomalee District	6 Hingurakgoda DS	7 Palugaswewa DS
Total Population	20,359,439	65,380	15,361	70,362	31,334	52,475	234,912	64,289	15,582
under 05 age group	1,643,862	5,721	1,551	6,155	3,098	3,546	20,071	5,918	1,260
between 05-14 age group	3,286,804	16,430	4,350	17,676	8,469	9,875	56,800	10,053	2,526
between 15-19 age group	1,644,249	7,521	1,445	8,091	3,724	4,766	25,547	4,551	1,174
between 20-64 age group	11,980,861	33,234	6,152	35,758	15,067	28,405	118,616	39,620	9,550
above 65	1,602,663	3,994	1,238	4,299	2,028	5,883	17,442	4,129	872

(Source: Census of Population and Housing of Sri Lanka, 2012 (Department of Census and Statistics))

Table 11.2-5 shows household size and population density of the three Districts. Average household size of Sri Lanka is 3.8 persons, and household sizes of the three districts are almost same level as Sri Lanka total.

Table 11.2-5 Household Size and Population Density of the Three Districts

Item	National Average	Trincomalee District	Polonnaruwa District	Anuradhapura District
Household Size	3.8	3.5	3.5	3.8
Population Density (Persons/km^2)	323 /km^2 (2012 census)	150 /km^2	131	129

(Source: 2012 census)

Table 11.2-6 shows population by race according to the three Districts. There are diverse races in the project area. In Polonnaruwa and Anuradhapura Districts, maximum ratio is 91 % of Sinhalese. In Trincomalee District, maximum ratio is 41 % of Sri Lanka Moors.

Table 11.2-6 Population by Race according to the Three Districts

Type	National Level		Trincomalee District		Polonnaruwa District		Anuradhapura District	
	Population	Ratio	Population	Ratio	Population	Ratio	Population	Ratio
Sinhalese	15,250,081	74.9 %	101,483	26.7 %	368,197	90.7 %	782,808	91.0 %
Sri Lanka Tamils	2,269,266	11.1 %	116,646	30.7 %	7,301	1.8 %	4,728	0.5 %
Sri Lanka Moors	1,892,638	9.3 %	158,771	41.8 %	30,177	7.4 %	70,692	8.2 %
Indian Tamils	839,504	4.1 %	1,227	0.3 %	161	0.0 %	477	0.1 %
Malay	44,130	0.2 %	356	0.1 %	46	0.0 %	161	0.0 %
Burger	38,293	0.2 %	966	0.3 %	88	0.0 %	246	0.0 %
Other	25,429	0.1 %	92	0.0 %	118	0.0 %	1,463	0.2 %
Total	20,359,439	100.0 %		100.0 %		100.0 %		100.0 %

(Source: Census of Population and Housing 2012 (Provisional information based on 5 % sample))

Table 11.2-7 shows population by religion according to the three Districts. There are diverse religions in the project area. In Polonnaruwa and Anuradhapura Districts maximum ratio is Buddhist, about 90 %. In Trincomalee District is maximum ratio is Islam, about 40 %.

Table 11.2-7 Population by Religion according to the Three Districts

Type	National Level		Trincomalee District		Polonnaruwa District		Anuradhapura District	
	Population	Ratio	Population	Ratio	Population	Ratio	Population	Ratio
Buddhist	14,222,844	70.2 %	98,772	26.1 %	361,920	89.7 %	772,0413	90.2 %
Hindu	2,554,606	12.6 %	98,113	25.9 %	6,835	1.7 %	3,391	0.4 %
Islam	1,967,227	9.7 %	159,251	42.1 %	30,427	7.5 %	71,386	8.3 %
Roman Catholic	1,237,038	6.1 %	14,795	3.9 %	2,956	0.7 %	6,189	0.7 %
Other Christians	272,568	1.3 %	7,097	1.9 %	1,134	0.4 %	3,120	0.3 %
Other	9,440	0.0 %	134	0.0 %	63	0.0 %	105	0.0 %
Total	20,263,723	100.0 %	378,184	100.0 %	403,335	100.0 %	856,232	100.0 %

(Source: Census of Population and Housing 2012 (Provisional information based on 5 % sample))

Table 11.2-8 shows Income and Expenditure according to the three Districts. Average incomes in the three districts are 15- 25 % lower than national average.

Table 11.2-8 Income and Expenditure according to the Three Districts

Unit: Rs (monthly)

Item	Type	National Level	Trincomalee District	Polonnaruwa District	Anuradhapura District
Level of Income (household)	Average	45,878	34,577	39,197	35,460
	Median	30,814	24,436	30,145	29,689
Level of income (per capita)	Average	11,819	7,622	9,877	9,877
	Median	7,881	5,385	7,824	7,824
Level of Expenditure (household)	Average	41,444	31,041	38,257	31,959
	Median	30,701	26,777	30,768	25,578

(Source: Census of Population and Housing 2012 (Provisional information based on 5 % sample))

Table 11.2-9 shows poverty percentage as head count ratio of the three Districts. Average poverty percentage level of Sri Lanka is low. Poverty percentage of the three districts is almost same level as average of Sri Lanka total.

Table 11.2-9 Poverty Percentage as Head Count Ratio of the Three Districts

Item	Unit	National Level	Trincomalee District	Polonnaruwa District	Anuradhapura District
Poverty level as head count ratio	Poverty percentage	6.7 %	9.0 %	6.7 %	7.6 %

(Source: Census of Population and Housing 2012 (Provisional information based on 5 % sample))

3) Other Social Conditions

Table 11.2-10 shows cover ratio of safe drinking water and using toilet of the three Districts. Cover ratios of safe drinking water in the three districts are 12 – 19 % lower than national average level. Ratios of using toilet in the three districts are high (97 - 98 %) and almost same level as national average.

Table 11.2-10 Cover Ratio of Safe Drinking Water and Using Toilet of the Three Districts

Item	National Total	Trincomalee District	Polonnaruwa District	Anuradhapura District
Access to safe drinking water	62.0 %	43.1 %	49.9 %	49.7 %
Using Toilet	98.3 %	97.2 %	96.6 %	97.7 %

(Source: Census of Population and Housing 2012 (Provisional information based on 5 % sample))

Table 11.2-11 shows percentage distribution of households in occupied housing units according to type of lighting by the three Districts. In the three districts where the project locates percentage distribution of households using electricity for lightning is a little smaller than national total level. On the other hand, percentage using Kerosene for lightning is slightly larger than national total level.

Table 11.2-11 Percentage Distribution of Households in Occupied Housing Units according to Type of Lighting by the Three Districts

District	Total Households	Total	Type of lightning					
			Electricity from National grid	Electricity from rural hydro power project	Kerosene	Solar power	Bio gas	Other
National Level	5,251,126	100.0	87.0	0.3	12.0	0.6	0.0	0.1
Trincomalee District	95,529	100.0	75.4	0.0	24.5	0.1	0.0	0.0
Polonnaruwa District	110,575	100.0	82.7	0.0	16.9	0.4	0.0	0.1
Anuradhapura District	231,771	100.0	85.1	0.0	14.4	0.6	0.0	0.0

(Source: Census of Population and Housing 2012 (Provisional information based on 5 % sample))

Table 11.2-12 shows percentage distribution of households in occupied housing units according to the method of solid waste disposal by the three Districts. In the three districts percentage distribution of households those waste are burned by occupants is larger than national level. In Polonnaruwa and Anuradhapura districts percentage distribution of households those waste are collected by local authorities is very small

Table 11.2-12 Percentage Distribution of Households in Occupied Housing Units according to the Method of Solid Waste Disposal by the Three Districts

District	Total Households	Total	Type of lightning					
			Collected by local authorities	Occupants burn	Occupants dispose within premises	Occupants composting solid waste	Occupants dispose solid waste into road, river, canal, sea, creek, forest	Other
National Level	5,251,126	100.0	20.4	46.9	23.5	7.8	0.9	0.5
Trincomalee District	95,529	100.0	32.9	52.4	12.2	1.8	0.6	0.1
Polonnaruwa District	110,575	100.0	3.6	60.4	26.2	9.7	0.1	0.1
Anuradhapura District	231,771	100.0	6.1	64.5	23.5	5.7	0.1	0.1

(Source: Census of Population and Housing 2012 (Provisional information based on 5 % sample))

Table 11.2-13 shows number of HIV/AIDS infection reported cases in three Districts.

Table 11.2-13 Number of HIV/AIDS Infection Reported Cases in Three Districts

Area	National Level	Trincomalee District	Polonnaruwa District	Anuradhapura District
HIV/AIDS Number of Infection Reported cases till 2013 December	2074	22	22	32

(Source: HIV/AIDS Surveillance Data in Sri Lanka-2014 and District Data form the AIDS Control Programme of the Ministry of Health)

4) Location and land use around Angular Points (AP)

Annex 11.2-3 shows location and land use around Angular Points (AP) with comments by the site survey by the Team.

11.2.2.3. Environmental Pollution

1) Air Quality

Table 11.2-14 and 11.2-15 show existing level of air quality measured at the places around the Project area.

Table 11.2-14 Existing Level of Air Quality around the Project Area (1)

Location	PM_{10} (24 hourly, μg/m^3)		CO (1 hourly, μg/m^3)		SO_2 (1 hourly, μg/m^3)		NOx (1 hourly, μg/m^3)	
	Range	Avg.	Range	Avg.	Range	Avg.	Range	Avg.
Sampoor	56-68	62	160-225	195	6-12	9	14-23	18
Muttur Town	65-78	71.5	320-460	398	7-13	9.25	12-24	18

(Source: Environmental Impact Assessment Report for Trincomalee Thermal Power Project, March 2015)

Table 11.2-15 Existing Level of Air Quality around the Project Area (2)

Location	time average	Concentration at each parameter (μg/m^3)				
		SO_2	NO_2	CO	SPM	PM_{10}
Kantale (Close to the Irrigation Department Quarters)	8 hrs	11	17	3200	18	-
	24 hrs	-	-	-	-	9

(Source: Rehabilitation and Upgrading road section from Kanthale to Trincomalee Environmental Assessment Report, March 2015)

Because there is none of large air pollution source, air pollution is not in progress around the Project area.

2) Noise

Table 11.2-16 shows existing level of noise measured at the places around the Project area.

Table 11.2-16 Existing Level of Noise Measured at the Places around the Project Area

Location	Category	Day time, dB(A)			Night time, dB(A)		
		Min	Max	LeqD	Min	Max	LeqN
Muttur town	Low Noise Areas	45.2	65.7	54.3	36.7	50.4	44.2
Sampoor village (1)	Low Noise Areas	40.1	50.3	46.8	40.4	45.3	43.2
Sampoor village (2)	Low Noise Areas	40.2	49.7	45.3	39.6	44.1	32.1

(Source: Environmental Impact Assessment Report for Trincomalee Thermal Power Project, March 2015)

During daytime and night time noise level are found to be well within the prescribed noise control regulations in Sri Lanka.

3) Water Quality

Table 11.2-17 shows existing level of surface water quality Measured at the water bodies around the Project area.

Table 11.2-17 Existing Level of Surface Water Quality measured around the Project Area

Parameters	Drinking Water Standard of Sri Lanka (1983) Maximum Permissible Limits	Water body	
		Koddal Parichch (Rivulet)	Mahaweli Ganga (River)
Total Solid (mg/l)	2000	2600	160
Oil & Grease (mg/l)	1.0	Nil	Nil
COD (mg/l)	10	<4	<4
BOD (mg/l)	-	<2	<2
Total Coliform MPN/100ml	10	Absent	Absent

(Source: Environmental Impact Assessment Report for Trincomalee Thermal Power Project, March 2015)

Level of pollution of turbid matter and organic matter is very low in these water bodies.

Table 11.2-18 shows existing level of chemical characteristics of soil around the Project area.

Table 11.2-18 Existing Level of Chemical Characteristics of Soil around the Project Area

Location Name	pH	Conductivity	Organic Matter	N	P	K	Na
		μmho/cm	%	mg/100g			
Sunkakuli (Agricultural land)	7.99	586	0.91	2.57	123.7	0.8	11.3
Kaddiaparichchan (Scrub forest land)	8.10	316	0.48	3.7	199.6	1.1	3.7

(Source: Environmental Impact Assessment Report for Trincomalee Thermal Power Project, January 2015)

Table 11.2-19 shows Cadmium concentration levels in uncultivated soil around the Project area. The level in uncultivated soil is very low.

Table 11.2-19 Cadmium Concentration Levels in Soil around the Project Area

Place of sampling	Anuradhapura district	Polonnaruwa district
uncultivated soil	0.023±0.014 mg/kg	0.0052±0.0043 mg/kg

(Source: Bandara et al , Chronic renal failure in Sri Lanka caused by elevated dietary cadmium, Toxicology Letters 198 (2010))

11.2.3. Comparison of Alternatives

Three alternatives shown in the Table 11.2-20 were considered at early stage of planning of the Project.

The alternatives were compared from the view point of economic efficiency, engineering, and environmental and social considerations. Evaluation was implemented and the current plan was selected as the project target.

Table 11.2-20 Examination of the Alternatives

Alternatives	Description	Evaluation Item					Evaluation
		Environmental and social impact	Power supply condition	Construction cost	Technical Feasibility	Consistency with other development plan	
Alternative 1 (Zero Option) The planned project (new T/L from Sampoor to Habarana associate with swiching station) for stable power supply is not conducted.	1) Meanwhile, 80 % of power supplied Sampoor coal-fired power plant is planned to be consumed at Colombo and suburb area. 2) If the planned project is not conducted, power generated by the plant cannot be transmitted to its main demand area.	No environmental and social impact occurs.	The power generation from Sampoor coal-fired power cannot transmit to Colombo. And collapse generation plan.	No needs to consider.	No needs to consider.	The Sampoor coal-fired plant project is implementing, therefore it don't have consistency.	Since the situations in the description cause collapse of national plan of power demand and supply, this alternative is impossible to be selected
Alternative 2 （Proposed plan designed finally） Powerline route of a 52 m corridor which takes environmental as well as socio-economic considerations into account.	1) The route of the powerline avoided sensitive areas in terms of ecology and avoided resettlement of any communities affected. 2) The powerline was carefully routed to avoid routing over any buildings etc. The route avoided the Hurulu UNESCO Man and Biosphere Forest Conservation Area, by routing through the Gal Oya Forest Reserve. 3) At Kithulutuwa, in order to avoid routing through the Somawathiya National Park the powerline was routed through the Anaolondewa Conservation Forest Reserve. 4) At Morakanda, in order to avoid social concerns, the line was routed across a mountain via the top of the mountain using high tension wires. 5) The power line avoided being routed over any affected community member's houses or any buildings and was routed during the last phase of the transmission line over large tracts of paddy fields instead.	1) Environmental and social impacts are quite limited. 2) No land acquisition and involuntary resettlement occur.	A higher amount of power can be transmitted. Additionally, there will be lower energy losses during transmission.	Construction cost will increase as route length increasing. (400 kV T/L construction cost: 90.5 Mil. JPY/ km)	Construction of powerline is technically feasible without difficulty.	It has consistency with other projects.	This alternative was chosen as the top priority option.
Alternative 3 Construction of two 220	1) The first power line followed the same route as alternative 2, however, the	1) Environmental and social impacts	Once plans of adding an extra 600MW in	Constructing two transmission lines	There is slightly difference from 400	It has consistency with other projects.	This alternative was not chosen because

kV powerlines instead of one 400 kV power line	second powerline will have to be routed either adjacent to the first 220 kV powerline or follow yet another route. 2) Either way two corridors, each of 35m width will have to be created. Creating two corridors will mean a higher disturbance to the ecology, and increased number of houses/ home gardens and possible resettlement of communities affected.	are larger than alternative 2. 2) Some numbers of involuntary resettlement occur. 3) Number of trees to be removed are larger than alternative 2.	2019 is completed, the 220 kV transmission line will be insufficient to transmit the extra power that will be generated.	will be more costly than constructing one 400 kV transmission line. (400 kV T/L construction cost: 90.5 Mil. JPY/ km, 220 kV T/L construction cost: 46.3 Mil. JPY/ km)	kV construction but it will not be obstacle to construct.		some numbers of involuntary resettlement occur.

(Source: Prepared by the Team using IEE report by CEB)

11.2.4. Scoping

40 items of Environmental and social impact were set, according mainly to the items listed in JICA Guidelines for Environmental and Social Considerations (April 2010). The expected impacts were evaluated and summarized as scoping.

Table 11.2-21 shows the results of scoping with the reason of assessment.

Table 11.2-21 Results of Scoping

Environmental Item		Rating: Pre-Construction Stage/ Construction Stage	Rating: Operation Stage	Scoping (Identified impacts and reasons)
Social Environment				
1	Land acquisition and Involuntary Resettlement	D		**Pre-Construction:** Both land acquisition and involuntary resettlement are unnecessary for development of the Project
			D	**Operation:** Operation works which cause land acquisition and resettlement are not expected.
2	Poor people	D		**Pre-Construction:** There are some poor people around the planned area. However there is no possibility that the Project affects directly on these poor people.
			D	**Operation:** Operation activities which impact negatively on poor people are not expected.
3	Indigenous people or ethnic minority	D	D	**Construction/Operation:** There is none of indigenous people around the project site. There are some ethnic minority around the planned area. However, there is no possibility that the Project affects directly on these people.
4	Local economy such as employment and livelihood, etc.	B+		**Construction:** Beneficial impact may be created employment opportunity for local people for construction works, even temporary.
			C+	**Operation:** Livelihood can lead to be diverse due to a stable power supply.
5	Utilization of land and local resources	B-		**Pre-Construction:** -Land use restriction of area used for the construction of tower footings and access road is expected, while the total affected area will be small. -Tall trees and trees within specific height which might cause damage to the conductor or towers have to be removed. **Construction:** Construction materials (stone, gravel, sand and soil) using for construction are expected to be obtained from the licensed quarries /borrow pits where environmentally controlled.
			D	**Operation:** Specific adverse impact is not expected.
6	Water usage	C-	C-	**Construction/Operation:** The selected route does not traverse above any of the irrigation tanks directly. However, the route crossing some rivers, streams and irrigation canals was unavoidable.
7	Existing social infrastructures and services	B-		**Construction:** -The traffic block is expected due to the traffic increase by transportation for construction. As the results reduction of accessibility to public facilities is possible to occur. -Since there is a possibility that facilities and lines of social infrastructure (telecommunications, water and sewerage, gas, etc.) exist on the ground or underground of the planned area. Confirmation is necessary with the relating agency.
			B+	**Operation:** The stable power supply can lead to improve the social services such as educational and health/medical facilities in wide service area.
8	Social institutions such a social infrastructure and local decision -	D	D	**Construction/Operation:** As the Project consists of a construction of new transmission line, and there would be little impact on social institutions and on decision-making institutions in the regional

Environmental Item		Rating: Pre-Construction Stage/ Construction Stage	Rating: Operation Stage	Scoping (Identified impacts and reasons)
	making institutions			areas.
9	Misdistribution of benefit and damage	B-	B-	**Construction/Operation:** It is expected that there is almost no possibility of misdistribution of benefit and damage through the execution of the Project. However, with regard to the impact by, for example, operation of transportation vehicles and heavy machineries during construction, or tentative use of paddy field by the Project, if the explanation to the residents is insufficient, distribution of benefit and damage is possible to occur.
10	Local conflict of interests	D	D	**Construction/Operation:** The Project is a construction of new transmission line, and itself not to cause a conflict of interest in the region.
11	Cultural, historical, archaeological and religious heritage site	D	D	**Construction/Operation:** There is no cultural, historical, archaeological and religious heritage site in and around the Project area. There are many small religious sites such as village temples, Hindu temples and mosques in the project area but these will not be affected by the project activities. There are no culturally or religiously sensitive areas in and around the project area. According to the survey carried out in the area by CEB there are no important historical and archeological sites within the project area.
12	Water rights, fishing rights and rights of common	C	C	**Construction/Operation:** -Water rights and fishing rights are seemed to be set in the river around the Project area. However it should be confirmed by hearing in the baseline survey. -No rights of common are seemed to be established in the peripheral forest around the Project site. However it should be confirmed by hearing in the baseline survey.
13	Landscape	C-	C-	**Construction/Operation:** Construction of new transmission line may affect some adverse impact on landscape, because power lines and towers have quite artificial image in landscape and are difficult to harmonize with natural landscape, such as forest or grassland. However, there is no particularly important existing landscape point with scenic, historical, cultural and recreational value along the project area. At some hilly places where transmission tower foundation supports are placed, aesthetics impact is expected to occur on the land surface.
14	Gender	D	D	**Construction/Operation:** Specific adverse impact is not expected.
15	Right of Children	D	D	**Construction/Operation:** No specific adverse impact on children's rights is expected with this Project.
16	Public health and Sanitation	C-		**Construction:** There may be temporary effects on health and sanitation of the residents around the labour camps and the worksites because of the influx of construction workers from outside.
			D	**Operation:** Specific adverse impact is not expected.
17	Infectious diseases such as HIV/AIDS	B-		**Construction:** Temporal influx of migrant construction workers and truck drivers are considered as having potential for the spread of infectious diseases such as HIV/AIDS by contacting with local women.
			D	**Operation:** Specific adverse impact is not expected.
18	Working condition (including occupational health)	B-		**Construction:** There is a possibility that the occupational safety and health of the workers may be jeopardized. In construction activities of this work includes many hazardous tasks and conditions such as work at height, excavations, noise, dust, power tools and equipment, confined spaces and

	Environmental Item	Rating		Scoping (Identified impacts and reasons)
		Pre-Construction Stage/ Construction Stage	Operation Stage	
				high tension power supply.
			D	**Operation:** Specific adverse impact is not expected.
19	Traffic accidents	B-		**Construction:** There is a possibility of accidents due to increase of traffic volume due to transportation vehicles for the project.
			D	**Operation:** Specific adverse impact is not expected.
20	Disaster	C-	C-	**Construction/Operation:** The project area is located to the interior of the coastal zone, more than 5 km away from Trincomalee Bay which is subject to frequent storms and cyclones. Hence, there are lesser possibilities of natural disasters due to storms and cyclones occurring within the project area. Impact of flooding on the project area is also non-significant. The whole project area falls within flat undulating terrain where there is no possibility for occurrence of any kind of landslide.
21	Global warming/ climate change	D		**Construction:** Generation of greenhouse gases is expected due to construction vehicles and heavy machineries. However, extent of impact on climate change is expected to be negligibly small.
			C+	**Operation:** -In the Project, by reduction of power loss in transmission network, suppression of greenhouse gas emission due to the transmission loss can be expected. Accordingly, for the Project it can be expected that greenhouse gas emission is reduced. However, the effect is quite slight.
22	Safety from Electromagnetic field	D		**Construction:** Specific adverse impact is not expected.
			C	**Operation:** There is a possibility that electromagnetic field may affect to human health. The conductor height will be controlled to maintain the electric field strength at much lower values below the level so that present households, villages, built-up areas and any future development will not be affected by the electric field.
23	Electromagnetic interference	C-	C-	**Construction/Operation:** There is a possibility of reception failure of radio/broadcasting by the pulse noise generated from power transmission line or by radio waves scattering/diffuse reflection by related structures (towers, etc.).
Natural Environment				
24	Protected Area	B-		**Pre-Construction /Construction:** There is no National Park, Nature Reserve, Strict Natural Reserve, National Heritage and Wilderness Area in the corridors of transmission line. However, there is a possibility that the transmission line will pass by the edge of few Forest Reserves and Conservation Forest reserve.
			D	**Operation:** Specific adverse impact is not expected.
25	Terrestrital Flora	C-		**Pre-Construction/Construction:** During a field survey by CEB, following three plant species listed in IUCN Red List 2012 criteria were observed in study area (not same as affected area). -Diospyros ebenum (Sinhara name: Kaluwara, common name: Ceylon ebony), an endangered species (EN) -Haldina cordifolia (Sinhara name: Kolon) and Mitragyna parvifolia (Sinhara name: Helamba) , vulnerable species (VU)
			D	**Operation:** Specific adverse impact is not expected.
26	Trees, Forest	B-		**Pre-Construction/Construction:** -To provide ground clearance and in the process of clearing routes, tall trees or trees with specific

Environmental Item		Rating: Pre-Construction Stage/ Construction Stage	Rating: Operation Stage	Scoping (Identified impacts and reasons)
				conditions will be removed in order to ensure the safety of the public and to avoid any damage to the transmission line. -Not less number of trees may have to be removed and a certain amount of deforestation will take place.
			D	**Operation:** Specific adverse impact is not expected.
27	Terrestrital Fauna	B-	B-	**Construction/Operation:** -There is a possibility which impact on fly of bird. -There is a possibility which impact on crossing of elephants during the construction and by the existence of transmission line equipment.
28	Aquatic Fauna and Flora	D	D	**Construction/Operation:** Large waterbodies are directly not encountered within the study area except for the Kantale Tank. Therefore, impacts on aquatic fauna are insignificant.
29	Hydrological situation	D		**Construction:** Activities for the project will not change the hydrological pattern of the area. Specific adverse impact is not expected. No tower foundations will be placed within river beds or too closer to river banks. In addition, regulations pertaining to the river reservations would be strictly adhered to. No water drainage paths or irrigation canals will be obstructed with tower foundations and any damage caused by temporary structures or access routes will be rectified to initial state.
			D	**Operation:** Specific adverse impact is not expected.
30	Topography and Geology	D		**Construction:** There is no possibility that civil works, such as cutting and filling will cause slope failures or landslides. In the past, landslides or earth slips have never been reported within the Project area and the area is stable at present.
			D	**Operation:** Specific adverse impact is not expected.
31	Soil erosion / Destabilization of soil	C-		**Construction:** Since the scale of land cutting and filling works is small and sites which are prone to the soil erosion are avoided, risk of the erosion or destabilization of soil is little. However, excavating deeper, there is a possibility that collapse of side is caused.
			D	**Operation:** Specific adverse impact is not expected.
32	Groundwater	C-		**Construction:** (Quantity of groundwater) It is not planned to use groundwater for construction. (Quality of groundwater) There is a possibility that contamination of groundwater occur from the vehicle maintenance area by accidental spillage of oil. Spills of oil, grease, fuel and other toxic materials used on-site may pollute groundwater.
			D	**Operation:** Specific adverse impact is not expected.
Environmental Pollution				
33	Air pollution	B-		**Construction:** Impact on air quality is expected by emission of dust and pollutants due to operation of construction vehicles and heavy machineries. However, since the work is temporary and the scale is small, the impact is limited to only within the surrounding area.
			D	**Operation:** Specific adverse impact is not expected.
34	Water pollution	C-		**Construction:** -The turbid water may occur due to soil runoff from the embankments and cut slopes, or for construction temporary roads.

Environmental Item		Rating: Pre-Construction Stage/ Construction Stage	Rating: Operation Stage	Scoping (Identified impacts and reasons)
				-There is a possibility of water pollution by waste water from construction site, construction vehicles or heavy machineries.
			C-	**Operation:** There is a slight possibility of water pollution by contamination of insulating oil for transformer.
35	Soil contamination	C-		**Construction:** There is a possibility of soil contamination caused by pollutants or oils included in solid waste from construction site, heavy machineries, transportation vehicles and worker's camp.
			D	**Operation:** Specific adverse impact is not expected.
36	Bottom sediment	D		**Construction:** Sedimentation and accumulation of water pollutants generated in construction work are not expected.
			D	**Operation:** No adverse impact is expected.
37	Waste	B-		**Construction:** Construction wastes, such as residual substances (metallic and non-metallic) and construction debris (soil, sand, etc.) are generated from the construction sites. Generation of hazardous waste is not expected. Daily general waste from the activities and living of the workers is generated.
			D	**Operation:** Specific adverse impact is not expected.
38	Noise and Vibration	B-		**Construction:** Noise are generated from transportation vehicles and construction machineries, however the level, scope and duration of generation is limited. Vibration may be generated by construction activities at each tower along the transmission line for a short duration. However, because there will be no blasting operation near residences and buildings, and drilling works will be restricted within small and shallow ground area, vibration impact for living environment is expected to be very small(Rating: D).
			D	**Operation:** No adverse impact is expected.
39	Land Subsidence	D	D	**Construction/Operation:** Since use of groundwater in a large quantity is not expected in the Project, there is no possibility of land subsidence.
40	Offensive Odor	D		**Construction:** There is a possibility of generation of offensive odor in construction stage if control of emission control of construction vehicles and heavy machineries is poor. However, the possibility is negligible small.
			D	**Operation:** Specific adverse impact is not expected.

11.2.5. TOR of Surveys on Environmental and Social Considerations

For the items selected from the results of scoping, details and methods were set as the TOR (Terms of Reference).

Table 11.2-22 shows the TOR of surveys on environmental and social considerations.

Table 11.2-22 TOR of Surveys on Environmental and Social Considerations

Environmental Item		Survey Item	Details and Methods of the Survey
Social Environment			
(1)	Indigenous people or ethnic minority	Situation of residence indigenous people or ethnic minority in and around the Project site	-Literature survey -Site observation
(2)	Utilization of land and local resources	1) Current land use in the Project area 2) Project affected area of paddy field and affected condition	1), 2) -Literature survey (IEE report by CEB, etc.) -Hearing from CEB -Site observation
(3)	Water usage	Present water usage in the Project site	-Literature survey -Site observation
(4)	Existing social infrastructure and services	Situation of infrastructure and social service facility, etc.) in and around the Project site.	-Literature survey -Hearing from CEB -Site observation
(5)	Misdistribution of benefits and damages	Expected damages and benefits.	Confirmation of the benefits to the region expected in the Project plan and negative impacts to the region expected in environmental impact examination
(6)	Water rights, fishing rights and rights of common	1) Conditions of setting of water rights, fishing rights of the rivers in the Project sites 2) Present water usage in the Project site	1) Literature survey 2) - Literature survey -Site observation
(7)	Landscape	Landscape evaluation with the surrounding landscape elements and design of the transmission line.	-Confirmation of existence of scenic area near the Project site.
(8)	Public health and sanitation	Conditions of medical care, health and sanitation facilities around the Project sites.	-Literature survey -Site observation
(9)	Infectious diseases such as HIV/AIDS	HIV/AIDS prevalence around the project area	Literature survey
(10)	Working condition (including occupational health)	1) Laws and regulations concerning working conditions/work safety 2) Measures for work safety	1) Literature survey 2) - Survey for existing cases - Confirmation measures for work safety in the Project planning
(10)	Traffic accidents	1) Current state of traffic accident in and around the Project sites. 2) Distance from construction sites to residential area and commercial area	1) -Literature survey 2) -Literature survey -Site observation
(11)	Disaster	State of occurrences of disasters (landslides, collapse of slopes, etc.) around the Project sites	Literature survey
(12)	Safety from Electromagnetic field	Human influence by electromagnetic field and safety criteria/standard	Literature survey (IEE report by CEB, etc.) - Hearing from CEB
(13)	Electromagnetic interference	Possibility of occurrence of electromagnetic interference	Literature survey
Natural Environment			
(14)	Protected Area	Existence of protected area within the Project area	-Literature survey (IEE report by CEB, etc.) -Hearing from CEB -Utilizing protected area map -Site observation
(15)	Terrestrial Flora	Current state of terrestrial flora in and around the Project site	-Literature survey (IEE report by CEB, etc.) -Site observation
(16)	Trees, Forest	1) Number and species of trees in and around the planned transmission line corridor 2) Number of trees to be cut/removed 3) Necessary procedure for cutting/removal of trees	1),2) 3) -Literature survey (IEE report by CEB, etc.) -Hearing from CEB
(17)	Terrestrial Fauna,	Current state of terrestrial fauna in and around the Project site	-Literature survey (IEE report by CEB, etc.) -Hearing from CEB -Site observation
(18)	Soil erosion / Destabilization of soil	Condition of topography, geology and soil in the planned area.	-Literature survey
(19)	Groundwater	1) Present ground water usage in the Project	1) -Literature survey

Environmental Item		Survey Item	Details and Methods of the Survey
		site 2) Impact on groundwater by construction activities	-Site observation 2) Confirmation of the construction activities relating to groundwater
Environmental Pollution			
(20)	Air pollution	1) Air quality standards in Sri Lanka 2) Current status of air quality of in the project area.	1) Literature survey 2) Literature survey
(21)	Water pollution	1) Water quality standards in Sri Lanka 2) Current status of water quality of rivers and water bodies in the project area. 3) Present water usage in the project site.	1) Literature survey 2) Literature survey 3) -Literature survey -Site observation
(22)	Soil contamination	1) Prevention measure of oil leakage during construction 2) Possibility of discharging of contaminant to soil during construction work	1)Literature survey 2) Confirmation of soil contamination source and process during construction work.
(23)	Waste	1) Current situation and regulation of treatment and disposal of construction waste and general waste in the region 2) Methods of treatment/ disposal of construction waste and general waste in the construction plan	1) Literature survey 2) Confirmation of method of treatment and disposal of waste in the construction plan
(24)	Noise and vibration	1) Noise and vibration standards in Sri Lanka 2) Current state of noise around the Project area 3) Locations of public service and residential area 4) Confirmation of source of noise and vibration in construction	1) Literature survey 2) Literature survey 3) -Literature survey -Site observation 4) Confirmation of the construction plan

(Source : Prepared by the Team)

11.2.6. Review of IEE Report

Review of IEE Report by CEB is as follows.

11.2.6.1. Impact on Physical Environment

Except for hilly areas, other areas do not have erosion issues due to the flat terrain and due to adequate ground cover. In hilly areas (which is only approximately 2 % of the Project area) where more than 80 % of the ground cover exists as forest cover. Erosion will not be a major issue either.

There will be minor soil erosion issues at a few transmission tower sites located in hill slopes, and excess soil after refilling of foundation could be disposed at a disposal site which is designated by the local authority to minimize soil erosion.

In addition, measures such as laying grass turf or preparation of retaining walls etc. can be used to avoid further erosion of these areas, if any.

Further, no prominent hazardous areas or unstable areas were observed in and around the locations of civil engineering structures of this project.

11.2.6.2. Impact on Protected Areas

There are no important natural areas, such as strict natural reserves, national parks and nature reserves, in the route alignment of the proposed transmission line.

However, the line route does run through a few Forest Reserves but for as minimum a length as possible. The transmission line crosses small portions of reserves namely Gal Oya, Chundankadu and Kanthalai Forest Reserves. The transportation line also crosses small portions of Anaolendewa Conservation Forest Reserve. These clearances have been given with an agreement with the FD and CEB

There are no important archaeological, historical, cultural and biological sites, such as World Heritage sites along the route alignment.

11.2.6.3. Impact on Terrestrial Flora

During a field survey (July, 2014) by CEB, 7 species of endemic plants were recorded. However since they are found regenerating naturally in nearby the Project areas, it is not affected by the Project activities.

During a field survey (July, 2014) by CEB, following species listed in IUCN Red List 2012 criteria were observed.

(i) Endangered Species (EN),

- *Diospyros ebenum* (Sinhara name: Kaluwara, common name: Ceylon ebony)

(ii) Vulnerable Species (VU)

- *Haldina cordifolia* (Sinhara name: Kolon)
- *Mitragyna parvifolia* (Sinhara name: Helamba)

They are common species found in seasonally water logged low-lying areas or near waterways.

Since trees of above EN and VU species exist commonly or are regenerating naturally in and nearby the Project areas, if some of the trees may have to be removed in the process of clearing routes, such activities in the area will not affect the species survival significantly.

Additionally trees of these three species will be transplanted and included in the reforestation program conducted by FD.

11.2.6.4. Impact on Terrestrial Fauna

There is a possibility of impact on crossing of elephants during the construction by the existence of transmission line equipment.

Necessary considerations for the impacts and adequate mitigation measures were considered by CEB. Mitigation measures for the impact on elephants are as follows.

- ✓ Construction should avoid rainy season and complete within a shorter duration. Construction is limited to daytime in forest area, and completed within a shorter duration.
- ✓ A minimum of 13m of clearance is kept between the transmission line and the ground where there are elephant crossings to ensure safety of the elephants. The foundations of towers are sufficiently strong and solid such that even of elephants weight in on the transmission towers, no damage is anticipated either to the tower or to the elephants themselves.
- ✓ Proper fencing should be used to secure excavated foundation areas during construction. The fencing may have to consider using suitably strong fencing to fend off elephants during construction at all construction sites which are known elephant habitat.

The foundations of towers are sufficiently strong and solid such that even if elephants weight in on the transmission towers, no damage is anticipated either to the tower or to the elephants themselves.

Nearly 142 faunal species were recorded from the project sites during the survey by CEB. Among the species observed, 9 are endemic to Sri Lanka. However, none of these species were restricted only in the study area.

No bird migratory routes and important bird habitats were recognized during the ecological study.

11.2.6.5. Impact on Trees and Forest

To provide ground clearance, tall trees or trees that eventually grow high, within a band of 26m on either side of the line (52 m band), will be removed in order to ensure the safety of the public and any fauna, by avoidance of any damage to the transmission line.

Allowable tree heights is 5.5 m from the conductor for all conditions i.e. where the conductor is at steady state, the conductor is swinging due to wind, tree at a steady state If the tree is swinging due to the wind, this minimum distance should be maintained.

Since there is an impact due to construction activities on-site where a certain amount of deforestation will take place, a reforestation program will be planned and conducted by FD using suitable indigenous species (taking into consideration habitat types) with financial assistance from the CEB.

11.2.6.6. Impact on Land Use

Most of the sections of the proposed transmission line lie across paddy lands and secondary forest areas. Houses, crops and high value trees will be avoided wherever possible, therefore land use changes are insignificant due to the construction of the transmission line and access roads.

Restriction of cultivating works for lands (mainly in paddy field) used for construction of towers during construction phase. Compensation for loss of income that the land owner may suffer shall be paid.

During initial creation of temporal access roads to sites, unnecessary damage to fences in paddy fields, paths to paddy fields and any other structures which belong to farmers will be avoided as much as possible.

In those few situations where farmers’ fences in paddy fields, paths to paddy fields and any other structures do get damaged, CEB shall recover to their original condition. If necessary, compensation shall be paid to those farmers who are affected.

11.2.6.7. Impact on Water Use

During route selection, a maximum effort has been taken to avoid freshwater bodies. As a result, the selected route does not traverse above any of the irrigation tanks directly.

During route selection, care has been exercised to avoid traversing any river/ stream/ canal more than once. The towers are located far away from any river/ stream/ canal banks except at a few places.

During the profile survey of the transmission line, CEB will ensure that no tower foundations will be placed within river beds, and no tower is too closer to river banks.

11.2.6.8. Land Acquisition and Involuntary Resettlement

The transmission line route has been carefully chosen by making the necessary deviations in order to avoid any adverse socio-economic impacts. It is expected that no land acquisition and no involuntary resettlement occur.

However, because of following potential impact, it is necessary to pay compensation by CEB to Project Affected Households (PAHs)

(i) Cutting/ removal of trees in home garden for Wayleave clearance..

(ii) Restriction of paddy land farming for the areas used by construction tower foundations and temporal access roads. Almost all paddy land used for construction of tower foundations can be cultivated again after the construction activities.

Income loss during temporal restriction of paddy land farming during construction shall be compensated. Affected paddy land area is estimated $900m^2$ /tower including construction work space and temporal access road.

(iii) Restriction of paddy land farming for the small areas (estimated $8m^2$ /tower) used by four tower footings.

The used area is very small itself and relatively very smaller than the total area which possessed by land owner. In such cases, for the benefit of each other it is common in Sri Lanka to pay compensation as the land use fee without land acquisition.

Accordingly, income loss during long term restriction of paddy land farming shall be compensated as the land use fee.

11.2.6.9. Environmental Pollution

During construction, vehicles and equipment can cause air and noise pollution. Following mitigation measures shall be taken.

- ✓ Maintain vehicles and equipment according to manufacturers' schedules and standards.
- ✓ Use noise reduction devices on vehicles and machinery near residential areas.
- ✓ Avoid work at night and weekends in populated areas.
- ✓ Select construction techniques and machinery seeking to minimize ground disturbance.
- ✓ Control speed of vehicles.

Installation of shoring may cause noise and vibration. It is better to use a non-vibrating hammer if the area is residential. Blasting activity will cause excessive noise and vibration in inhabited areas. Blasting will be required only if the foundations are on rock, which could not be excavated using conventional methods; the possibility of which is very less (Comment by the Team: It is expected that there is no blasting work near the residence and buildings).

Construction equipment must be well maintained. Spills of oil, grease and fuel used on-site can pollute surface and ground water (Comment by the Team: pollution of ground water by these pollution sources is expected rarely to occur).

It is necessary that location of worker's camp and construction sites near waterbodies shall be avoided as much as possible.

11.2.6.10. Other Environmental Impacts

There are other impacts which are rather limited in affected scale and period. These impacts can be minimized by adopting the adequate mitigation measures propose by CEB.

11.2.6.11. Environmental Monitoring

CEB prepared monitoring program. An Environmental Management Office (EMO) will be established by the CEB. The overall responsibility of implementation of the monitoring program will be entrusted to the EMO. It will instruct the contractor(s) so that they will follow monitoring program and the stipulated mitigation plan. The EMO will be staffed with specialists to cover all important fields such as ecology and socioeconomics.

Other than implementation of the monitoring program by EMO, following detailed monitoring mechanisms were proposed in the IEE report.

- ✓ Monitoring Committee (MC) similar as the present Project Scoping Committee level during the Project period
- ✓ Divisional Monitoring Committees (DMC) of Divisional Secretary level based within the individual Divisional Secretariat

11.2.6.12. Public Consultation and Information Disclosure

Contents of the project and the potential impacts have been adequately explained to the local stakeholders in the stakeholders meeting and small public meeting.

11.2.6.13. Conclusion and Recommendation

The designing of the transmission line was carefully selected by considering various options to minimize the environmental and social impacts. CEB has extensively elaborated negative impacts to the environment and social issues. These issues would be suitably managed by the mitigation measures shown in the IEE report.

CEB prepared adequate monitoring program to confirm the implementation of mitigation measures. However, since proposed monitoring mechanisms are rather complicated, the Team recommends these mechanisms should be considered more to shape up.

Contents of the project, the potential impacts and mitigation measures have been adequately explained to the local stakeholders and they understood well.

CEB submitted IEE report to PAA (Project Approving Agency, Ministry of Power and Energy) in November 2014. PAA approved IEE report and issued an official approval on 10th December 2014.

The IEE report has conditions that meet the requirements of JICA Guidelines.

11.2.7. Results of the Environmental and Social Survey

Environmental and social survey according to the TOR is conducted by review of IEE report and survey which supplement the review of IEE report.

Survey results, except for the portion described previously in “11.2.6. Review of IEE Report”, are shown below.

1) Utilization of Land and Local Resources

Impact on utilization of land and local resources is same as described in “11.2.6.6. Impact on Land Use”.

2) Water Usage

Waterways in the area will not be affected in any way due to project activities. The towers are located far away from any river/ stream/ canal banks except at a few places.

The degree of impact to water usage will remain at minimum, although a certain amount of surface water will be used for the construction.

3) Existing Social Infrastructure and Services

Temporary congestion of traffic or speed limit for traffic security may occur. Therefore, there is a possibility of occurrence of some inconvenience, such as reduction of accessibility to public facilities

4) Misdistribution of Benefits and Damages

With regard to the aim and expected environmental impacts of the Project, CEB have been explained to inhabitants on a stakeholders meeting and other small meetings on which affected persons or representatives of communities participated.

5) Water Rights, Fishing Rights and Rights of Common

There are local notions of rights to water for different tanks and for individual users within the tank command areas, which have been used to argue for customary rights to water.

No fishing rights are set on surface water.

6) Landscape

There is no particularly important existing landscape resource or view point in and around the Project area.

7) Public Health and Sanitation

Labor camps with adequate sanitation, waste disposal, water supply and health facilities will be provided according to labour laws.

Hygienically sound sanitation facilities are to be set up in and around labour camps, which should not cause ground or surface water pollution.

8) Infectious Diseases such as HIV/AIDS

Since there are people infected with HIV to some extent in relevant three districts, it is important to prevent the spread of HIV/AIDS.

9) Traffic Accidents

It is expected that traffic accidents on the key roads in and around the Project area sometimes occur at present. It is important to prevent traffic accident by transportation vehicles for the Project.

10) Disaster

A part of the proposed transmission line pass through the flood plains of Mahaweli River and associated network of smaller rivers/streams Flooding in the project area may be due to the flooding of rivers (mainly Mahaweli River), inundation of low lying areas at times of heavy rainfall or overflow of storm water drains. Consideration for period and season of construction is necessary.

11) Safety from Electromagnetic Field

In populated areas height of 15 m from ground to the sag point of the line is kept. With this height of the line, strength of the electromagnetic field in ground level and upper floor level will be under the public electromagnetic exposure limit of the International Commission for Non-Ionizing Radiation Protection (ICNIRP).

12) Electromagnetic Interference

Since there isn’t a single house underneath the 20 m width corridor of the transmission line and towers are installed far from living places, there is almost no possibility that any electromagnetic interference occurs.

13) Public Health and Sanitation

Increased risk of accidents associated with the construction work is expected within the site if no safety management is applied.

All acts and regulations of the GOSL will be followed. The contractor should comply with all precautions as required to ensure the safety of workmen as per the International Labour Organization (ILO).

14) Protected Areas

Protected Areas were presented on the map of transmission line corridor.

15) Terrestrial Flora

Impacts on terrestrial flora are same as described in “11.2.6.3. Impact on Terrestrial Flora”.

16) Trees and Forest

Impacts on trees, forest are same as described in “11.2.6.5. Impact on Trees and Forest”.

17) Terrestrial Fauna,

Impacts on terrestrial fauna are same as described in “11.2.6.4. Impact on Terrestrial Fauna”.

18) Soil Erosion/ Destabilization of Soil

There is a possibility that earthmoving activities cause soil runoff from a few transmission tower sites located in hill slopes. When earthmoving activities are done, clearing vegetation will be minimized and earth bunds will be built beside drainage channels to avoid overspill. Excess soil after refilling of foundation could be disposed at a disposal site which is designated by the local authority to minimize soil erosion.

In addition, measures such as laying grass turf, preparation of retaining walls etc., can be used to avoid further erosion of these areas, if any.

19) Air Pollution

Air pollution is expected by emission of dust and some pollutants from transportation vehicles.

There is also a possibility that air pollution is expected by emission of some pollutants from and heavy machineries. However, since the work is temporary and the scale the work is small, the impact is limited to proximity of construction area.

20) Water Pollution

The turbid water may occur due to soil runoff from the drilling works and cut slopes. However, by holding drainage water in sedimentation ponds to reduce the sediment content and by use of silt traps etc. prior to discharge to waterbodies, possibility of water quality degradation in downstream basin is very small.

Spills of oil, grease, fuel used on-site is expected to pollute surface water, though the pollution level may be very low.

21) Soil Contamination

All solid waste from construction activities will be collected and properly managed, in order to prevent contamination of soil and groundwater. All solid waste will be disposed in a waste disposal site designated by the local authority of the area.

All solid waste from construction activities will be collected and properly managed, in order to prevent contamination of soil and groundwater.

Construction waste and waste from worker's camp shall be collected, segregated, properly reused and recycled according to regulations and rules of local government. Then all remained waste will be disposed to disposal site designated by local authority, without causing visual or leachate pollution or hazards to other users.

22) Noise and Vibration

Generation of noise and from transportation vehicles and heavy machineries is expected. However the level, scope and duration of generation are limited.

Vibration may be generated mainly by construction activities at each tower along the transmission line for a short duration. Because there will be no basting operation near residences and buildings, and drilling works will be restricted within small and shallow ground area. There is a slight possibility of using rock blasting only in the place far from the residences and buildings.

Accordingly, vibration impacts on living environment by main vibration sources during construction are expected to be negligible.

11.2.8. Environmental Impact Assessment

Based on the results of the surveys on environmental and social considerations and scoping, for items with a rating of B-, C-, or C during the pre-construction/construction or operation stage, the environmental impacts of the project are assessed.

Table 11.2-23 shows the results of the assessment with the reason of assessment.

Table 11.2-23 Results of Environmental Impact Assessment

Environmental Item		Assumed Rating of Impacts in the Scoping		Assessment Rating of Impacts based on the Results of the Survey		Reason of Assessment (Identified Impacts and Reasons)
		Pre-Construction Stage/ Construction Stage	Operation Stage	Pre-Construction Stage/ Construction Stage	Operation Stage	
Social Environment						
1	Utilization of land and local resources	B-	D	B-	D	**Pre-Construction:** -Cultivation is restricted on some part of paddy field due to the construction of tower footings and temporal access roads, while the total affected area will be small. For the income loss by restriction of paddy farming, compensation shall be paid by CEB -Tall trees or trees that eventually grow high in home gardens, within a band of 26m on either side of the line (52m band), will be removed. Compensation shall be paid by the CEB to the respective home garden landowners.
2	Water usage	C-	C-	D	D	**Construction:** Waterways in the area will not be affected in any way due to project activities. The towers are located far away from any river/ stream/ canal banks. The degree of impact to water usage will remain at minimum, although a certain amount of surface water will be used.
3	Existing social infrastructures and services	B-	B+	B-	B+	**Construction** -Due to transportation of construction material/ equipment and construction waste, temporal traffic congestion or speed limit may occur. Therefore, there is a possibility of occurrence of some inconvenience, such as reduction of accessibility to public facilities. -Transmission line route was designed to avoid existing utilities wherever possible. -If any utilities must be moved, preparation of relocation plans must be prepared with service providers. -Usually 4 m width temporary access roads will be constructed carefully minimizing the disruptions to paddy farming operations. These temporal access roads will be completely removed after the construction.
4	Misdistribution of benefit and damage	B-	B-	D	D	**Construction/Operation:** -The project itself would not cause any unfair misdistribution of benefit and damage to the peripheral areas. - With regard to the aim and expected environmental impacts of the Project CEB been to inhabitants on a stakeholders meeting and other small meetings on which affected persons or representatives of communities participated. -Consideration on employment priority should be given to local residents for simple construction work. -Through these activities misunderstanding for misdistribution of benefit and damage has been resolved.
5	Water rights, fishing rights and rights of common	C	C	D	D	**Construction/Operation:** -In Sri Lanka legal ownership of all surface water is government. However, as in most places with centuries of experience with irrigation, there are local notions of rights to water for different tanks and for individual users within the tank command areas, which have been used to argue for customary rights to water. - No fishing rights are set on surface water. Some irrigated farming household may use water for fishing.
6	Landscape	C-	C-	D	D	**Construction/Operation:**

Environmental Item		Assumed Rating of Impacts in the Scoping		Assessment Rating of Impacts based on the Results of the Survey		Reason of Assessment (Identified Impacts and Reasons)
		Pre-Construction Stage/ Construction Stage	Operation Stage	Pre-Construction Stage/ Construction Stage	Operation Stage	
						-There is no particularly important existing landscape resource or view point in and around the Project area. -At some hilly places where transmission tower foundation supports are placed, surrounding trees and shrubs can moderate aesthetics impact.
7	Public health and Sanitation	C-	D	B-	D	**Construction:** -There may be effects on health and sanitation around temporary labor camps. -Other generation source of sanitation problem may be wastes, water discharge.
8	Infectious diseases such as HIV/AIDS	B-	D	B-	D	**Construction:** There is a possibility that temporal migrating construction workers and drivers spread infectious diseases such as HIV/AIDS by contact with local women.
9	Working condition (including occupational health)	B-	D	B-	D	**Construction:** -In construction activities of the Project includes many hazardous tasks and conditions such as work at height, excavations, noise, dust, power tools and equipment, confined spaces and high tension power supply. -Accordingly, it is expected that there are risks of impairment to the health and safety of construction workers. -The contractor should comply with all precautions as required to ensure the safety of workmen as per the International Labor Organization (ILO). -CEB and the contractor shall be not violating the regulations in Sri Lanka that covers working conditions, the welfare of workers and safety and health.
10	Traffic accidents	B-	D	B-	D	**Construction:** Occurrence of accidents due to transportation vehicles and self-propelled heavy machineries is expected.
11	Disaster	C-	C-	B-	D	**Construction:** A part of the proposed transmission line pass through the flood plains of Mahaweli River and associated network of smaller rivers/streams Flooding in the project area may be due to the flooding of rivers, inundation of low lying areas at times of heavy rainfall or overflow of storm water drains. Consideration for period and season of construction is necessary. **Operation:** Constructed T/L and towers are stable and operation and maintenance are not affected even in rainy season.
12	Safety from Electromagnetic field	D	C	D	D	**Operation:** In populated areas height of 15m from ground to the sag point of the line is kept. With this height of the line, strength of the electromagnetic field in ground and upper level will be under the public exposure limit of the ICNIRP (International Commission for Non-Ionizing Radiation Protection).
13	Electromagnetic interference	C-	C-	D	D	**Construction/Operation:** Since there isn't a house underneath the 20m width corridor of the transmission line, impact of electromagnetic interference by transmission line may be very small.
Natural Environment						
14	Protected Area	B-	D	B-	D	**Pre-Construction /Construction:**

Environmental Item		Assumed Rating of Impacts in the Scoping		Assessment Rating of Impacts based on the Results of the Survey		Reason of Assessment (Identified Impacts and Reasons)
		Pre-Construction Stage/ Construction Stage	Operation Stage	Pre-Construction Stage/ Construction Stage	Operation Stage	
						-There is no National Park, Nature Reserve, Strict Natural Reserve, National Heritage and Wilderness Area in the corridors of transmission line. -However, there is a possibility that the transmission line will pass by the edge of few Forest Reserves and Conservation Forest Reserve. -It was observed that a large amount of these forest areas traversed by the line is in a degraded state due to public encroachment and roadside clearing for security purposes. Care has been exercised to locate the line route even through the degraded forest areas.
15	Terrestrital Flora	C-	D	B-	D	**Pre-Construction/Construction:** During a field survey by CEB, following three plant species listed in IUCN Red List 2012 criteria were observed in the Project area. -*Diospyros ebenum* (Sinhara name: Kaluwara, common name: Ceylon ebony): endangered species (EN) Kaluwara is found regenerating naturally in and around the Project areas. -*Haldina cordifolia* (Sinhara name: Kolon) and *Mitragyna parvifolia* (Sinhara name: Helamba) : vulnerable species (VU) They are common species found in seasonally water logged low-lying areas or near waterways. Since trees of above EN and VU species exist commonly or are regenerating naturally in and nearby the Project areas, if some of the trees may have to be removed in the process of clearing routes, such activities in the area will not affect the species survival significantly.
16	Trees, Forest	B-	D	B-	D	**Pre-Construction/Construction:** -Since there is an impact due to construction activities on site where a small amount of deforestation will take place, a reforestation program will be planned and conducted by FD using suitable indigenous species (taking into consideration habitat types) with financial assistance from the CEB. *
17	Terrestrital Fauna	B-	B-	B-	B-	**Construction/Operation:** -No bird migratory routes and important bird habitats were recognized during the ecological study by CEB. -There is a possibility which impact on crossing of elephants during the construction and by the existence of transmission line equipment.
18	Soil erosion / Destabilization of soil	C-	D	B-	D	**Construction:** There is a possibility that earthmoving activities cause soil runoff from a few transmission tower sites located in hill slopes. In hilly areas where more than 80 % of the ground cover exists as forest cover. A part of hilly areas there is a small possibility of erosion.
19	Groundwater	C-	D	D	D	**Construction:** Possibility of contamination of ground water is very small. -The vehicle maintenance area will be located as to prevent contamination of groundwater by accidental spillage of oil. -All solid waste will be disposed in a waste disposal site designated by the local authority of the area.
Environmental Pollution						

No.	Environmental Item	Assumed Rating of Impacts in the Scoping: Pre-Construction Stage/ Construction Stage	Assumed Rating of Impacts in the Scoping: Operation Stage	Assessment Rating of Impacts based on the Results of the Survey: Pre-Construction Stage/ Construction Stage	Assessment Rating of Impacts based on the Results of the Survey: Operation Stage	Reason of Assessment (Identified Impacts and Reasons)
20	Air pollution	B-	D	B-	D	**Construction**: Air pollution is expected by emission of dust and some pollutants from transportation vehicles. There is also a possibility that air pollution is expected by emission of some pollutants from heavy machineries. However, since the work is temporary and the scale the work is small, the impact is limited to proximity of construction area.
21	Water pollution	C-	C-	B-	D	**Construction:** There is a slight possibility of turbid water pollution by earthmoving activities. There is a possibility of water pollution by oil leakage from transportation vehicles, heavy machineries or bad managed wastewater. **Operation:** There is no activity to leak oil from the transformer in this Project.
22	Soil contamination	C-	D	D	D	**Construction:** There is a possibility of soil contamination caused by emissions of pollutants or oils from waste. However from the reason shown below, possibility of occurrence of soil contamination is very small. All solid waste from construction activities will be collected and properly managed, in order to prevent contamination of soil and groundwater. All solid waste will be disposed in a waste disposal site designated by the local authority of the area. The disposal site is controlled so as to prevent contamination of soil by accidental spillage of pollutants or oils.
23	Waste	B-	D	B-	D	**Construction:** Construction wastes, such as residual substances (metallic and non-metallic) and construction debris (soil, sand, etc.) are generated from the construction sites. Daily general waste by the activities and living of the workers is generated in labors camp. Generation of hazardous waste is not expected.
24	Noise and Vibration	B-	D	B-	D	**Construction:** Generation of noise and from transportation vehicles and heavy machineries is expected. However the level, scope and duration of generation are limited. Vibration may be generated mainly by construction activities at each tower along the transmission line for a short duration. Because there will be no basting operation near residences and buildings, and drilling works will be restricted within small and shallow ground area. There is a slight possibility of using rock blasting only in the place far from the inhabitances and buildings. Accordingly, vibration impacts on living environment by large vibration sources in construction are expected to be negligible.

11.2.9. Environmental Management Plan (EMP)

For the implementation of the project, there is no serious environmental and social impact. However, some items have negative environmental impacts to some extent. Accordingly, mitigation measures will be taken for these items.

1) Structure of the Implementation System

In consideration of the scale of impacts on environmental and social conditions by the Project, the implementation system of EMP will be consisted by two parts as shown in Table 11.2-24.

Table 11.2-24 Structure of the Implementation System of EMP

Plan Item	Important Matters in the Environmental Management Plan
Implementation of the monitoring plan	-Monitoring shall be implemented according to the plan. -Response/action to a comment and instruction from the local government and inhabitants shall be made according to the plan. -The report on the monitoring result shall be made according to the monitoring form, and reporting shall be conducted at a designated frequency.
Implementation of the mitigation measures	-CEB and the contractors shall securely implement the respective mitigation measures. -When a problem on environmental and social conditions still remains after implementing the mitigation measures, more effective and feasible mitigation measures shall be examined and applied to mitigate the impact under the responsibility of CEB.

(Source : Prepared by the Team)

2) Framework of the Implementation System of EMP

An Environmental Management Office (EMO) will be established by the CEB. The overall responsibility of implementation of the mitigation and monitoring plan will be entrusted to the EMO. It will instruct the contractor so that it will also follow the stipulated mitigation plan.

An Environmental Manager will be appointed who will be responsible for all the monitoring activities. The EMO will be staffed with specialists to cover all important fields such as ecology and socioeconomics. In general, setting EMO and assignment of Environmental Manager will be done at the timing of about half of year before starting of construction work(tentatively October,2016).

11.2.10. Mitigation Measures

Table 11.2-25 shows the mitigation measures and cost of the mitigation measures such items that classified as “B-” in the environmental impact assessment.

Table 11.2-25 Mitigation Measures and Cost of the Mitigation Measures

Environmental Item	Mitigation measures	Implementing Organization	Responsible Organization	Cost
Pre-Consulting & Construction Stage				
Social Environment				
1 Utilization of land and local resources (1) Land use restriction of area used for the construction of tower foundations and access roads	- Compensation will be paid for the restriction of paddy land use due to construction of tower foundations and temporal access roads. -Almost all paddy land used for construction of tower foundations can be cultivated again after the construction activities. -Temporal access roads will be sited carefully to minimize the disruptions to paddy farming. -Temporal access roads will be completely removed after the construction. -To remove top soil carefully and restore same after construction of tower foundations -Estimated paddy land of farming restriction: total 8 ha	CEB	CEB	CEB 688 k LKR
2 Utilization of land and local resources (2)Trees in home gardens to be cut/ removed	Compensation shall be paid for cutting/ removal of trees in home gardens. Affected households: 24 Number of trees to be cut/removed: 227 CEB should recommend affected people to short plant suitable home garden such as lime, orange and cashew which can grow under the power lines.	CEB	CEB FD	CEB 2,239 k LKR
3 Utilization of land and local resources	Compensation shall be paid for farming restriction of paddy land for the areas for four tower footings	CEB	CEB	CEB 550 k LKR

Environmental Item	Mitigation measures	Implementing Organization	Responsible Organization	Cost
(3) Land use restriction of area used for the tower footings				
4.Safety management for tree felling	Thorough safety management during tree felling (1) Clarification of the boundaries of the areas for tree felling. (2) Prior public announcement of schedule of tree felling.. (3) The Contractor prohibits the residents coming into the place of tree felling during the work.	Contractor	CEB Contractor	Contractor
Natural Environment				
5 Protected Area	There are no protected areas such as National Parks, Sanctuaries, or Conservation Forest managed by the Department of Wildlife Conservation and Forest Department along the ROW of 35 m or 200 m corridor of the line.	CEB Contractor	CEB	CEB
6 Terrestrial Flora	Endangered species (EN)- *Diospyros ebenum* (Kaluwara) is found regenerating naturally in and near the Project area. Vulnerable species (VU)- *Haldina cordifolia* (Kolon) and *Mitragyna parvifolia* (Helamba) They are common species found in seasonally water logged low-lying areas or near waterways. Trees of these three species will be transplanted and included in the reforestation program conducted by FD.	CEB Contractor	CEB FD	CEB
7 Trees in forests	Reforestation program for cutting/removal of trees in forest is planned and conducted by FD. (cost for reforestation program: roughly 2,000 USD per ha) The reforestation program will be conducted using suitable indigenous species at other suitable locations selected by FD. An arboretum will be established at Habarana or at a suitable area as decided by FD to fulfill the requirement.	CEB	CEB FD	CEB
8 Terrestrial Fauna Disturbance to elephants behavior in forest areas	1) A minimum of 13m of clearance is kept between the transmission line and the ground where there are elephant crossings to ensure safety of the elephants. The foundations of towers are sufficiently strong and solid such that even of elephants weight in on the transmission towers, no damage is anticipated either to the tower or to the elephants themselves. 2) Construction should complete within a shorter duration and limited to daytime in forest area. 3) Proper fencing should be used to secure excavated foundation areas during construction. The fencing may have to consider using suitably strong fencing to fend off elephants at all construction sites where elephants are possible to come close.	CEB Contractor	CEB	CEB 2,000 k LKR (Fence construction Cost)
9 Soil erosion / Destabilization of soil	To avoid earthworks on erosion-prone areas during the rainy season. When earthmoving activities are done, clearing vegetation will be minimized and earth bunds will be built beside drainage channels to avoid overspill. Levelling and stabilization of tower construction sites will be done smoothly after completion of construction activity in order to avoid increased acceleration of surface run off and damage to the top soil.	CEB Contractor	CEB	Contractor
Construction Stage				
Social Environment				
10 Existing social infrastructures and services	1) In the construction plan, consideration should be given so as not to interfere with the access to social service facilities. 2) Information disclosure well in advance on the construction work schedule and temporary traffic congestion. 3) Time shift of transportation and construction work, if	CEB Contractor	CEB	CEB

Environmental Item	Mitigation measures	Implementing Organization	Responsible Organization	Cost
	necessary. 4) Prepare 'Traffic Management Plan' with relevant local government agencies. -Plan routes to avoid narrow roads or populated areas. -Validate routes by considering condition of roads, bridges, present traffic loads, safety records, etc. 5) If any utilities have to be moved, preparation of relocation plans must be prepared with service providers. 6) Installation of traffic induction staffs during construction			
11 Public health and Sanitation	1) Proper water and sanitary facilities shall be provided in labor camps prepared by the contractor. 2) To install temporal toilets of septic tank type in the construction site, if necessary. 3) Waste from worker's camp shall be collected, segregated, properly reused and recycled according to regulations and rules of local government. Then all remained waste will be disposed to disposal site designated by local authority, without causing visual or leachate pollution to other local users.	CEB Contractor	CEB	Contractor 2) 800 k LKR (Temporal toilet)
12 Infectious diseases such as HIV/AIDS	1) Thorough education of prevention and cure of HIV/AIDS to migrating construction workers. 2) Education of prevention of HIV/AIDS to inhabitants. 3) Employing preferentially local residents as much as possible.	Contractor CEB	CEB	Contractor 1), 2) 100 k LKR (HIV/AIDS program) CEB 3)
13 Working condition (including occupational health)	1) The contractor and workers employed shall comply with the laws and regulations of Sri Lanka relating to the working conditions and working environment. 2) The contractor should take tangible safety measures as follows. -Installation of safety equipment which prevents working accidents -Physical zoning for of safety work area and installation of warning signs -Wearing of basic safety equipment such as safety shoes, gloves and helmet -Wearing safety best at high place 3) The contractor should take intangible safety measures as follows. -To prepare safety and health management plan, including traffic safety, accident prevention and public sanitation, etc. according to the regulations relating to working conditions. -To conduct educational training of safety, health and public sanitation to workers and staffs.	Contractor CEB	CEB	Contractor
14 Traffic Accidents	1) Selecting the transportation route that has lowest possibility of accident. 2) Posting signs on the main roads to inform the time zone and the passage of transportation vehicles. 3) Clarification of the boundaries of the construction areas with rope, fences and other means. 4) Thorough instruction of safety driving and working to drivers of transportation vehicles. 5) Prior public announcement of contents and schedule of loading and unloading materials/ equipment, construction work schedule and temporary traffic congestion. 6) Time shift of construction work and operation of transport vehicles and vessels, if necessary.	CEB Contractor	CEB	Contractor

Environmental Item	Mitigation measures	Implementing Organization	Responsible Organization	Cost
15 Disaster	Period of construction works shall be selected to avoid the influence by flooding.	CEB Contractor	CEB	CEB
Environmental Pollution				
16 Air pollution	1) Use of low emission heavy machineries and vehicles, appropriate maintenance of them and use of good-quality fuel and oil. 2) To sprinkle water to prevent scattering dust from the construction site where soil soars during excavation and transportation. 3) Regulation of overload transportation vehicles. 4) Setting staff in charge of complaints from inhabitants and construction activity improvement corresponding to the complaints. 5) Construction work should not be carried out at night (construction time zone: 6am-7pm). 6) Air quality monitoring around the access roads.	Contractor CEB	Contractor CEB	Contractor
17 Water pollution	1) If necessary, drainage water from excavation site is held in sedimentation ponds to reduce the turbidity content prior to discharge by use of silt traps etc. 2) Oils of transportation vehicles and construction heavy machineries shall be used with no leakage. Waste oils shall be stored and disposed safely. 3) Concrete curing water shall be discharged after neutralization. 4) Water quality will be monitored during construction period.	Contractor CEB	Contractor CEB	Contractor 1) 1,200 k LKR
18 Waste	1) The contractor should carry out properly segregation collection, treating and disposal of construction waste in strict compliance with the waste-related laws of Sri Lanka and regulations and rules of local government. 2) To stock and dispose safely of waste oils used in vehicles and heavy machineries. 3) The contractor shall provide education and enlightenment for activities such as decreasing quantity, segregation, reusing and recycling) to workers.	Contractor	Contractor CEB	Contractor
19 Noise and Vibration	1) To maintain thoroughly the vehicles and heavy machineries and to operate at low noise and vibration conditions. 2) To install sound proof fence or a buffer zone, if necessary. 3) Construction work should not be carried out principally at night (construction time zone: 6am-7pm). 4) To set staff in charge of complaints from inhabitants and construction activity improvement corresponding to the complaints. 5) Explanation of the construction work schedule to local people.	Contractor	Contractor CEB	Contractor
	Total Cost	Cost without the description of the amount CEB: Within the Project management cost: Contractor: within the construction management cost:		7,577 k LKR*

Note: * At present area of land clearance is not identified. Thus, cost for reforestation program is excluded.
(Source : Prepared by the Team)

11.2.11. Monitoring Plan

Table 11.2-26 shows Monitoring Plan.

Table 11.2-26 Monitoring Plan

Category	Environmental Item	Monitoring Indicator	Monitoring/ Measurement place (Point)	Monitoring Method	Frequency	Total No of times /samples	Implementing Organization	Responsible Organization	Cost (LKR) Burden Organization
Pre-Construction Stage									
Social Environment	Compensation for cutting/ removal of trees in home garden	Number of PAHs (Project Affected Households) which have received full amount of compensation	House of PAH	Confirmation with PAHs	3 times during pre-construction period	3 times	CEB	CEB	CEB*
	Safety management for tree felling	Status of safety management	Site of tree felling	Site observation	Occasional timing during tree felling		Contractor	Contractor CEB	Contractor**
	Compensation for tentative land use restriction of area used for the construction of tower footings and access roads	Number of PAHs who have received full amount of compensation	House of PAH	Confirmation with PAHs	3 times during pre-construction period	3times	CEB	CEB	CEB*
	Compensation for long period land use restriction of area used for the tower footings	Number of PAHs who have received full amount of compensation	House of PAH	Confirmation with PAHs	3 times during pre-construction period	3times	CEB	CEB	CEB*
Pre-Construction and Consultation Stage									
Natural Environment	Flora	Existence of endangered species	Species, Number	Ecological site survey	3 times during pre-construction and construction period	3 times	Local consultant	CEB Local consultant	CEB 150 k LKR
	Progress of cutting/ removal of trees in Forest	Ratio of finished area/total area that is necessary to be cut/removed	Area (ha)	Confirmation with FD	3 times during pre-construction and construction period	3 times	Local consultant	CEB Local consultant	CEB 60 k LKR

Category	Environmental Item	Monitoring Indicator	Monitoring/ Measurement place (Point)	Monitoring Method	Frequency	Total No of times /samples	Implementing Organization	Responsible Organization	Cost (LKR) Burden Organization
	Fauna Activity of Elephant	Occurrence of Elephant-Human conflict Evidence of unusual activity of Elephant	Near the place for tower construction	Observation	9 times during pre-construction and construction period	9 times	Local consultant	CEB Local consultant	CEB 360 k LKR
Construction Stage									
Social Environment	Temporal traffic congestion	Occurrence of complaints for traffic congestion	Around the main roads	Hearing from inhabitants	2 times /month during construction	48 times	Contractor	CEB Contractor	Contractor**
	Health and Sanitation	Conditions of drinking water and sanitary facilities	Workers Camp	Observation	2 times /month during construction	48 times	Contractor	CEB Contractor	Contractor**
	Infectious diseases such as HIV/AIDS	Number of HIV-positive persons	Relevant District office	Hearing from relevant District offices	2 times/ year (During construction)	4 times	Contractor	CEB Contractor	Contractor**
	Traffic accidents	Traffic accidents	Relevant District office	Hearing from relevant District offices	Occasional y, (When an accident occur) (During construction)		Contractor	CEB Contractor	Contractor**
	Working Condition (Including Work Safety)	Work Safety	Construction sites	Observation of working condition	During usual working time (During construction)		Contractor	CEB Contractor	Contractor**
Natural Environment	Protected Area	Condition of Natural Environment	In three Forest Reserve and one Conservation Forest Reserve	Ecological Inspection	yearly for 4 areas	2 times for 4 areas	Local consultant	CEB	CEB 320 k LKR
	Soil erosion / Destabilization of soil	Extent of Soil erosion and effect of the mitigation measures	Tower construction sites	On site observation	monthly (During construction)	24 times	Contractor	CEB Contractor	Contractor**
Environment-a l Pollution	Air quality	SO_2 NO_2 CO PM_{10} SPM	Near four AP (4 points) -Habarana at substation site -One point between Habarana and Kantale -Kantale -Sampoor	On site measuring	dry season Pre-construction :1 During construction :4	20measurements	Local consultant (measurement)	CEB	CEB 1,000 k LKR

Category	Environmental Item	Monitoring Indicator	Monitoring/ Measurement place (Point)	Monitoring Method	Frequency	Total No of times /samples	Implementing Organization	Responsible Organization	Cost (LKR) Burden Organization
	Water quality	SS BOD_5 Turbidity Oil & Grease	5 water bodies (surface layer) -Mahaweli River -Uppu aru -Verical aru -Two canal	Standard Sensor/ Analyzer Digital turbidity meter	dry season Pre-construction :1 During construction :4	25 samples	Local consultant (measurement)	CEB	CEB 875 k LKR
	Noise and Vibration	1) Noise (day and night) 2) Vibration	1) Noise - 4 Points same as air quality (day & night for each measurement) 2) Vibration – boundary of generation source	1) Noise - Sound level meter 2) Vibration level meter	1) Noise - dry season Pre-construction :1 During construction :8 2) Vibration - dry season Pre-construction :1 During construction – when vibration generating machine is operated	1) Noise - 36 measurements (day & nigh for each time)	Local consultant (measurement)	CEB	CEB 720k LKR
	Waste	Construction Waste	Construction site	Visual observation Condition of discharge and treatment of waste	2 times / month Particularly important when complaint is reported. (During construction period)	48 times	Contractor	Contractor	Contractor**
		General daily waste	Workers camp						
Total cost									3,485 k LKR

Note: *: CEB; Within Project general administration cost

**: Contractor ; Within construction management cost

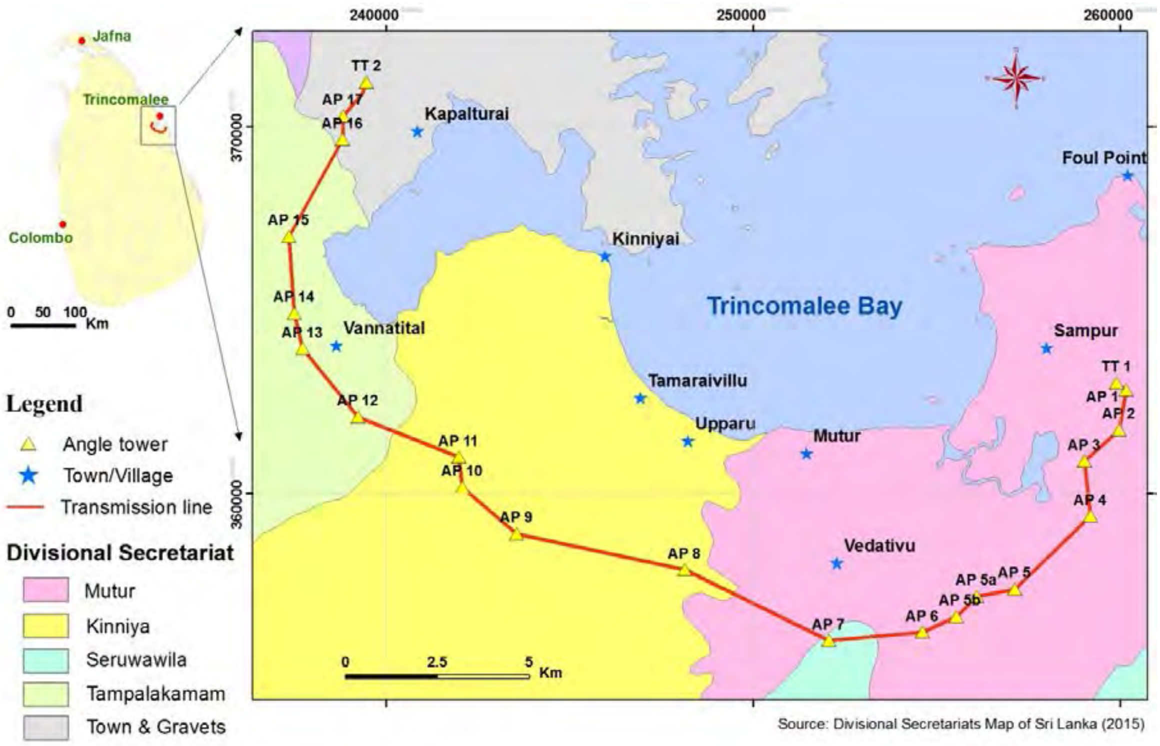
(Source : Prepared by the Team)

11.3. Environmental and Social Consideration for 220 kV Sampoor-Kappalturai T/L

11.3.1. Description of the Proposed Project

The transmission line from proposed Sampoor Switching Station to Kappalturai GSS is 37.4 km in length. The line traverses through paddy fields, abandoned paddy fields, scrublands, dry-mixed evergreen forests, riverine forests along the banks of Uppu Aru and Mahaweli, and flood plains of Mahaweli River.

There are no protected areas such as National Parks, Sanctuaries, or Conservation Forest managed by the Department of Wildlife Conservation and Forest Department along the ROW of 35 m or 200 m corridor of the line. However, the transmission line crosses several patches of Muttur Government Forests found either side of the ring road. The boundaries of these forest patches are demarcated by the Forest Department on the ground using the concrete posts. The proposed transmission line is mainly passing through paddy fields, villages and semi-urban areas in Trincomalee district. The project is located within the DS Divisions of Town and Gravets, Tambalagamuwa, Kinniya, Seruvila and Muttur (Figure 11.3-1).



(Source: CEB)

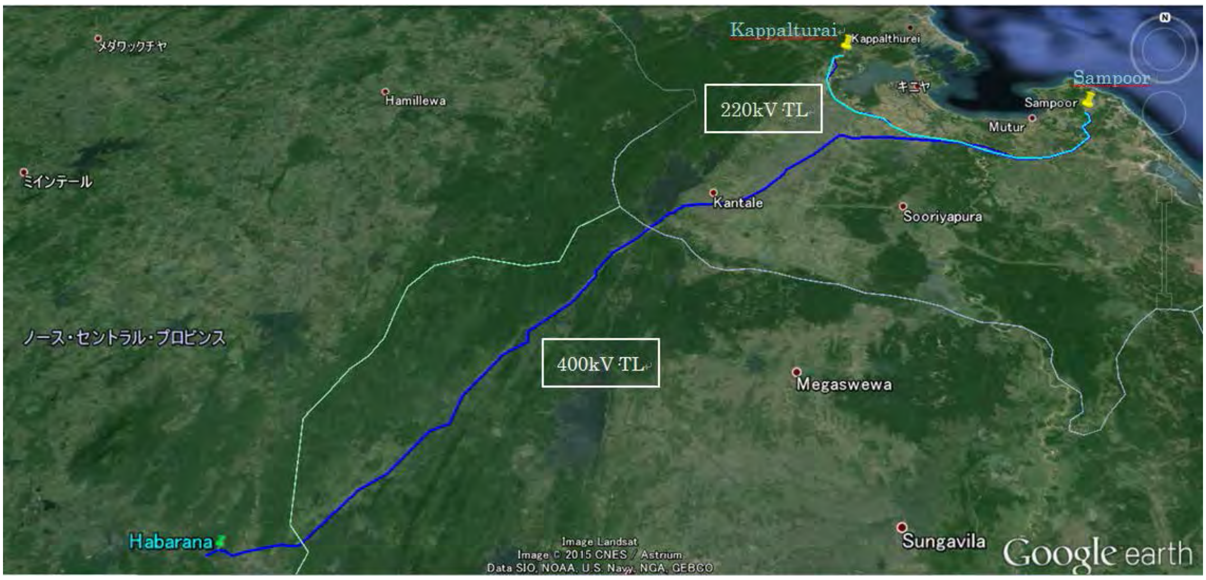
Figure 11.3-1 Proposed 220 kV Transmission Line

11.3.2. Present Ownership of the Project Site

The site for the proposed Sampoor Grid Substation is a property of the CEB and consists of scrublands and abandoned paddy fields. The land area is 8.4 ha (160 x 525 m) and it is located in the southern part of the land earmarked for the Sampoor Coal Power Plant. From that point transmission line (37.4 km) traverses over the private lands including paddy fields, government forest lands, scrublands, crossing the Mahaweli river and several small rivers (aru) and a few seasonal tanks. The tower foundations will be established on the highlands land owned by the private land owners, government forest lands or paddy lands belonging to the farmers. Regarding the tower foundations, CEB has to negotiate with the respective land owners on payment of compensation before any construction work commences.

The selected land for the Kappalturai GSS is a teak plantation bordering the Habarana to Trincomalee main road (A6) near 186 km post. The teak plantation was established by the Forest Department and within the teak plantation several indigenous tree species common to the dry zone can be seen. The teak trees were damaged by the elephants and the remaining trees have no commercial value as timber.

Figure 11.3-2 shows Routes of the 400 kV T/L and the 220 kV T/L.



(Source: CEB)

Figure 11.3-2 Routes of 400 kV T/L and the 220 kV T/L

11.3.3. Existing Environmental and Social Conditions of the Project Area

11.3.3.1. Climate and Meteorology

1) Rainfall and Temperature

The major rainfall receiving to the proposed transmission line is characterized to the following seasons:

Inter monsoon season (March-April), Inter monsoon (October-November) and Northeast monsoon (December-February).

The average rainfall distribution pattern is somewhat similar in all three regions in the zone, but the amount of rainfall is considerably different. Thirty year average rainfall data of the three major stations around the proposed transmission line are given in the Table 11.3-1.

Table 11.3-1 Thirty Years Average Rainfall of the Three Major Stations

Station		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Palampoddaru	Avg	208	116	41	93	90	29	68	71	155	227	495	420	2014
	Min	0	0	0	0	0	0	0	0	0	27	37	26	
	Max	509	608	164	390	301	116	352	261	309	497	959	1253	
	SD	166	161	52	99	92	38	89	71	105	144	246	322	
Kantalai	Avg	147	87	49	92	63	20	54	54	127	180	310	303	1485
	Min	4	0	0	1	0	0	0	0	0	23	75	49	
	Max	330	497	276	215	138	90	198	210	313	506	578	725	
	SD	103	115	65	60	41	26	47	55	90	104	156	191	
Allai	Avg	121	62	37	40	33	21	35	53	108	171	311	317	1309
	Min	2	0	0	0	0	0	0	0	0	45	43	69	
	Max	306	248	200	205	120	85	159	193	374	310	565	610	
	SD	88	73	53	55	41	30	46	50	97	84	156	180	

(Source: Department of Meteorology, Sri Lanka)

According to climatic zones the proposed transmission line is located within the eastern part of the dry zone (Figure 11.3-3). Agro-ecologically, the area belongs to the low country dry zone, and the proposed transmission line is located in DL 1**,** DL 2 and DL 2-4 agro-ecological regions.

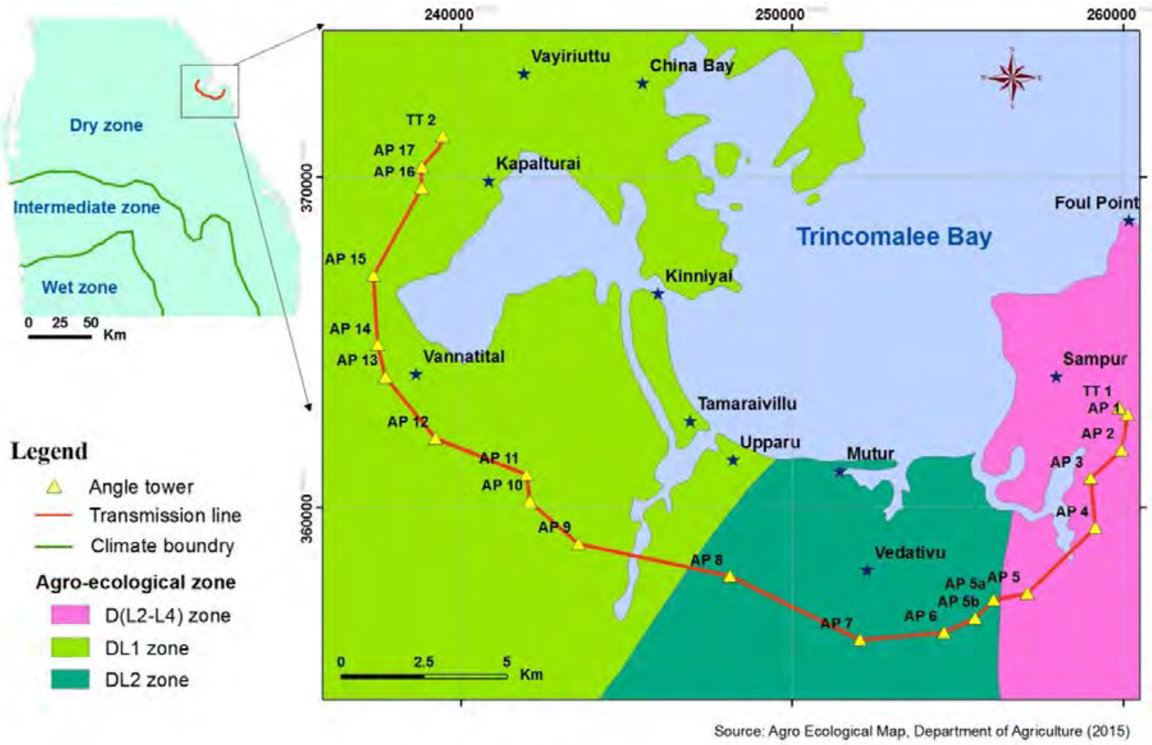


Figure 11.3-3 Agro-Ecological Zones across the Proposed Transmission Line

2) Wind

Wind direction and speed across the proposed transmission line is highly depending on the terrain morphology. According to maps developed by the Department of Meteorology, wind roses are developed for months of January, April, July and October. According to the observations general winds are dominant during the north-east monsoons with heavy rainfall. However, during the south-west monsoons dry wind roses are present along the terrain.

11.3.3.2. Topography

Topography along the proposed transmission line can be explained in terms of contour, slope, aspect and land use. Contour map of the area is clearly demarcating very flat terrain along the transmission line. Therefore, slope and aspects are not important for the proposed area. Major topographical variation present in the area is isolated rock outcrops. However, those outcrops are not located across the proposed transmission line and some of them are having 90 m of elevation with respect to the mean sea level.

Therefore, the flat topography of the area has no any threat in terms of landslides. However, there is a significant possibility for river flooding during the rainy seasons. Especially, along the flat river bank/ flood plains of the Mahaweli River, since it brings higher amount of water during the rainy season. However, other rivers are having lower threats from flooding.

11.3.3.3. Geology & Soil

1) Basement rocks

The rocks in the Trincomalee area belong to Highland Complex gneisses with both meta-sedimentary and meta-igneous of origin. However, basement rocks along the transmission line is predominantly covered by alluvial deposits, hence rock out crops are limited. Major lithological variation along the line can be given as follows: Alluvial deposits, Charnockitic gneiss, Undifferentiated charnockitic gneiss, Garnet-sillimanite-biotite gneiss, Quartzite and Marble.

2) Soil

Residual soils in the region are formed from a variety of rocks, mainly meta-igneous rocks and meta-sedimentary rocks. Soils along the proposed transmission line is differ from the other parts of the country due to dominant alluvial formation and lower weathering intensity in insitu soils with montmorillonite-kaolinite clays (Chemical Index of Alteration (CIA) < 60). Non-agricultural insitu weathered soils are mainly immature unconsolidated fine-grained sandy clay loams. Conversely, transported soils are having variable properties and texture.

11.3.3.4. Hydrology

1) Surface water

Major surface water sources along the proposed transmission line are major rivers and its tributaries and manmade tanks. Small tributaries are extensively present in the area due to formation of delta along the river channels. In addition, meanderings and braided rivers are dominantly formed around the proposed transmission line. The area is covered by flat topography hence there is a slow water flow presents which effectively formed alluvial deposit around the meanderings and braided formations. Major rivers having water during both dry and rainy seasons and the tributaries are having water only in the rainy season.

Mahaweli Ganga, Valavachar Aru, Kaddaiparichchan Aru, Verical Aru and Uppu Aru are the major rivers present across the proposed transmission line. Tributaries of those rivers are also present around the line. The proposed transmission line cross the Mahaweli Ganga and Verical Aru between the angle towers 7 and 8. The line cross the Uppu Aru between the angle towers 8 and 9, Kaddaiparichchan Aru between the angle towers 5a and 6 and Valavachar Aru between the angle towers 6 and 7.

In addition, several manmade small tanks are present in the area but most of them are abandoned (Figure 11.3-4). Only two tanks are crossing the proposed transmission line. The known tanks are mostly present around TT 1 to AP 5 because that area is lacking of major river channels for agricultural activities. Conversely, in between the major river channels there are no any manmade tanks.

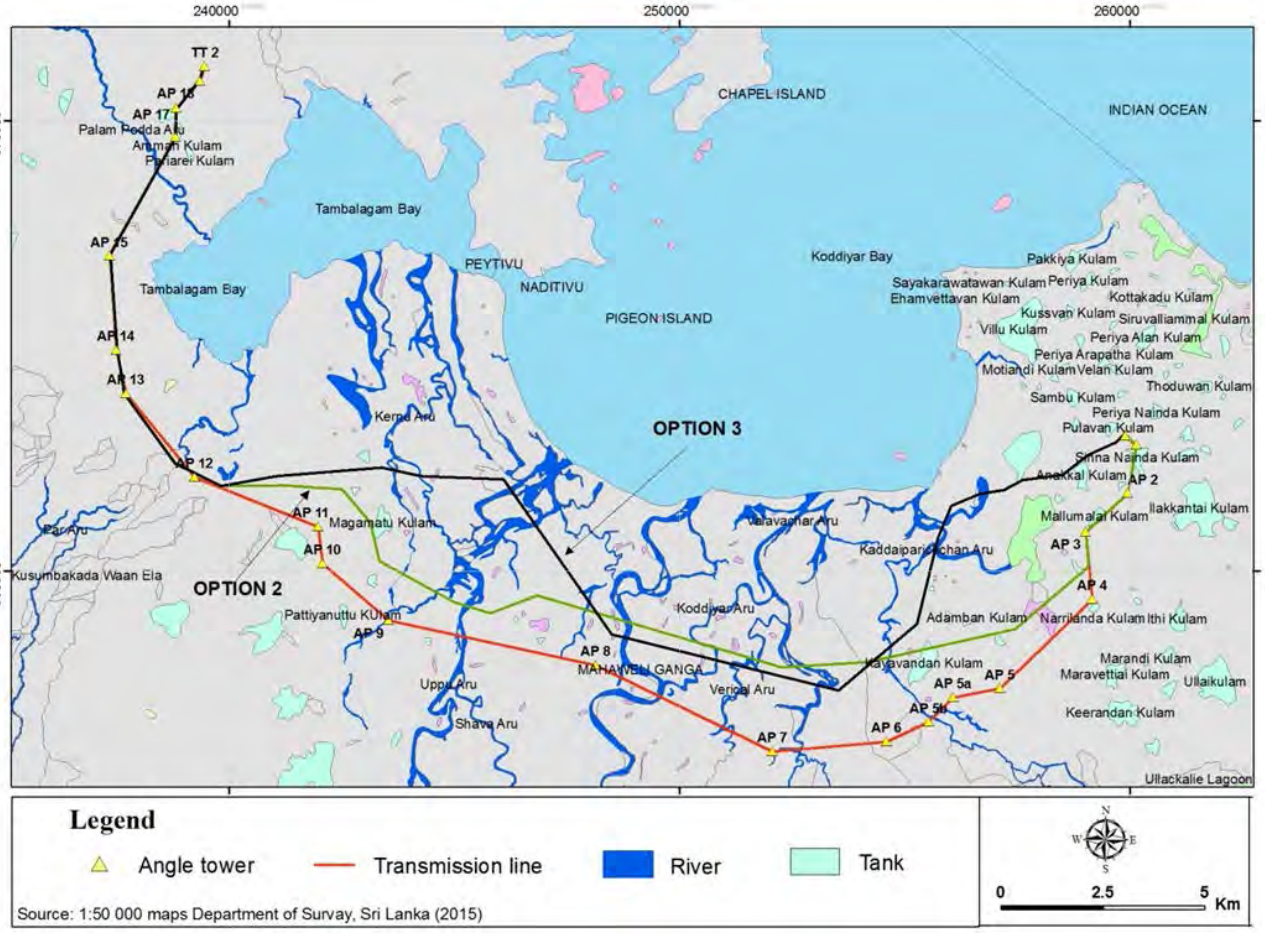


Figure 11.3-4 Surface Water Resources along the Proposed Transmission Line

2) Groundwater

The proposed transmission line is located along the flat terrain between Mahaweli River, Valavachar Aru and Uppu Aru. Major groundwater bearing formation of the area is unconfined alluvial aquifer whereas near to berm and beach area shallow sandy aquifers are present. In addition, shallow regolith aquifers are also present few miles away from proposed mineral sand mining site. The main water resources of the area are groundwater and surface water. Groundwater recharge rate is seem be significantly high in the area due to continuous fresh water supply by the Mahaweli river and others. Therefore, groundwater depth is generally shallow and unconfined. Thereby, shallow and unconfined nature of the groundwater around the proposed transmission line is susceptible to easy contaminations by anthropogenic pollutions.

11.3.3.5. Biota and Ecology

1) Ecological Resources

(i) Habitats in the project area

The two major habitats found along the proposed transmission line are paddy fields and scrublands. Some paddy fields were not cultivated for a long time due to the lack of irrigation facilities. In addition, dry-mixed evergreen forest, riverine forest, teak plantation with some indigenous tree species, degraded lands, home gardens are also found in the ROW of the proposed transmission line from Sampoor to Kappalturai. Riverine forests are found on the banks of Mahaweli River and Uppu aru. Several mangrove areas are also found close to the transmission line corridor close to Thangapuram and Patthinipuram. Also the line passes through few seasonal tanks in the area. The main habitat found in the land selected for the Kappalturai Grid substation is degraded teak plantation with some indigenous tree species. The plantation is degraded due to the elephant damage of teak trees. Sampoor GSS land consists of habitats such as scrublands and abandoned paddy lands. A mixed species vegetation which include both introduced and indigenous tree species are found next to home gardens, comparatively very small area.

(ii) Flora of the Project Area

A total of 223 plant species (60 families and 183 genera) including four (4) endemic and 174 indigenous species were recorded from all the habitats found along the transmission line corridor from Sampoor to Kappalturai. Forty five (45) plant species recorded in the study area are introduced species. About twenty nine (29) of them are now naturalized and this indicates that the area is moderately disturbed due to human influence. All recorded flora species are not unique or restricted to the project area. Terrestrial habitats such as scrublands, dry mixed evergreen forest, riverine forests in the project area are comparatively less diverse. Paddy fields (including abandoned paddy fields), scrublands, dry mixed evergreen forests, riverine forests, mangroves, seasonal tanks, home gardens and teak plantation having 116, 114, 110, 54, 21, 58, 79, 74 species, respectively.

(iii) Fauna of the Project Area

Total number of 162 faunal species was recorded in the project area representing snails, butterflies, dragonflies, inland fishes, amphibians, reptiles, birds and mammals. This included 7 species that are endemic to Sri Lanka. Further, the faunal assemblage recorded in the project area also included two exotic fish species and 7 species of migrant birds that inhabit forest habitats. The highest faunal diversity was recorded in the Scrublands followed by paddy fields, dry mixed evergreen forests, riverine forest and home gardens.

(iv) Protected Area

There are no protected areas such as National Parks, Sanctuaries, or Conservation Forest managed by the Department of Wildlife Conservation and Forest Department along the ROW of 35 m or 200 m corridor of the line.

11.3.3.6. Social Environment

1) Demographic conditions

(i) Population, Household

Table 11.3-2 shows population of relevant Divisional Secretaries. The population ratio of female to male in the project area is slightly smaller than the national level.

Table 11.3-2 Population of Relevant Divisional Secretaries

Gender	National Total	Trincomalee District					
		1 Muttur DS	2 Seruvila DS	3 Kinniya DS	4 Tambalagamuwa DS	5 Town and Gravets DS	1-5 Total In Trincomalee District
Male	9,856,634	27,762	6,742	32,468	14,003	47,145	128,120
Female	10,502,805	28,859	6,890	32,145	14,524	50,342	132,760
Male :Female	1:1.066						1:1.036
Total	20,359,439	56,621	13,632	64,613	28,527	97,487	260,880

(Source: Census of Population and Housing of Sri Lanka, 2012 (Department of Census and Statistics))

Table 11.3-3 shows population of classified ages of relevant Divisional Secretaries. Population ratio of 20-64 age group (maturity age) in National total is 59 %. Population ratios of 20-64 age group (maturity age) in Hingurakgoda and Palugaswewa DS are 62 %, 61 % respectively. The ratio of five DS total in Trincomalee District is 50 %.

Table 11.3-3 Population of Classified Ages of Relevant Divisional Secretaries

Gender	National Total	Trincomalee District					
		1 Muttur DS	2 Seruvila DS	3 Kinniya DS	4 Tambalagamuwa DS	Town and Gravet DS	1-5 Total In Trincomalee District
Total Population	20,359,439	56,621	13,632	64,613	28,527	97,487	260,880
under 05 age group	1,743,862	6,857	1,542	8,143	3,281	8,572	28,395
between 05-14 age group	3,387,804	12,642	2,474	15.173	6,317	17,540	54,146
between 15-19 age group	1,644,249	5,980	1,118	7,497	2,989	9,757	27,341
between 20-64 age group	11,980,861	29,159	7,823	31,709	14,706	55.841	139,238
above 65	1,602,663	1,983	675	2,091	1,234	5,777	11,760

(Source: Census of Population and Housing of Sri Lanka, 2012 (Department of Census and Statistics))

Table 11.3-4 shows household size and population density of Trincomalee District. Average household size of Sri Lanka is 3.8 persons, and household sizes of the three districts are almost same level as Sri Lanka total.

Table 11.3-4 Household Size and Population Density of Trincomalee District

Item	National Average	Trincomalee District
Household Size	3.8	3.5
Population Density (Persons/km^2)	323 /km^2 (2012 census)	150 /km^2

(Source: 2012 census)

Total population in the 13 GN divisions affected by the transmission line is around 19,000. Of them Tamil speaking population is highest and is the majority in both Muttur and Thampalakamam. Kinniya, the GN Divisions affected by the project is totally represented by the Muslim speaking communities. Sinhala population is not present significantly in any of the GN divisions.

In contrast to other divisional secretaries of Trincomalee District, Kinniya is dominated by a large Muslim community in which almost 96 % of the people are Sri Lankan Moors. The ethnic minorities are Tamils (4.01 %) and Singhalese (0.06 %). The main religion in Kinniya is Islam. Tamil is the mother tongue of both Muslim and Tamil inhabitants.

Table 11.3-5 shows population by race in the Trincomalee District.

In Trincomalee District, maximum ratio is 41 % of Sri Lanka Moors.

Table 11.3-5 Population by Race according to the Trincomalee District

Type	National Level		Trincomalee District	
	Population	Ratio	Population	Ratio
Sinhalese	15,250,081	74.9 %	101,483	26.7 %
Sri Lanka Tamils	2,269,266	11.1 %	116,646	30.7 %
Sri Lanka Moors	1,892,638	9.3 %	158,771	41.8 %
Indian Tamils	839,504	4.1 %	1,227	0.3 %
Malay	44,130	0.2 %	356	0.1 %
Burger	38,293	0.2 %	966	0.3 %
Other	25,429	0.1 %	92	0.0 %
Total	20,359,439	100.0 %		100.0 %

(Source: Census of Population and Housing 2012 (Provisional information based on 5 % sample))

Table 11.3-6 shows population by religion according to Trincomalee District. There are diverse religions in the project area. In Trincomalee District is maximum ratio is Islam, about 40 %.

Table 11.3-6 Population by Religion according to Trincomalee District

Type	National Level		Trincomalee District	
	Population	Ratio	Population	Ratio
Buddhist	14,222,844	70.2 %	98,772	26.1 %
Hindu	2,554,606	12.6 %	98,113	25.9 %
Islam	1,967,227	9.7 %	159,251	42.1 %
Roman Catholic	1,237,038	6.1 %	14,795	3.9 %
Other Christians	272,568	1.3 %	7,097	1.9 %
Other	9,440	0.0 %	134	0.0 %
Total	20,263,723	100.0 %	378,184	100.0 %

(Source: Census of Population and Housing 2012 (Provisional information based on 5 % sample))

2) Other Social Conditions

Table 11.3-7 shows Income and Expenditure according to Trincomalee District. Average incomes in the district is about 25 % lower than national average.

Table 11.3-7 Income and Expenditure according to Trincomalee District

Unit: Rs (monthly)

Item	Type	National Level	Trincomalee District
Level of Income (household)	Average	45,878	34,577
	Median	30,814	24,436
Level of income (per capita)	Average	11,819	7,622
	Median	7,881	5,385
Level of Expenditure (household)	Average	41,444	31,041
	Median	30,701	26,777

(Source: Census of Population and Housing 2012 (Provisional information based on 5 % sample))

Table 11.3-8 shows percentage distribution of households in occupied housing units according to the method of solid waste disposal by Trincomalee District. In the district percentage distribution of households those waste are burned by occupants is larger than national level.

Table 11.3-8 Percentage Distribution of Households in Occupied Housing Units according to the Method of Solid Waste Disposal by Trincomalee District

District	Total Households	Total	Type of lightning					
			Collected by local authorities	Occupants burn	Occupants dispose within premises	Occupants composting solid waste	Occupants dispose solid waste into road, river, canal, sea, creek, forest	Other
National Level	5,251,126	100.0	20.4	46.9	23.5	7.8	0.9	0.5
Trincomalee District	95,529	100.0	32.9	52.4	12.2	1.8	0.6	0.1

(Source: Census of Population and Housing 2012 (Provisional information based on 5 % sample))

Table 11.3-9 shows number of HIV/AIDS infection reported cases in three Districts.

Table 11.3-9 Number of HIV/AIDS Infection Reported Cases in Trincomalee Districts

Area	National Level	Trincomalee District
HIV/AIDS Number of Infection Reported cases till 2013 December	2074	22

(Source: HIV/AIDS Surveillance Data in Sri Lanka-2014 and District Data form the AIDS Control Programme of the Ministry of Health)

Table 11.3-10 shows Income and Expenditure according to Trincomalee District. Average incomes in the three districts are 15- 25 % lower than national average.

Table 11.3-10 Income and Expenditure in Trincomalee District

Unit: Rs (monthly)

Item	Type	National Level	Trincomalee District
Level of Income (household)	Average	45,878	34,577
	Median	30,814	24,436
Level of income (per capita)	Average	11,819	7,622
	Median	7,881	5,385
Level of Expenditure (household)	Average	41,444	31,041
	Median	30,701	26,777

(Source: Census of Population and Housing 2012 (Provisional information based on 5 % sample))

Table 11.3-11 shows poverty percentage as head count ratio of Trincomalee District. Average poverty percentage level of Sri Lanka is low. Poverty percentage of Trincomalee District is almost same level as average of Sri Lanka total.

Table 11.3-11 Poverty Percentage as Head Count Ratio of Trincomalee District

Item	Unit	National Level	Trincomalee District
Poverty level as head count ratio	Poverty percentage	6.7 %	9.0 %

(Source: Census of Population and Housing 2012 (Provisional information based on 5 % sample))
(Source: HIV/AIDS Surveillance Data in Sri Lanka-2014 and District Data form the AIDS Control Programme of the Ministry of Health)

3) Land use

The detail land use maps along the proposed transmission line are given in the annexes. Percentage calculations of the land use in 200 m study area and 35 m way leave corridor are also given. According to the calculations most of the study area and way leave corridor covered by the paddy fields and scrublands. In addition, lower percentages are covered by homesteads and the forest.

In general, field investigations revealed that paddy fields across the area are fully covered by the paleo-river deposits. Most of the homesteads are associated with those paddy fields. Some of the paddy fields are abandoned and some of those river deposits are allocated for sand mining. Scrublands mainly having scattered bush/ trees and some of them are used for chena cultivations. Teak is the only plantation available at the grid substation, Kappalturai, and the proposed transmission line is not passing through any plantation. In addition, there is a very few infrastructures across the proposed transmission line. Road networks are not effectively crossing the proposed transmission line. The proposed line is crossing main roads two times and it is moving parallel to the Trincomalee Ring road.

River morphology of the area is quite complicated. Heavy sediment load is extensively accumulated in the wider flood plans of the rivers. Especially, meanderings and braided river formations are extensively developed around the non-selected transmission line options 2 and 3. The paleo-river flood plan land use is having unconsolidated materials (sand) thus very easy to anthropogenic contaminations. Some areas of the flood plains having silt and clay deposits which effectively utilized for cultivations due to rich in nutrients and organic matter. Also some areas of the flood plains are developed as forest and scrubs due to availability of nutrients. Few marshy lands are also present around the proposed transmission line which developed by the accumulation of rain water as well as inundation by sea water. The sea water inundated marshy land area is mainly covered by different soil type than the alluvial deposit.

11.3.3.7. Environmental Pollution

1) Air Quality

Table 11.3-12 and 13 show existing level of air quality measured at the places around the Project area.

Table 11.3-12 Existing Level of Air Quality around the Project Area (1)

Location	PM_{10} (24 hourly, μg/m^3)		CO (1 hourly, μg/m^3)		SO_2 (1 hourly, μg/m^3)		NOx (1 hourly, μg/m^3)	
	Range	Avg.	Range	Avg.	Range	Avg.	Range	Avg.
Sampoor	56-68	62	160-225	195	6-12	9	14-23	18
Muttur Town	65-78	71.5	320-460	398	7-13	9.25	12-24	18

(Source: Environmental Impact Assessment Report for Trincomalee Thermal Power Project, March 2015)

Table 11.3-13 Existing Level of Air Quality around the Project Area (2)

Location	time average	Concentration at each parameter (μg/m^3)				
		SO_2	NO_2	CO	SPM	PM_{10}
Kantale (Close to the Irrigation Department Quarters)	8 hrs	11	17	3200	18	-
	24 hrs	-	-	-	-	9

(Source: Rehabilitation and Upgrading road section from Kanthale to Trincomalee Environmental Assessment Report, March 2015)

Because there is none of large air pollution source, air pollution is not in progress around the Project area.

2) Noise

Table 11.3-14 shows existing level of noise measured at the places around the Project area.

Table 11.3-14 Existing Level of Noise Measured at the Places around the Project Area

Location	Category	Day time, dB(A)			Night time, dB(A)		
		Min	Max	LeqD	Min	Max	LeqN
Muttur town	Low Noise Areas	45.2	65.7	54.3	36.7	50.4	44.2
Sampoor village (1)	Low Noise Areas	40.1	50.3	46.8	40.4	45.3	43.2
Sampoor village (2)	Low Noise Areas	40.2	49.7	45.3	39.6	44.1	32.1

(Source: Environmental Impact Assessment Report for Trincomalee Thermal Power Project, March 2015)

During daytime and night time noise level are found to be well within the prescribed noise control regulations in Sri Lanka.

3) Water Quality

Table 11.3-15 shows existing level of surface water quality Measured at the water bodies around the Project area.

Table 11.3-15 Existing Level of Surface Water Quality Measured around the Project Area

Parameters	Drinking Water Standard of Sri Lanka (1983) Maximum Permissible Limits	Water body	
		Koddal Parichch (Rivulet)	Mahaweli Ganga (River)
Total Solid (mg/l)	2000	2600	160
Oil & Grease (mg/l)	1.0	Nil	Nil
COD (mg/l)	10	< 4	< 4
BOD (mg/l)	-	< 2	< 2
Total Coliform MPN/100ml	10	Absent	Absent

(Source: Environmental Impact Assessment Report for Trincomalee Thermal Power Project, March 2015)

Level of pollution of turbid matter and organic matter is very low in these water bodies.

Table 11.3-16 shows existing level of chemical characteristics of soil around the Project area.

Table 11.3-16 Existing Level of Chemical Characteristics of Soil around the Project Area

Location Name	pH	Conductivity	Organic Matter	N	P	K	Na
		μmho/cm	%	mg/100g			
Sunkakuli (Agricultural land)	7.99	586	0.91	2.57	123.7	0.8	11.3
Kaddiaparichchan (Scrub forest land)	8.10	316	0.48	3.7	199.6	1.1	3.7

(Source: Environmental Impact Assessment Report for Trincomalee Thermal Power Project, January 2015)

Table 11.3-17 shows Cadmium concentration levels in uncultivated soil around the Project area. The level in uncultivated soil is very low.

Table 11.3-17 Cadmium Concentration Levels in Soil around the Project Area

Place of sampling	Anuradhapura district	Polonnaruwa district
uncultivated soil	0.023±0.014 mg/kg	0.0052±0.0043 mg/kg

(Source: Bandara et al , Chronic renal failure in Sri Lanka caused by elevated dietary cadmium, Toxicology Letters 198 (2010))

11.3.4. Comparison of Alternatives

11.3.4.1. Necessary condition of alternatives for the Project

Basically the length of the line provides CEB the option in terms of cost. The shorter the line, the less the cost of construction. Nevertheless there are several important considerations based on which CEB finalize the route selection for transmission lines. As a principle, alignments are generally preferred at least 500m away from major towns, whenever possible, to account for future urban expansion. It is also preferred that the alignments are sited at least 50m away from any houses or structures purely due to minimize adverse environmental and social impacts. In this regard CEB prefers that the lines are aligned along the paddy fields despite the relatively high foundation cost and to select a route which may have a higher foot print of paddy land than highlands.

Table 11.3-18 shows the alternatives the CEB had in this in terms of the length of the line.

Table 11.3-18 Examination of the Alternatives

Alternatives	Description	Evaluation Item		
		Environmental and social impact	Construction cost	Technical Feasibility
Alternative 0 (Zero Option) The planned project (new 220 kV T/L from Sampoor to Habarana for stable power supply is not conducted.	If the planned project is not conducted, Sampoor coal-fired power generated by the plant cannot be transmitted to its main demand area.	No environmental and social impact occurs.	No needs to consider.	No needs to consider.
Alternative 1 (Proposed plan designed finally) Alternative 3 Line Length of 220 kV : 37.4 km	Line Length of 220 kV : 37.4 km 35 m way Leave Corridor Forest: 6.8 ha Marsh: 3.9 ha Stream: 3.3 ha Paddy land: 68.1 ha Home garden: 6.7 ha Coconut: 0.6 ha	Environmental and social impacts are quite limited. No land acquisition and involuntary resettlement occur.	Construction cost was estimated as the highest among the three alternatives. However, the differences are small. (46.3 Mil. JPY/ km)	Construction of T/L is technically feasible without difficulty.
Alternative 2 Line Length of 220 kV : 35.8. km	Line Length of 220 kV : 35.8 km 35 m way Leave Corridor Forest: 10.4 ha Marsh: 3.9 ha Stream: 4.9 ha Paddy land: 55.1 ha Home garden: 6.7 ha	The percentages of marshes and streams higher than Alternative 1. This alternative passes through forest area considerably larger than Alternative 1.	Construction cost was estimated lower than lower than Alternative 1. However, the difference is small.	Construction of T/L is technically feasible without difficulty.
Alternative 3 Line Length of 220 kV : 35.9 km	Line Length of 220 kV : 35.8 km 35 m way Leave Corridor Forest: 10.1 ha Marsh: 10.4 ha Stream: 4.9 ha Paddy land: 58.0 ha Home garden: 11.5 ha	The percentages of marshes and streams higher than Alternative 1. This alternative passes through forest area considerably larger than Alternative 1.	Construction cost was estimated lower than Alternative 1. However, the difference is small.	Construction of T/L is technically feasible without difficulty.

In considering the alternative, in those cases, alternatives have been sought in terms of avoiding environmentally sensitive areas such as wetlands and mangroves, homesteads and houses over the shortest possible path of the line. In terms of the length, the shortest had been a line with a length of 35.8 km (option 2). Nonetheless, CEB opted to decide on the most feasible line route not on the basis of the length. As per the table below, the Sampoor-Kappalturai transmission line route, the distance for the selected option 1 has been 37.4 km (the longest route of the three options).

Alternative routes have further been in terms of their different types of land use classes. Table 11.3-19 lists land use classes of the area to be occupied under each of the alternative route 1, 2 & 3.

The selected option 1 shows 51.8 % of the line through paddy fields (cultivated, uncultivated or abandoned) compared to 44.5 % (option 2) and 46.2 % (option 3). The line option 1 passes through a forest area of 5.17 % while options 2 and 3 traverse the forest 8.4 % and 8.04 %, respectively. The percentages of marshes and streams in options 2 and 3 are higher and this shows that these two options are not feasible due to ecological and environmental sensitiveness of marshes and the wetland habitats close to the Koddiyar bay. Therefore selecting option 1 has been a clear strategy to minimize environmental and social implication of the project.

Table 11.3-19 Comparison Table Showing Different Land Use Classes under Each of the Alternative Routes of 220 kV Line (Sampoor- Kappalturai)

	Total Line Length of 220 kV line	37.4 km Option 1 (selected)		35.8 km Option 2		35.9 km Option 3	
	Land Use 35 m Way Leave Corridor	ha	%	ha	%	ha	%
i)	Forest	6.8	5.17	10.4	8.40	10.1	8.04
ii)	Marsh	3.9	2.96	3.9	3.15	10.4	8.30
iii)	Other	0.3	0.23	0.3	0.24	1.6	1.27
vi)	Home garden	6.7	5.09	5.8	4.68	11.5	9.15
v)	Scrub	36.5	27.75	32.8	26.50	22.4	17.83
vi)	Tank	3.7	2.81	7.4	5.98	2.3	1.83
vii)	Stream	3.3	2.50	4.9	3.95	6.5	5.17
viii)	Paddy	68.1	51.80	55.1	44.50	58.0	46.20
ix)	Chena	0.7	0.53	2.1	1.70	1.2	0.95
x)	Sand	0.3	0.23	-	-	-	-
xi)	Teak	0.6	0.45	0.6	0.48	0.6	0.47
xii)	Coconut	0.6	0.45	0.5	0.40	1.0	0.79
		131.5		123.8		125.6	

(Source: CEB)

11.3.5. Scoping

40 items of Environmental and social impact were set, according mainly to the items listed in JICA Guidelines for Environmental and Social Considerations (April 2010). The expected impacts were evaluated and summarized as scoping.

Table 11.3-20 shows the results of scoping with the reason of assessment.

Table 11.3-20 Results of Scoping

Environmental Item		Rating: Pre-Construction Stage/ Construction Stage	Rating: Operation Stage	Scoping (Identified impacts and reasons)
Social Environment				
1	Land acquisition and Involuntary Resettlement	C		**Pre-Construction:** According to satellite image and site observation it is expected that both land acquisition and involuntary resettlement are expected to be unnecessary for execution of the Project. It will be confirmed by the IEE study by CEB.
			D	**Operation:** Operation works which cause land acquisition and resettlement are not expected.
2	Poor people	D		**Pre-Construction:** Since the proposed transmission line will be passed through a non-residential area, impact on poor people is not expected.
			D	**Operation:** Operation activities which impact on poor people are not expected.
3	Indigenous people or ethnic minority	C	C	**Construction/Operation:** There is none of indigenous people. Ethnic minority around the project site shall be surveyed.
4	Local economy such as employment and livelihood, etc.	B+		**Construction:** Beneficial impact may be created employment opportunity for local people for construction works, even temporary.
			C+	**Operation:** Livelihood can lead to be diverse due to a stable power supply.
5	Utilization of land and local resources	B-		**Pre-Construction:** -Land use restriction of area used for the

No.	Environmental Item	Rating: Pre-Construction Stage/ Construction Stage	Rating: Operation Stage	Scoping (Identified impacts and reasons)
				construction of tower foundations and access roads are expected, while the total affected area will be small. -Tall trees and trees within specific height which might cause damage to the conductor or towers have to be removed. **Construction:** Construction materials (stone, gravel, sand and soil) using for construction are expected to be obtained from licensed quarries /borrow pits where environmentally controlled.
			D	**Operation:** Specific adverse impact is not expected.
6	Water usage	C-		**Construction:** The selected route does not traverse above any of the irrigation tanks directly. Though the route crossing some rivers, streams and irrigation canals are unavoidable, impact on water usage is slight.
			D	**Operation:** Specific adverse impact is not expected.
7	Existing social infrastructures and services	B-		**Construction:** -The traffic congestion is expected due to the traffic increase by transportation for construction. -Since there is a possibility that existing of facilities and lines of social infrastructure, confirmation is necessary by the IEE study by CEB.
			B+	**Operation:** The stable power supply can lead to improve the social services such as educational and health/medical facilities in wide service area.
8	Social institutions such a social infrastructure and local decision-making institutions	D	D	**Construction/Operation:** As the Project consists of a construction of new transmission line, and there would be little impact on social institutions and on decision-making institutions in the regional areas.
9	Misdistribution of benefit and damage	B-	B-	**Construction/Operation:** It is expected that there is almost no possibility of misdistribution of benefit and damage through the execution of the Project. However, with regard to the impact by, for example, operation of transportation vehicles and heavy machineries during construction, or tentative use of paddy field by the Project, if the explanation to the residents is insufficient, distribution of benefit and damage is possible to occur.
10	Local conflict of interests	D	D	**Construction/Operation:** The Project is a construction of new transmission line, and itself not to cause a conflict of interest in the region.
11	Cultural, historical, archaeological and religious heritage site	C		**Construction/Operation:** It is expected that no important cultural, religious, historical and archeological sites within the project area. It will be confirmed by the IEE study by CEB.
			D	**Operation:** Specific adverse impact is not expected.
12	Water rights, fishing rights and rights of common	C		**Construction/Operation:** Water rights and fishing rights are seemed not to be set in the river around the Project area. However it should be confirmed.
			D	**Operation:** Specific adverse impact is not expected.
13	Landscape	C-	C-	**Construction/Operation:** According to Satellite image and site observation it is expected that no particularly important existing landscape point with scenic, historical, cultural and recreational value along the project area.
14	Gender	D	D	**Construction/Operation:** Specific adverse impact is not expected.
15	Right of Children	D	D	**Construction/Operation:** No specific adverse impact on children's rights is expected with this Project.
16	Public health and Sanitation	B-		**Construction:** There may be temporary effects on health and sanitation of the residents around the

Environmental Item		Rating Pre-Construction Stage/ Construction Stage	Operation Stage	Scoping (Identified impacts and reasons)
				labor camps and the worksites.
			D	**Operation:** Specific adverse impact is not expected.
17	Infectious diseases such as HIV/AIDS	B-		**Construction:** A temporary influx of migrant construction workers and truck drivers are considered as having potential for the spread of infectious diseases such as HIV/AIDS by contacting with local women.
			D	**Operation:** Specific adverse impact is not expected.
18	Working condition (including occupational health)	B-		**Construction:** There is a possibility that the occupational safety and health of the workers may be jeopardized. In construction activities of this work includes many hazardous tasks and conditions such as work at height, excavations, noise, dust, power tools and equipment, confined spaces and high tension power supply.
			D	**Operation:** Specific adverse impact is not expected.
19	Accident	B-		**Pre-Construction:** (1) Risk during tree felling There is possibility that this risk occurs during Wayleave clearance. **Construction:** (2) Traffic Accident There is a possibility of accidents due to increase of traffic volume due to transportation vehicles for the project.
			D	**Operation:** Specific adverse impact including lightening danger is not expected.
20	Disaster	C-	C-	**Construction/Operation:** There are lesser possibilities of natural disasters due to storms and cyclones occurring within the project area. However, there is a possibility that impact by flooding may occur.
21	Global warming/ climate change	D		**Construction:** Impact on climate change is expected to be negligibly small.
			D	**Operation:** For the Project it can be expected that greenhouse gas emission is reduced. However, the effect is quite slight.
22	Safety from Electromagnetic field	D		**Construction:** Specific adverse impact is not expected.
			C	**Operation:** Height of towers and ground clearance will be designed so that strength of the electromagnetic field in ground level and upper floor level will be under the public electromagnetic exposure limit of the ICNIRP (International Commission for Non-Ionizing Radiation Protection).
23	Electromagnetic interference	C	C	**Construction/Operation:** The possibility of reception failure of radio/broadcasting by the pulse noise generated from power transmission line is expected to be very slight.
Natural Environment				
24	Protected Area	C		**Pre-Construction /Construction:** It will be confirmed by the IEE study by CEB.
			D	**Operation:** Specific adverse impact is not expected.
25	Terrestrital Flora	B-		**Pre-Construction/Construction:** There are possibilities that Endangered and Vulnerable plant species exist in transmission line corridor. It will be confirmed by the IEE study by CEB.
			D	**Operation:** Specific adverse impact is not expected.
26	Trees, Forest	B-		**Pre-Construction/Construction:** According to Satellite image and site observation it is expected that both land acquisition and

Environmental Item		Rating: Pre-Construction Stage/ Construction Stage	Operation Stage	Scoping (Identified impacts and reasons)
				involuntary resettlement are expected to be unnecessary for execution of the Project. It will be confirmed by the IEE study by CEB.-To provide ground clearance and in the process of clearing routes, tall trees or trees with specific conditions will be removed in order to ensure the safety of the public and to avoid any damage to the transmission line.
			D	**Operation:** Specific adverse impact is not expected.
27	Terrestrital Fauna	B-	B-	**Construction/Operation:** According site observation it is expected that that Endangered (including elephant) and Vulnerable animal species exist in transmission line corridor.
28	Aquatic Fauna and Flora	D	D	**Construction/Operation:** Large waterbodies are not directly encountered within the Project area.
29	Hydrological situation	D		**Construction:** Activities for the project will not change the hydrological pattern of the area. Specific adverse impact is not expected. No tower foundations will be placed within river beds or too closer to river banks.
			D	**Operation:** Specific adverse impact is not expected.
30	Topography and Geology	D		**Construction:** In the project area, there is almost no slope area where possibility that landslides or earth slips are expected to cause. The area is stable at present.
			D	**Operation:** Specific adverse impact is not expected.
31	Soil erosion / Destabilization of soil	C-		**Construction:** Possibility that earthmoving activities cause soil erosion is small because most earthmoving activities are not located on high land slopes, and the scale of land cutting and filling works is small.
			D	**Operation:** Specific adverse impact is not expected.
32	Groundwater	C-		**Construction:** It is not planned to use groundwater for construction. There is a possibility that contamination of groundwater occur from the vehicle maintenance area by accidental spillage of oil. Spills of oil, grease, fuel used on-site may pollute groundwater. However the possibility is very small.
			D	**Operation:** Adverse impact is not expected.
Environmental Pollution				
33	Air pollution	B-		**Construction:** Impact on air quality is expected by emission of dust and pollutants due to operation of construction vehicles and heavy machineries.
			D	**Operation:** Specific adverse impact is not expected.
34	Water pollution	C-		**Construction:** -There are almost no possibilities that soil runoff occur from a transmission tower construction sites and cause water quality degradation in downstream water areas -There is a possibility of water pollution by waste water from construction site, construction vehicles heavy machineries or workers camp.
			D	**Operation:** Specific adverse impact is not expected.
35	Soil contamination	C-		**Construction:** There is a possibility of soil contamination caused by pollutants or oils included in solid waste from construction site, heavy machineries, transportation vehicles and worker's camp. However the possibility is small.
			D	**Operation:** Specific adverse impact is not expected.
36	Bottom sediment	D		**Construction:** Sedimentation and accumulation of

Environmental Item		Rating Pre-Construction Stage/ Construction Stage	Operation Stage	Scoping (Identified impacts and reasons)
				water pollutants generated in construction work are not expected.
			D	**Operation:** No adverse impact is expected.
37	Waste	B-		**Construction:** Construction wastes, such as residual substances (metallic and non-metallic) and construction debris (soil, sand, etc.) are generated from the construction sites. Generation of hazardous waste is not expected. Daily general waste from the worker's camp is generated.
			D	**Operation:** Specific adverse impact is not expected.
38	Noise and Vibration	B-		**Construction:** Noise are generated from transportation vehicles and construction machineries, however the level, scope and duration of generation is limited. There will be no blasting operation near houses and buildings, and drilling works will be restricted within small and shallow ground area, vibration impact is expected to be very small.
			D	**Operation:** No adverse impact is expected.
39	Land Subsidence	D	D	**Construction/Operation:** Since use of groundwater in a large quantity is not expected in the Project, there is no possibility of land subsidence.
40	Offensive Odor	D		**Construction:** The possibility of generation of offensive odor is negligible small.
			D	**Operation:** Specific adverse impact is not expected.

11.3.6. TOR of Surveys on Environmental and Social Considerations

For the items selected from the results of scoping, details and methods were set as the TOR (Terms of Reference).

Table 11.3-21 shows the TOR of surveys on environmental and social considerations.

Survey method is use of the results of IEE study by CEB and utilization of information and data relating to the survey.

Table 11.3-21 TOR of Surveys on Environmental and Social Considerations

Environmental Item		Survey Item	Details and Methods of the Survey
Social Environment			
(1)	Land acquisition and Involuntary Resettlement	Situations of residents, buildings and occupation of land in the areas affected by the Project.	Field survey in the IEE study by CEB
(2)	Indigenous people or ethnic minority	Situation of residence indigenous people or ethnic minority in and around the Project site	Field survey in the IEE study by CEB
(3)	Utilization of land and local resources	1) Current land use in the Project area 2) Project affected area of home garden and paddy field and affected situation	1), 2) -Literature survey (IEE report by CEB, etc.) - Field survey in the IEE study by CEB
(4)	Water usage	Present water usage in the Project site	-Literature survey - Field survey in the IEE study by CEB
(5)	Existing social infrastructure and services	Situation of infrastructure and social service facility, etc.) in and around the Project site.	-Literature survey -Hearing from CEB - Field survey in the IEE study by CEB

Environmental Item		Survey Item	Details and Methods of the Survey
(6)	Misdistribution of benefits and damages	Expected damages and benefits.	Confirmation of the benefits to the region expected in the Project plan and negative impacts to the region expected in environmental impact examination
(7)	Cultural, historical, archaeological and religious heritage site	Existence of cultural, historical, archaeological and religious heritage site	Field survey andliterature survey (IEE study by CEB)
(8)	Water rights, fishing rights and rights of common	1) Conditions of setting of water rights, fishing rights of the rivers and water bodies in the Project sites 2) Present water usage in the Project site	1) Literature survey 2) Field survey in the IEE study by CEB
(9)	Landscape	Landscape evaluation with the surrounding landscape elements and design of the transmission line.	-Confirmation of existence of scenic area near the Project site. - Consideration about landscape harmonization between the transmission line and surrounding environment.
(10)	Public health and sanitation	Conditions of medical care, health and sanitation facilities around the Project sites.	-Literature survey -Field survey in the IEE study by CEB
(11)	Infectious diseases such as HIV/AIDS	HIV/AIDS prevalence around the project area	-Literature survey -collecting information from local government (in IEE study by CEB)
(12)	Working condition (including occupational health)	1) Laws and regulations concerning working conditions/work safety 2) Measures for work safety	1) Literature survey 2) - Survey for existing cases - Confirmation measures for work safety in the Project planning
(12)	Accidents	1) Current state of traffic accident in and around the Project sites. 2) Distance from construction sites and main roads to residence area and commercial area	1) -Literature survey concerning accidents 2) -Literature survey - Field survey in the IEE study by CEB
(13)	Disaster	State of occurrences of disasters (landslides, collapse of slopes, etc.) around the Project sites	-Literature survey -Survey in the IEE study by CEB
(14)	Safety from Electromagnetic field	Human influence by electromagnetic field and safety criteria/standard	- Literature survey (IEE report by CEB, etc.) - Hearing from CEB
(15)	Electromagnetic interference	Possibility of occurrence of electromagnetic interference	- Literature survey (IEE report by CEB, etc.)
Natural Environment			
(16)	Protected Area	Existence of protected area within the Project area	-Literature survey and field survey (IEE report by CEB, etc.) -Data concerning protected area and conditions of conservation
(17)	Terrestrial Flora	Current state of terrestrial flora in and around the Project site	- Field survey and literature survey (IEE report by CEB, etc.)
(18)	Trees, Forest	1) Number and species of trees to be cut/removed in and around the planned transmission line corridor 2) Necessary procedure for cutting/removal of trees	1) ,2) - Field survey and literature survey (IEE study by CEB)
(19)	Terrestrial Fauna,	Current state of terrestrial fauna in and around the Project site	- Field survey and literature survey (IEE study by CEB) - Collection information concerning

Environmental Item		Survey Item	Details and Methods of the Survey
			activities of elephants
(20)	Soil erosion / Destabilization of soil	Condition of topography, geology and soil in the planned area.	Field survey and literature survey (IEE study by CEB
(21)	Groundwater	1) Present ground water usage in the Project site 2) Impact on groundwater by construction activities	1), 2) Field survey and literature survey (IEE study by CEB)
Environmental Pollution			
(22)	Air pollution	1) Air quality standards in Sri Lanka 2) Current status of air quality in the project area.	1) Literature survey 2) Survey in IEE study by CEB
(23)	Water pollution	1) Water quality standards in Sri Lanka 2) Current status of water quality of rivers and water bodies in the project area. 3) Present water usage in the project site.	1) Literature survey 2) Survey in IEE study by CEB 3) Survey in IEE study by CEB
(24)	Soil contamination	1) Condition of oil leakage during construction 2) Possibility of discharging of contaminant to soil during construction work	1) Confirmation of prevention measure of oil leakage in construction activities. 2) Confirmation of soil contamination source and process during construction work.
(25)	Waste	1) Current situation and regulation of treatment and disposal of construction waste and general waste in the region 2) Methods of treatment/ disposal of construction waste and general waste in the construction plan	1) -Literature survey -Survey in IEE study by CEB 2) Confirmation of method of treatment and disposal of waste in the construction plan
(26)	Noise and vibration	1) Noise and vibration standards in Sri Lanka 2) Current state of noise around the Project area 3) Locations of public service and residential area 4) Confirmation of source of noise and vibration in construction	1) Literature survey 2) Literature survey 3) -Literature survey -Site observation 4) Confirmation of the construction plan

11.3.7. Results of the Environmental and Social Survey

Environmental and social survey according to the TOR was conducted in the IEE study by CEB. The Team utilized IEE draft final report and information and data obtained through IEE study by CEB.

Summary of the results of the environmental and social survey is as follows.

1) Land acquisition and Involuntary Resettlement

There is no house within 35 m corridor (within ROW). Accordingly, both land acquisition and involuntary resettlement are unnecessary for development of the Project.

Because of following potential impact, it is necessary to pay compensation by CEB to Project Affected Households (PAHs)

(i) Cutting/ removal of trees in home garden for Wayleave clearance..

(ii) Restriction of paddy land farming for the areas used by construction tower foundations and temporal access roads.

Income loss during restriction of paddy land farming shall be compensated. Affected paddy land area is estimated 900m^2 /tower including construction work space and temporal access road.

Almost all paddy land used for construction of tower foundations can be cultivated again after the construction activities.

(iii) Restriction of paddy land farming for the small areas (estimated 8m^2 /tower) used by four tower footings.

Income loss during long term restriction of paddy land farming shall be compensated.

2) Indigenous People or Ethnic Minority

There is none of indigenous people in and around the Project area.

Main ethnic minorities in Trincomalee District are Indian Tamils, Malay and Burger.

3) Utilization of Land and Local Resources

(Impacts of construction activities on Agriculture (Paddy lands))

The total amount of paddy land which is within 35 m corridor is about 70 ha. The farmers working on the paddy fields work one (mostly) or two agricultural seasons and that they work collectively for large expanse paddy lands, in order to manage water and pest problems. The farmer organizations stick to crop calendar, because any deviation means loss of opportunity to cultivate crops on time and thereby loss of income. The tower foundations will occupy 10m x 10m land area and that excavation will result in removing top soil, using construction materials such as cement, aggregates and iron etc. which if not properly managed will have adverse impacts when the farmers commence the agricultural activities. The work can obstruct the irrigation flow of water if spoils are dumped haphazardly.

Though tower foundations will occupy 10m x 10m land area, affected area of paddy field is tentatively estimated as 900m^2 /tower including construction work space and temporal access road. Income loss during restriction of paddy land farming in the area shall be compensated as described above 1).

4) Water usage

There are no project activities which obstruct water supply paths or canals. The degree of impact to water usage will remain at minimum, although a certain amount of surface water will be used for the construction.

5) Existing social infrastructure and services

Temporary congestion of traffic or speed limit for traffic security may occur. Therefore, there is a possibility of occurrence of some inconvenience, such as reduction of accessibility to public facilities

6) Misdistribution of benefits and damages

With regard to the aim of the Project and expected environmental impacts of the Project, CEB have been explained to inhabitants on several meetings on which affected persons or representatives of communities participated.

7) Cultural, historical, archaeological and religious heritage site

A large number of archaeological and historically significant sites are located in Trincomalee district. However, none of these are found in the transmission line corridor of 35 m (ROW) or the study area of 100 m either side of the line.

8) Water rights, fishing rights and rights of common

There are local notions of rights to water for different tanks and for individual users within the tank command areas, which have been used to argue for customary rights to water.

No fishing rights are set on surface water.

9) Landscape

There is no particularly important existing landscape resource or view point in and around the Project area.

10) Public health and sanitation

Labor camps with adequate sanitation, waste disposal, water supply and health facilities will be provided according to labour laws.

Hygienically sound sanitation facilities are to be set up in and around labour camps, which should not cause ground or surface water pollution.

11) Infectious diseases such as HIV/AIDS

Since there are people infected with HIV to some extent in Trincomalee district, it is important to prevent the spread of HIV/AIDS.

12) Working condition (including occupational health)

Since the nature of work require manual labor, working on high rise platforms, in muddy areas and with difficult working conditions accident can happen. During energizing of the lines, accidents may be caused due to electrocution.

Increased risk of accidents associated with the construction work is expected within the site if no safety management is applied.

All acts and regulations of the GOSL will be followed. The contractor should comply with all precautions as required to ensure the safety of workmen as per the International Labour Organization (ILO).

13) Accidents

(i) Traffic accidents

It is expected that traffic accidents on the key roads in and around the Project area sometimes occur at present. It is important to prevent traffic accident by transportation vehicles for the Project.

(ii) Lightening Danger from Transmission Lines and Transformers

If lightening hits a tower, which is always made of steel, the tower is already earthed to accommodate such lightning strikes.

As far as transmission lines are concerned, these are made of steel and lightning can strike the lines as well.

If for example, a farmer stands under a tower or even transmission lines, he is safe since they are both earthed.

(iii) Public Safety during construction phase

Public safety will be at stake due to construction work especially when the sites are in close proximity to public receptors such as schools. Transport of heavy equipment and due to increased vehicular movements, public safety will be at stake. During tree felling the general public will have risks specially those living close by and the pedestrians.

14) Disaster

The proposed transmission line passes through the flood plains of Mahaweli River and associated network of smaller rivers/streams (aru). Angle points 4 to 8 and 13-15 are located in the flood prone area map of Trincomalee district prepared by the Irrigation Department. Flooding in the Project area may be due to the flooding of rivers, inundation of low lying areas at times of heavy rainfall, overflow of storm water drains and coastal flooding due to rise in sea level (e.g. storm surges).

15) Safety from Electromagnetic field

In populated areas height of 15 m from ground to the sag point of the line is kept. With this height of the line, strength of the electromagnetic field in ground level and upper floor level will be under the public electromagnetic exposure limit of the International Commission for Non-Ionizing Radiation Protection (ICNIRP).

16) Electromagnetic interference

Since there isn’t a single house underneath the 35 m (ROW) width corridor of the transmission line and towers are installed far from living places, there is almost no possibility that any electromagnetic interference occurs.

17) Protected Area

There are no protected areas such as National Parks, Sanctuaries, or Conservation Forest managed by the Department of Wildlife Conservation and Forest Department crossing the ROW of 35 m or 200 m corridor of the T/L. However, the transmission line crosses several patches of Muttur Government Forests found either side of the ring road. The boundaries of these forest patches are demarcated by the Forest Department on the ground using the concrete posts.

18) Terrestrial Flora

(i) Impacts on Flora

Four plant species recorded during the field survey in 200 m corridor (100 m either side from the T/L center line) are endemic to the country (Table 11.3-22). Six nationally threatened plant species were also listed during the field survey (Table 11.3-23). All recorded endemic and indigenous flora species are not unique or restricted to the project area.

The ROW of 35 m that will be directly impacted by the project in forest, riverine forest and scrubland areas does not support any critical habitats. Most of the project related impacts would be confined to the 35 m corridor. All the endemic flora species and their populations are found in the nearby area that will not be impacted by the project activities. Some of the individuals of endemic or threatened tree species such as Makulla, Dikwenna, Palu, Burutha, Godakaduru and Kalu Ela are found within the ROW will be felled or uprooted due to the clearing of the area for tower bases or stringing. Individuals of these species are found in the nearby area so that their populations will not be affected due to a removal of few individuals. As the proposed activities will not result in a significant impact on habitats or species specific mitigation measures such as restoration of habitats, replanting or enrichment planting are not needed to protect the ecological resources present at the project affected area.

Table 11.3-22 Endemic Plant Species Observed along the Proposed Sampoor- Kappalturai Transmission Line

Family	Species	Local Name	HA	NCS
Achariaceae	*Hydnocarpus venenata*	Makulu	T	LC
Ebenaceae	*Diospyros nummulariifolia*	Kalu Ela	T	LC
Fabaceae	*Derris parviflora*	Sudu Kala wel	C	LC
Malvaceae	*Diplodiscus verrucosus*	Dikwenna	T	LC

HA-=Habit (T - Tree; C - Creeper;), NCS=National Conservation Status :National Redlist 2012 (LC-Least Concerned)
Area of Survey: 200 m corridor (100 m either side from the T/L center line)
(Source: CEB)

Table 11.3-23 Threatened Plant Species Observed along the Proposed Sampoor - Kappalturai Transmission Line

Family	Species	Local Name	HA	TS	NCS
Celastraceae	*Salacia oblonga*	Himbutu	C	In	EN
Loganiaceae	*Strychnos nux-vomica*	Goda Kadura	T	In	VU
Menispermaceae	*Tinospora cordifolia*	Rasankinda	C	In	VU
Orchidaceae	*Vanda tessellata*	Rassana	Ep	In	VU
Rutaceae	*Chloroxyclon swietania*	Burutha	T	In	VU
Sapotaceae	*Manilkara hexandra*	Palu	T	In	VU

HA=Habit (T - Tree, C - Climbers, Ep - Epiphyte), TS= Taxonomic Status (In - Indigenous)
NCS=National Conservation Status : National Redlist 2012 (EN - Endangered, VU – Vulnerable)
Area of Survey: 200 m corridor (100 m either side from the T/L center line)
(Source: CEB)

19) Trees, Forest

Table 11.3-24 gives number of trees to be felled within 35 m corridor (within ROB).

Table 11.3-24 Number of Trees to be Felled within 35 m Corridor

Total number of trees to be felled in 35 m corridor		
in home gardens	in forest between AP 1 and AP 17	in scrublands from AP 17 to TT2
6 coconut trees	234 trees	3,154 trees

(Source: CEB)

Approximately 234 forest trees and 6(six) home garden trees will be removed from the ROW of the transmission line. The initial construction works along the alignment involving land clearance, cutting and filling may cause loss of vegetation. This will be irreversible impact. Care has been taken to avoid the dense vegetation as far as possible and many tower locations are selected at paddy fields where the vegetation is sparse. This will minimize the tree loss. At the planning stage the CEB has selected the 220 kV line from with a corridor that traverses 51.8 % through paddy fields.

(i) Ecological Impacts

The transmission line is passing through human modified habitats such as paddy fields, homesteads, scrublands, and natural habitats; riverine forest and dry- mixed evergreen forests. The total area impacted is estimated to be approximately 146 ha (the land for development of switching station at Sampoor and the 35 m way leave corridor that has to be maintained along the 37.4 km long transmission line from Sampoor to Kappalturai). The site selected for Sampoor switching station and more than 70 % of the transmission line affects man made habitats such as paddy fields (both cultivated and abandoned) and homesteads while rest of the transmission line passes through scrublands, riverine forest and dry-mixed evergreen forest. Therefore, out of the 140 ha of land directly impacted by the project, natural habitats such as scrublands (36.5 ha) and forest (6.8 ha) comprise of about 43 ha.

(ii) Impact on Aquatic Ecology

No significant impacts on aquatic ecology of Mahaweli river, Uppu aru and other water ways/ streams associated with Mahaweli River are envisaged, as there will be careful selection of the tower sites near the river, streams and other aquatic habitats to avoid river pollution and disturbance to the aquatic fauna of the area.

20) Terrestrial Fauna

(i) Impacts on Fauna

Only a few nationally threatened species of fauna were identified in 200 m study area (Table 11.3-25).

Table 11.3-25 Threatened Animal Species Observed along the Proposed T/L

Family	Scientific Name	Local Name	TS	NCS	GCS
Testudinidae	*Geochelone elegans*	Taraka ibba	N	NT	LC
Anhingidae	*Anhinga melanogaster*	Abikava	N	LC	NT
Bucerotidae	*Anthracoceros coronatus*	Poru-Kandaththa	N	LC	NT
Ciconiidae	*Ciconia episcopus*	Padili Manawa	N	NT	VU
Columbidae	*Columba livia*	Podu Paraviya	N	CR	LC
Meropidae	*Merops philippinus*	Nilpenda Binguharaya	N/M	CR	LC
Threskiornithidae	*Threskiornis melanocephalus*	Hisakalu Dakaththa	N	LC	NT
Cercopithecida	*Semnopithecus priam*	Eli-wdura	N	LC	NT
Cervidae	*Rusa unicolor*	Gona	N	NT	VU
Elephantidae	*Elephas maximus*	Aliya	N	EN	EN

TS= Taxonomic Status (N - Native, M - Migrant)
NCS=National Conservation Status :National Red list 2012 (EN - Endangered, NT - Near Threatened, CR - Critically endangered, LC – Least Concerned), GCS=Global Conservation Status: IUCN Red list 2015 (EN - Endangered, VU - Vulnerable NT - Near Threatened, LC – Least Concerned)
Area of Survey: 200 m corridor (100 m either side from the T/L centre line)
(Source: CEB)

The fauna observed in the project impacted area are common species that can easily adapt to change. Only a few endemic and threatened species of fauna were identified in 200 m corridor area. This includes 7 species of endemic animals. Three animal species that are listed as nationally threatened. This is the normal habitats in the dry zone under influence of human activity which functions as repositories of common species rather than rare, endemic or threatened fauna. Therefore, the proposed project will not have a significant impact on threatened or endemic species or habitats that can be considered as critically important for conservation of biodiversity.

(ii) Impact on small mammals and reptiles

Migratory paths of small mammals and reptiles maybe affected due to construction activities. However, this is not critical due to the distance between towers is long enough and therefore adequate passages are available for them to move from the places where the construction activities are being carried out. Therefore, mitigatory measures such as over passes, under passes or separate corridors for their movement are not required during the construction period.

(iii) Impact on elephants

The location identified for Sampoor GSS and the transmission line sections located in the Sampoor area are used by Asian Elephants seasonally as evidenced by the secondary signs such as fecal droppings and interview surveys held with local community members. There is no evidence published or otherwise to indicate that the project site is located in an identified migratory route of elephants. At present the human-elephant conflict in the area is at a very low level. Elephants are large mammals with a home range that exceeds more than 5000 ha. Therefore projected loss of habitat (43 ha) resulting due to the proposed project is negligible. Further, the proposed project will not affect the movement patterns of elephants in the area. Therefore, proposed project interventions will not have a significant impact on elephants or result in an escalation of human elephant conflict in the area.

(iv) Impacts on Avifauna

Transmission lines are known to have an impact on the avifauna such as birds and bats. Therefore, the possibility of this impact due to the proposed intervention was also given due consideration. Based on the species assemblage observed along the transmission line route only few species were found to fly at the height at which the transmission line will be located. Further during the field visit inspection of the already existing transmission lines similar to the proposed transmission line indicated that there are no avifaunal impacts on such transmission lines. Therefore, it can be concluded that the proposed transmission line will not have an impact on the avifauna- accidental striking and electrocution of birds in the project affected area.

21) Soil erosion /Destabilization of slope

(i) Impact on Topography :Soil Erosion due to excavation and land clearing

The removal of herbaceous vegetation from the soil and loosening of the top soil generally causes soil erosion. However, such impacts would be primarily confined to the project site during initial periods of the construction phase and would be minimized through adoption of mitigation measures.

(ii) Impacts on slope stability

The proposed transmission line is passing through almost flat terrain, hence there is almost no direct impacts in terms of slope stability.

(iii) Impact on Soil and Geology

Excavation inside the Switching Station and the tower foundation bases may result in cut and fill operations. Transmission line laying work may require removal of trees/vegetation clearance. These activities will expose soil for excessive erosion, if work coincides with rainy seasons. During the excavation top fertile soil may be removed.

(iv) Soil compaction

Soil compaction can take place due to use of heavy machineries and vehicles and also can take place as a secondary process due to top soil erosions as well. This may lead to the reduction of infiltration capacity of soil layers and increase the runoff during the rainfall. This indicate soil compaction indirectly help topsoil erosion. The proposed project has minimum soil compaction impacts and mainly taking place only around the tower installations. However, hard laterite soil is commonly available along the proposed line were the compaction is not dominant.

22) Groundwater

Groundwater recharge rate is seem be significantly high in the area due to continuous fresh water supply by the Mahaweli river and others. Therefore, groundwater depth is generally shallow and unconfined. Thereby, shallow and unconfined nature of the groundwater around the proposed transmission line is susceptible to easy contaminations by anthropogenic pollutions.

Nevertheless, possibility of contamination of ground water by the Project is very small. The reasons are as follows.

- ✓ The vehicle maintenance area will be located as to prevent contamination of groundwater by accidental spillage of oil.

- ✓ All solid waste will be disposed in a waste disposal site designated by the local authority of the area.

23) Air pollution

During the construction stage, there will be increased traffic due to the additional vehicular movement when transporting personnel and materials to respective work sites. The traffic will be an additional public concern for those areas where traffic had not been experienced as a day to day phenomenon especially in those community access roads which are mostly gravel. Dust percolation and vehicular emissions can cause deterioration of the air quality.

There is also a possibility that air pollution is expected by emission of some pollutants from and heavy machineries. However, since the work is temporary and the scale the work is small, the impact is limited to proximity of construction area.

24) Water pollution

During the tower constructions excavation of alluvial soils should be carried out carefully. Alluvial soils are mixture of sand, silt and clay and possible to increase turbidity in surface water bodies even in the flat terrain. In order to control the turbidity in surface water bodies, it can be recommended to stop or control the construction activities during the rainy season.

Many of the angle towers are having easy access from Trincomalee ring road and other roads which are having permanent bridges across the river channels. Hence, no need any temporary road constructions across the river channels. Therefore, there is no significant impact on river morphology and surface water quality during the transportation of materials for construction.

Spills of oil, grease, fuel used on-site is expected to pollute surface water, though the pollution level may be very low.

In general, surface water quality will not be affected by the proposed project and pure water is usually available in the area. However, it is necessary to minimize addition of materials to surface water sources such as cements and chemicals during the proposed construction.

25) Soil contamination

All solid waste from construction activities will be collected and properly managed, in order to prevent contamination of soil and groundwater. All solid waste will be disposed in a waste disposal site designated by the local authority of the area.

26) Waste

All solid waste from construction activities will be collected and properly managed, in order to prevent contamination of soil and groundwater. Construction waste and waste from worker's camp shall be collected, segregated, properly reused and recycled according to regulations and rules of local government. Then all remained waste will be disposed to disposal site designated by local authority, without causing visual or leachate pollution or hazards to other users.

27) Noise and vibration

Noise, vibration and emission from construction vehicles, equipment will occur during construction and pre-construction stages in temporary manner.

(i) Noise

During the construction phase, the major sources of noise pollution are from the equipment used for tree felling, drilling (in case of small scale rock blasting) & movement of vehicles transporting the construction material and equipment to the site. The major work of the construction is expected to be carried out during the day time and that neighboring communities will not be disturbed during night hours. The noise produced during the construction will have negligible impact on the residents as the predominant land use along most part of the alignment is paddy fields, scrublands and forest.

(ii) Vibration

Vibration may be generated mainly by construction activities at each tower along the transmission line for a short duration. Because there will be no basting operation near residences and buildings, and drilling works will be restricted within small and shallow ground area far from the residences and buildings. Accordingly, vibration impacts on living environment by main vibration sources during construction are expected to be negligible.

11.3.8. Summary of Review for IEE Report

The designing of the transmission line was carefully selected by considering various options to minimize the environmental and social impacts. The alignment is sited away from major settlements, with accounting for future urban expansion.

CEB has extensively elaborated negative impacts relating to the environment and social issues. Overall, the major environmental and social impacts associated with the Project can be mitigated to acceptable levels by implementation of recommended measures in the IEE report and by best engineering and environmental practices.

CEB prepared adequate monitoring program to confirm the implementation of mitigation measures.

CEB prepared DFR (Draft Final Report) on September 3, 2015. CEB submitted final IEE report to PAA (Project Approving Agency, CEA) beginning of October 2015.

11.3.9. Environmental Impact Assessment

Based on the results of the surveys on environmental and social considerations and scoping, for items with a rating of B-, C-, or C during the pre-construction/construction or operation stage, the environmental impacts of the project are assessed.

Table 11.3-26 shows the results of the assessment with the reason of assessment.

Table 11.3-26 Results of Environmental Impact Assessment

Environmental Item		Assumed Rating of Impacts in the Scoping		Assessment Rating of Impacts based on the Results of the Survey		Reason of Assessment (Identified Impacts and Reasons)
		Pre-Construction Stage/ Construction Stage	Operation Stage	Pre-Construction Stage/ Construction Stage	Operation Stage	
Social Environment						
1	Land acquisition and Involuntary Resettlement	C	D	D	D	**Pre-Construction:** There are no houses within 35 m corridor (within ROW). Accordingly, both land acquisition and involuntary resettlement are unnecessary for development of the Project.
2	Indigenous people or ethnic minority	C	C	D	D	**Construction/Operation:** There is none of indigenous people in and around the Project area. Main ethnic minorities in Trincomalee District are Indian Tamils, Malay and Burger. There is no possibility that the Project affects directly on these people.
3	Utilization of land and local resources	B-	D	B-	D	**Pre-Construction:** -Cultivation is restricted temporally on some part of paddy field due to the construction of tower foundations and temporal access roads, while the total affected area will be small. For the income loss by restriction of paddy farming, compensation shall be paid by CEB. -Cultivation is restricted in long period on the area used for the tower footings, while the total affected area will be very small. For the income loss by restriction of paddy farming, compensation shall be paid by CEB. **Construction:** Earth and sand using for construction are obtained from the project site and licensed quarries /borrow pits where environmentally controlled.
4	Water usage	C-	D	D	D	**Construction:** There are no project activities which obstruct water supply paths or canals. The degree of impact to water usage will remain at minimum, although a certain amount of surface water will be used for the construction.
5	Existing social infrastructures and services	B-	B+	B-	B+	**Construction:** -Due to transportation of construction material/ equipment and construction waste, temporal traffic congestion or speed limit may occur. Therefore, there is a possibility of occurrence of some inconvenience, such as reduction of accessibility to public facilities. -Transmission line route was designed to avoid existing utilities wherever possible. -If any utilities must be moved, preparation of relocation plans must be prepared with service providers. -Usually 4 m width temporary access roads will be constructed carefully minimizing the disruptions to paddy farming operations. These temporal access roads will be completely removed after the construction.
6	Misdistribution of benefit and damage	B-	B-	D	D	**Construction/Operation:** -The project itself would not cause any unfair misdistribution of benefit and damage to the peripheral areas. - With regard to the aim and expected environmental impacts of the Project CEB have been explained to inhabitants on a stakeholders meeting and other small meetings on which affected persons or representatives of communities participated.

Environmental Item		Assumed Rating of Impacts in the Scoping		Assessment Rating of Impacts based on the Results of the Survey		Reason of Assessment (Identified Impacts and Reasons)
		Pre-Construction Stage/ Construction Stage	Operation Stage	Pre-Construction Stage/ Construction Stage	Operation Stage	
						-Consideration on employment priority should be given to local residents for simple construction work. -Through these activities misunderstanding for misdistribution of benefit and damage has been resolved.
7	Cultural, historical, archaeological and religious heritage site	C	D	D	D	**Construction:** A large number of archaeological and historically significant sites are located in Trincomalee district. However, none of these are found in the transmission line corridor of 35 m ROW or the study area of 100 m either side of the line.
8	Water rights, fishing rights and rights of common	C	D	D	D	**Construction:** -In Sri Lanka legal ownership of all surface water is government. However, as in most places with centuries of experience with irrigation, there are local notions of rights to water for different tanks and for individual users within the tank command areas, which have been used to argue for customary rights to water. - No fishing rights are set on surface water. Some irrigated farming household may use water for fishing.
9	Landscape	C-	C-	D	D	**Construction/Operation:** -There is no particularly important existing landscape resource or view point in and around the Project area. -At some forest places where transmission tower foundations are placed, surrounding trees and shrubs can moderate aesthetics impact.
10	Public health and Sanitation	B	D	B-	D	**Construction:** -There may be effects on health and sanitation around temporary labor camps. -Other generation source of sanitation problem may be wastes and water discharge.
11	Infectious diseases such as HIV/AIDS	B-	D	B-	D	**Construction:** There is a possibility that temporal migrating construction workers and drivers spread infectious diseases such as HIV/AIDS by contact with local women.
12	Working condition (including occupational health)	B-	D	B-	D	**Construction:** -Since the nature of work require manual labor, working on high rise platforms, in muddy areas and with difficult working conditions accident can happen. During energizing of the lines, accidents may be caused due to electrocution. -Increased risk of accidents associated with the construction work is expected within the site if no safety management is applied. -Accordingly, it is expected that there are risks of impairment to the health and safety of construction workers.
13	Accidents	B-	D	B-	D	**Pre-Construction:** (Risk during tree felling) During tree felling the general public will have risks specially those living close by and the pedestrians. **Construction:** (Traffic Accident) There is a possibility of accidents due to increase of traffic volume due to transportation vehicles for the project, particularly on key roads.

No.	Environmental Item	Assumed Rating of Impacts in the Scoping: Pre-Construction Stage/ Construction Stage	Assumed Rating of Impacts in the Scoping: Operation Stage	Assessment Rating of Impacts based on the Results of the Survey: Pre-Construction Stage/ Construction Stage	Assessment Rating of Impacts based on the Results of the Survey: Operation Stage	Reason of Assessment (Identified Impacts and Reasons)
14	Disaster	C-	C-	B-	D	**Construction:** Several angle points are located in the flood prone area map of Trincomalee district prepared by the Irrigation Department. Flooding in the project area may be due to the flooding of rivers (mainly Mahaweli river), inundation of low lying areas at times of heavy rainfall, overflow of storm water drains and coastal flooding due to rise in sea level (e.g. storm surges). Consideration for period and season of construction is necessary. **Operation:** Constructed T/L and towers are stable and operation and maintenance are not affected even in rainy season.
15	Safety from Electromagnetic field	D	C	D	D	**Operation:** Strength of the electromagnetic field in ground and upper level of houses within ROW corridor will be under the public exposure limit of the ICNIRP (International Commission for Non-Ionizing Radiation Protection).
16	Electromagnetic interference	C	C	D	D	**Construction/Operation:** Since there isn't a house underneath the 35m corridor (within ROW) of the transmission line, impact of electromagnetic interference by transmission line may be very small.
17	Protected Area	C	D	D	D	**Pre-Construction /Construction:** -There are no protected areas such as National Parks, Sanctuaries, or Conservation Forest managed by the Department of Wildlife Conservation and Forest Department crossing the 35 m (within ROW) or 200 m corridor of the T/L.
Natural Environment						
18	Terrestrital Flora	B-	D	B-	D	**Pre-Construction/Construction:** -Four plant species recorded during the field survey within the Project area are endemic to the country. Six nationally threatened plant species were also listed during the field survey. All recorded endemic and indigenous flora species are not unique or restricted to the project area. -Most of the project related impacts would be confined to the 35m corridor. All the endemic flora species and their populations are found in the nearby area that will not be impacted by the project activities. Some of the individuals of endemic or threatened tree species such as Makulla, Dikwenna, Palu, Burutha, Godakaduru and Kalu Ela are found within the ROW will be felled or uprooted due to the clearing of the area for tower bases or stringing. -Individuals of these species are found in the nearby area so that their populations will not be affected due to a removal of few individuals. Specific mitigation measures such as restoration of habitats, replanting or enrichment planting are not needed to protect the ecological resources present at the project affected area.
19	Trees, Forest	B-	D	B-	D	**Pre-Construction/Construction:** -Tall trees or trees that eventually grow high in home gardens, within a band of 17.5m on either side of the line (within ROW), will be removed. Compensation shall be paid by the CEB to the respective home garden landowners. -Approximately 234 forest trees and 6(six) home garden trees will be removed from the ROW of the transmission line and two lands

Environmental Item		Assumed Rating of Impacts in the Scoping		Assessment Rating of Impacts based on the Results of the Survey		Reason of Assessment (Identified Impacts and Reasons)
		Pre-Construction Stage/ Construction Stage	Operation Stage	Pre-Construction Stage/ Construction Stage	Operation Stage	
						in Sampoor and Kappalturai. -The initial construction works along the alignment involving land clearance, cutting, filling, and leveling may cause loss of vegetation.
20	Terrestrital Fauna	B-	B-	B-	B-	**Construction/Operation:** -The location identified for Sampoor SS and the T/L project area are used by Asian Elephan**ts** seasonally as evidenced by the secondary signs such as fecal droppings and interview surveys held with local community members. At present the human-elephant conflict in the area is at a very low level. -The fauna observed in the project impacted area are common species that can easily adapt to change. Only a few endemic and threatened species of fauna were identified in 200 m corridor area. This is the normal habitats in the dry zone under influence of human activity which functions as repositories of common species rather than rare, endemic or threatened fauna. Therefore, the proposed project will not have a significant impact on threatened or endemic species or habitats that can be considered as critically important for conservation of biodiversity.
21	Soil erosion / Destabilization of soil	C-	D	B-	D	**Construction:** -The proposed transmission line is passing through almost flat terrain. Except for hilly areas, other areas do not have erosion and destabilization issues due to adequate ground cover. -The removal of herbaceous vegetation from the soil and loosening of the top soil causes soil erosion. However, such impacts would be primarily confined to the hilly site during initial periods of the construction phase.
22	Groundwater	C-	D	D	D	**Construction:** Possibility of contamination of ground water is very small. -The vehicle maintenance area will be located as to prevent contamination of groundwater by accidental spillage of oil. -All solid waste will be disposed in a waste disposal site designated by the local authority of the area.
Environmental Pollution						
23	Air pollution	B-	D	B-	D	**Construction**: Air pollution is expected by emission of dust and some pollutants from transportation vehicles. Community access roads are mostly gravel and dust percolation and vehicular emissions can cause deterioration of the air quality. There is also a possibility that air pollution is expected by emission of some pollutants from heavy machineries. However, since the work is temporary and the scale the work is small, the impact is limited to proximity of construction area.
24	Water pollution	C-	D	B-	D	**Construction:** There is a slight possibility of turbid water pollution by earthmoving activities. There is a possibility of water pollution by oil leakage from transportation vehicles, heavy machineries or bad managed wastewater. It is necessary to minimize addition of materials to surface water sources such as cements and chemicals during the proposed construction spills of oil, grease, fuel used on-site is expected to

Environmental Item		Assumed Rating of Impacts in the Scoping		Assessment Rating of Impacts based on the Results of the Survey		Reason of Assessment (Identified Impacts and Reasons)
		Pre-Construction Stage/ Construction Stage	Operation Stage	Pre-Construction Stage/ Construction Stage	Operation Stage	
						pollute surface water, though the pollution level may be very low. **Operation:** There is no activity to leak oil from the transformer in this Project.
25	Soil contamination	C-	D	D	D	**Construction:** There is a possibility of soil contamination caused by emissions of pollutants or oils from waste. However from the reason shown below, possibility of occurrence of soil contamination is very small. All solid waste from construction activities will be collected and properly managed, in order to prevent contamination of soil and groundwater. All solid waste will be disposed in a waste disposal site designated by the local authority of the area. The disposal site is controlled so as to prevent contamination of soil by accidental spillage of pollutants or oils.
26	Waste	B-	D	B-	D	**Construction:** Construction wastes, such as residual substances (metallic and non-metallic) and construction debris (soil, sand, etc.) are generated from the construction sites. Daily general waste by the activities and living of the workers is generated in labors camp. Generation of hazardous waste is not expected.
27	Noise and Vibration	B-	D	B-	D	**Construction:** -Generation of noise and from transportation vehicles and heavy machineries is expected. However, the level, scope and duration of generation are limited. The noise produced during the construction will have negligible impact on the residents as the predominant land use along most part of the alignment are paddy fields, scrublands and forest. -Vibration may be generated mainly by construction activities at each tower along the transmission line for a short duration. Because there will be no basting operation near residences and buildings, and drilling works will be restricted within small and shallow ground area. There is a slight possibility of using rock blasting only in the place far from the inhabitances and buildings. Accordingly, vibration impacts on living environment by large vibration sources in construction are expected to be negligible.

11.3.10. Environmental Management Plan (EMP)

For the implementation of the project, there is no serious environmental and social impact. However, some items have negative environmental impacts to some extent. Accordingly, mitigation measures will be taken for these items.

1) Structure of the Implementation System

In consideration of the scale of impacts on environmental and social conditions by the Project, the implementation system of EMP will be consisted by two parts as shown in Table 11.3-27.

Table 11.3-27 Structure of the Implementation System of EMP

Plan Item	Important Matters in the Environmental Management Plan
Implementation of the monitoring plan	-Monitoring shall be implemented according to the plan. -Response/action to a comment and instruction from the local government and inhabitants shall be made according to the plan. -The report on the monitoring result shall be made according to the monitoring form, and reporting shall be conducted at a designated frequency.
Implementation of the mitigation measures	-CEB and the contractors shall securely implement the respective mitigation measures. -When a problem on environmental and social conditions still remains after implementing the mitigation measures, more effective and feasible mitigation measures shall be examined and applied to mitigate the impact under the responsibility of CEB.

(Source: Prepared by the Team)

2) Framework of the Implementation System of EMP

An Environmental Management Office (EMO) will be established by the CEB. The overall responsibility of implementation of the mitigation and monitoring plan will be entrusted to the EMO. It will instruct the contractor so that it will also follow the stipulated mitigation plan.

An Environmental Manager will be appointed who will be responsible for all the monitoring activities. The EMO will be staffed with specialists to cover all important fields such as ecology and socioeconomics. In general, setting EMO and assignment of Environmental Manager will be done at the timing of about half of year before starting of construction work (tentatively October,2016).

The duties of the EMO at the corporate level are as follows.

- ✓ Monitoring and implementation of mitigation measures during construction and operation phases of the project.
- ✓ Coordinate the preparation of suitable environmental management reports at various project sites.
- ✓ Advising and coordinating field environmental management cells activity towards effective environment management.
- ✓ Liaise with the Ministry of Power and Energy and Central Environmental Authority (CEA), relevant state agencies and seek their help to solve the environment related issues of the project implementation.
- ✓ Advice project planning cell on environmental and social issues to avoid negative environmental impacts.
- ✓ Provide training and awareness on environmental and social issues related to power transmission projects to the project staff.
- ✓ Liaise with the Forest Department and seek help of forest officers in resolving environment monitoring related issues.
- ✓ Make the contractor staff aware on environmental and social issues related to power transmission projects so that EMP could be managed effectively.

11.3.11. Mitigation Measures

Table 11.3-28 shows the mitigation measures and cost of the mitigation measures such items that classified as “B-” in the environmental impact assessment.

Table 11.3-28 Mitigation Measures and Cost of the Mitigation Measures

Environmental Item	Mitigation measures	Implementing Organization	Responsible Organization	Cost
Pre-Consulting & Construction Stage				
Social Environment				
1 Utilization of land and local resources (1) Land use restriction of area used for the construction of tower foundations and access roads	- Compensation will be paid for the restriction of paddy land use due to construction of tower foundations and temporal access roads. -Almost all paddy land used for construction of tower foundations can be cultivated again after the construction activities. -Temporal access roads will be sited carefully to minimize the disruptions to paddy farming. -CEB will inform in advance the relevant farmer organization and Grama Niladhari of the impending construction activities (through the Divisional Secretaries and GNDs). -Temporal access roads will be completely removed after the construction. -To remove top soil carefully and restore same after construction of tower foundations -Estimated paddy land of farming restriction: total 5.4 ha	CEB	CEB	CEB 464 k LKR
2 Utilization of land and local resources (2)Trees in home gardens to be cut/ removed	-Compensation shall be paid for cutting/ removal of trees in home gardens. -Affected households: 1 -Number of trees to be cut/removed: 6	CEB	CEB FD	CEB 180 k LKR
3 Utilization of land and local resources (3) Land use restriction of area used for the tower footings	-Compensation shall be paid for farming restriction of paddy land for the areas for four tower footings	CEB	CEB	CEB 206k LKR
4.Safety management for tree felling	Thorough safety management during tree felling (1) Clarification of the boundaries of the areas for tree felling. (2) Prior public announcement of schedule of tree felling.. (3) The Contractor prohibits the residents coming into the place of tree felling during the work.	Contractor	CEB Contractor	Contractor
Natural Environment				
5 Protected Area	-There are no protected areas such as National Parks, Sanctuaries, or Conservation Forest managed by the Department of Wildlife Conservation and Forest Department along the ROW of 35 m or 200 m corridor of the line.	CEB Contractor	CEB	CEB
6 Terrestrial Flora	-Some of the individuals of endemic or threatened tree species such as Makulla, Dikwenna, Palu, Burutha, Godakaduru, and Ilapaththa are found within the ROW. -Individuals of these species are found in the nearby area so that their populations will not be affected due to a removal of few individuals. -Specific mitigation measures such as restoration of habitats, replanting or enrichment planting are not needed to protect the ecological resources present at the project affected area.	CEB Contractor	CEB FD	CEB
7 Trees in forests	-Mitigation measures including cost bearing for removal and cutting of trees in several patches of Muttur Government Forests shall be consulted with Muttur Government and Forest Department.	CEB	CEB FD	CEB
8 Terrestrial Fauna Disturbance to elephants behavior in forest areas	1) A minimum of 13m of clearance is kept between the transmission line and the ground where there are elephant crossings to ensure safety of the elephants. The foundations of towers are sufficiently strong and solid such that even of elephants weight in on the transmission towers, no damage is anticipated either to the tower or to the elephants themselves. 2) Construction should complete within a shorter duration and limited to daytime in forest area. 3) Proper fencing should be used to secure excavated foundation areas during construction. The fencing may have to consider using suitably strong fencing to fend off	CEB Contractor	CEB	CEB 2,000 k LKR (Fence construction Cost)

Environmental Item	Mitigation measures	Implementing Organization	Responsible Organization	Cost
	elephants at all construction sites where elephants are possible to come close.			
9 Soil erosion / Destabilization of soil	-To avoid earthworks on erosion-prone areas during the rainy season. -When earthmoving activities are done, clearing vegetation will be minimized and earth bunds will be built beside drainage channels to avoid overspill. -Levelling and stabilization of tower construction sites will be done smoothly after completion of construction activity in order to avoid increased acceleration of surface run off and damage to the top soil. -Through the contractors, CEB will ensure carrying out turfing and other soil protection and erosion control measures close to the tower foundations	CEB Contractor	CEB	Contractor
Construction Stage				
Social Environment				
10 Existing social infrastructures and services	1) In the construction plan, consideration should be given so as not to interfere with the access to social service facilities. 2) Information disclosure well in advance on the construction work schedule and temporary traffic congestion. 3) Time shift of transportation and construction work, if necessary. 4) Prepare 'Traffic Management Plan' with relevant local government agencies. -Plan routes to avoid narrow roads or populated areas. -Validate routes by considering condition of roads, bridges, present traffic loads, safety records, etc. 5) If any utilities have to be moved, preparation of relocation plans must be prepared with service providers. 6) Installation of traffic induction staffs during construction	CEB Contractor	CEB	Contractor
11 Public health and Sanitation	1) Proper water and sanitary facilities shall be provided in labor camps prepared by the contractor. 2) To install temporal toilets of septic tank type in the construction site, if necessary. 3) Waste from worker's camp shall be collected, segregated, properly reused and recycled according to regulations and rules of local government. Then all remained waste will be disposed to disposal site designated by local authority, without causing visual or leachate pollution to other local users.	CEB Contractor	CEB	2) 800 k LKR (Temporal toilet)
12 Infectious diseases such as HIV/AIDS	1) Thorough education of prevention and cure of HIV/AIDS to migrating construction workers. 2) Education of prevention of HIV/AIDS to inhabitants. 3) Employing preferentially local residents as much as possible.	Contractor CEB	CEB	Contractor 1), 2) 100 k LKR (HIV/AIDS program)
13 Working condition (including occupational health)	1) The contractor and workers employed shall comply with the laws and regulations of Sri Lanka relating to the working conditions and working environment. 2) The contractor should take tangible safety measures as follows. -Installation of safety equipment which prevents working accidents -Physical zoning for of safety work area and installation of warning signs -Wearing of basic safety equipment such as safety shoes,	Contractor CEB	CEB	Contractor

Environmental Item	Mitigation measures	Implementing Organization	Responsible Organization	Cost
	gloves and helmet -Wearing safety best at high place 3) The contractor should take intangible safety measures as follows. -To prepare safety and health management plan, including traffic safety, accident prevention and public sanitation, etc. according to the regulations relating to working conditions. -To conduct educational training of safety, health and public sanitation to workers and staffs.			
14 Traffic Accidents	(1) Selecting the transportation route that has lowest possibility of accident. (2) Posting signs on the main roads to inform the time zone and the passage of transportation vehicles. (3) Clarification of the boundaries of the construction areas with rope, fences and other means. 4) Thorough instruction of safety driving and working to drivers of transportation vehicles. 5) Prior public announcement of contents and schedule of loading and unloading materials/ equipment, construction work schedule and temporary traffic congestion. 6) Time shift of construction work and operation of transport vehicles and vessels, if necessary.	CEB Contractor	CEB	Contractor
15 Disaster	Period of construction works shall be selected to avoid the influence by flooding.	CEB Contractor	CEB	Contractor
Environmental Pollution				
16 Air pollution	1) Use of low emission heavy machineries and vehicles, appropriate maintenance of them and use of good-quality fuel and oil. 2) To sprinkle water to prevent scattering dust from the construction site where soil soars during excavation and transportation. 3) Regulation of overload transportation vehicles. 4) Setting staff in charge of complaints from inhabitants and construction activity improvement corresponding to the complaints. 5) Construction work should not be carried out at night (construction time zone: 6am-7pm). 6) Air quality monitoring around the access roads.	Contractor CEB	Contractor CEB	Contractor
17 Water pollution	1) If necessary, drainage water from excavation site is held in sedimentation ponds to reduce the sediment content prior to discharge by use of silt traps etc. 2) Oils of transportation vehicles and construction heavy machineries shall be used with no leakage. Waste oils shall be stored and disposed safely. 3) Concrete curing water shall be discharged after neutralization. 4) Avoid entering of construction waste (cement particles, rock, rubbles and waste water) and sanitary waste to the surrounding water bodies. 5) Water quality will be monitored during construction period.	Contractor CEB	Contractor CEB	Contractor 2) 1,200 k LKR
18 Waste	1) The contractor should carry out properly segregation collection, treating and disposal of construction waste in strict compliance with the waste-related laws of Sri Lanka and regulations and rules of local government. 2) To stock and dispose safely of waste oils used in vehicles and heavy machineries. 3) The contractor shall provide education and	Contractor	Contractor CEB	Contractor

Environmental Item	Mitigation measures	Implementing Organization	Responsible Organization	Cost
	enlightenment for activities such as decreasing quantity, segregation, reusing and recycling) to workers.			
19 Noise and Vibration	1) To maintain thoroughly the vehicles and heavy machineries and to operate at low noise and vibration conditions. 2) To install sound proof fence or a buffer zone, if necessary. 3) Construction work should not be carried out principally at night (construction time zone: 6am-7pm). 4) To set staff in charge of complaints from inhabitants and construction activity improvement corresponding to the complaints. 5) Explanation of the construction work schedule to local people.	Contractor	Contractor CEB	Contractor
	Total Cost	Cost without the description of the amount CEB: Within the Project management cost: Contractor: within the construction management cost:		4,950 k LKR

11.3.12. Monitoring Plan

Table 11.3-29 shows Monitoring Plan.

Table 11.3-29 Monitoring Plan

Category	Environmental Item	Monitoring Indicator	Monitoring/ Measurement place (Point)	Monitoring Method	Frequency	Total No of times /samples	Implementing Organization	Responsible Organization	Cost (LKR) Burden Organization
Pre-Construction Stage									
Social Environment	Compensation for cutting/ removal of trees in home garden	Number of PAHs (Project Affected Households) which have received full amount of compensation	House of PAH	Confirmation with PAHs	3 times during pre-construction period	3 times	CEB	CEB	CEB*
	Safety management for tree felling	Status of safety management	Site of tree felling	Site observation	Occasional timing during tree felling		Contractor	Contractor CEB	Contractor**
	Compensation for temporal land use restriction of area used for the construction of tower foundations and access roads	Number of PAHs who have received full amount of compensation	House of PAH	Confirmation with PAHs	3 times during pre-construction period	3times	CEB	CEB	CEB*
	Compensation for long period land use restriction of area used for the tower footings	Number of PAHs who have received full amount of compensation	House of PAH	Confirmation with PAHs	3 times during pre-construction period	3times	CEB	CEB	CEB*
Pre-Construction and Consultation Stage									
Natural Environment	Flora	Existence of endangered species	Species, Number	Ecological site survey	3 times during pre-construction and construction period	3 times	Local consultant	CEB Local consultant	CEB 150 k LKR
	Progress of cutting/ removal of trees in Forest	Ratio of finished area/total area that is necessary to be cut/removed	Area (ha)	Confirmation with FD	3 times during pre-construction and construction period	3 times	Local consultant	CEB Local consultant	CEB 60 k LKR

Category	Environmental Item	Monitoring Indicator	Monitoring/ Measurement place (Point)	Monitoring Method	Frequency	Total No of times /samples	Implementing Organization	Responsible Organization	Cost (LKR) Burden Organization
	Fauna Activity of Elephant	Occurrence of Elephant-Human conflict Evidence of unusual activity of Elephant	Near the place for tower construction	Observation	9 times during pre-construction and construction period	9 times	Local consultant	CEB Local consultant	CEB 360 k LKR
Construction Stage									
Social Environment	Temporal traffic congestion	Occurrence of complaints for traffic congestion	Around the main roads	Hearing from inhabitants	2 times /month during construction	48 times	Contractor	CEB Contractor	Contractor**
	Health and Sanitation	Conditions of drinking water and sanitary facilities	Workers Camp	Observation	2 times /month during construction	48 times	Contractor	CEB Contractor	Contractor**
	Infectious diseases such as HIV/AIDS	Number of HIV-positive persons	Relevant District office	Hearing from relevant District offices	2 times/ year (During construction)	4 times	Contractor	CEB Contractor	Contractor**
	Traffic accidents	Occurrence of Traffic accidents	Relevant District office	Hearing from relevant District offices	Occasional timing (During construction)		Contractor	CEB Contractor	Contractor**
	Working Condition (Including Work Safety)	Work Safety	Construction sites	Observation of working condition	During usual working time (During construction)		Contractor	CEB Contractor	Contractor**
Natural Environment	Protected Area	Condition of Natural Environment	In three Forest Reserve and one Conservation Forest Reserve	Ecological Inspection	yearly for 4 areas	2 times for 4 areas	Local consultant	CEB	CEB 320 k LKR
	Soil erosion / Destabilization of soil	Extent of Soil erosion and effect of the mitigation measures	Tower construction sites	On site observation	monthly (During construction)	24 times	Contractor	CEB Contractor	Contractor**
Environmental Pollution	Air quality	SO_2 NO_2 CO PM_{10} SPM	Near fourAP (4 points) -Sampoor at switching station site -Kappalturai SS site -Two point between Sampoor and Kappalturai	On site measuring	dry season Pre-construction :1 During construction:4	20 measurements	Local consultant (measurement)	CEB	CEB 1,000 k LKR

Category	Environmental Item	Monitoring Indicator	Monitoring/ Measurement place (Point)	Monitoring Method	Frequency	Total No of times /samples	Implementing Organization	Responsible Organization	Cost (LKR) Burden Organization
	Water quality	SS BOD_5 Turbidity Oil & Grease	5 water bodies (surface layer) -Mahaweli Ganga -Verical Aru -Uppu Aru -One rivulet -Two canal	Standard Sensor/ Analyzer Digital turbidity meter	dry season Pre-construction :1 During construction :4	25 samples	Local consultant (measurement)	CEB	CEB 875 k LKR
	Noise and Vibration	1) Noise (day and night) 2) Vibration	1) Noise 4 Points same as air quality (day & night for each measurement) 2) Vibration – boundary of generation source	1) Noise - Sound level meter 2) Vibration - Vibration level meter	1) Noise - dry season Pre-construction :1 During construction:8 2) Vibration - dry season Pre-construction :1 During construction – when vibration generating machine is operated	1) Noise -36 measurements (day & night for each time)	Local consultant (measurement)	CEB	CEB 720 k LKR
	Waste	Construction Waste	Construction site	Visual observation Condition of discharge and treatment of waste	2 times / month Particularly important when complaint is reported. (During construction period)	48 times	Contractor	Contractor	Contractor**
		General daily waste	Workers camp						
Total cost									3,485 k LKR

Note: *: CEB; Within Project general administration cost

**: Contractor ; Within construction management cost

(Source: Prepared by the Team)

11.4. Land Acquisition and Involuntary Resettlement

11.4.1. Necessity of Land Acquisition and Involuntary Resettlement

11.4.1.1. 400 kV T/L

In the plan of the Project, height of 15m from ground to the sag point of the conductivity line is kept for houses, villages and public buildings area. With this height of the line, strength of the electromagnetic field from ground level to upper floor level of will be under the public exposure limit of the ICNIRP (International Commission for Non-Ionizing Radiation Protection).

There are no houses of 3-storey or more within the ROW corridors. Accordingly, both land acquisition and involuntary resettlement are unnecessary for development of the Project.

11.4.1.2. 220 kV T/L

There is no house within 35m corridor (within ROM) of the proposed transmission line. Accordingly, both land acquisition and involuntary resettlement are unnecessary for development of the Project.

11.4.1.3. Necessity of compensation

Though land acquisition and involuntary resettlement are unnecessary for development of the Project, because of following potential impact, it is necessary to pay compensation by CEB to Project Affected Households (PAHs)

(i) Cutting/ removal of trees in home garden.

(ii) Restriction of paddy land farming for the areas used by construction tower foundations and temporal access roads.

(iii) Restriction of paddy land farming for the areas used by four tower footings.

For these potential impacts it is necessary to pay compensation by CEB to Project Affected Households (PAHs)

11.4.2. Legal and Policy Framework

11.4.2.1. Land Acquisition Act of Sri Lanka

Land Acquisition Act (1950, as amended from time to time) is the core law for land acquisition regulations of Sri Lanka. It was built upon the Land Acquisition Ordinance of 1876.

The lands are acquired under the provisions of the Land Acquisition Act and regulations imposed thereto and compensation and interests are paid to the land owners in respect of the lands acquired.

In case where a land is required for a public purpose of any Ministry, Department, Corporation, Statutory Board, Provincial Council or a Local Government Institution, the Head of the particular Department forwards an acquisition proposal to the Secretary, Ministry of Land through the Secretary to the Ministry of which the particular institution fallen under the purview.

After confirming accuracy of the proposal, the acquisition procedure is commenced on the approval of the Minister of Land and Land Development.

The latest several amendments of LAA are the 1986 version and the Revised Regulations of 2008, which were gazetted as No. 1585/7 in January 2009. It provides the basis for assessing the market value of land or compensation necessitated by the acquisition of land.

LAA stipulates only general provisions for land acquisition procedures and compensation for land, structures and crops. It stipulates no provision for involuntary resettlement. It did not direct project executing agencies to address key resettlement planning and implementation issues such as 1) exploring alternative project options to avoid or minimize impacts on people, 2) compensating the non-titled persons who will be affected by a project, 3) consulting affected persons and resettlement hosts on resettlement options, 4) rehabilitating affected persons.

The process and relevant organizations for land acquisition, which is based on LAA is shown in Table 11.4-1.

After the receipt of compensation, no objection from land owners will be permitted. The landowner is notified of the amount of compensation that will be paid for the land by the project implementation agency through relevant offices of the Divisional Secretariat.

Table 11.4-1 Land Acquisition Process and Relevant Organizations

Step	Organization/Agency	Procedure
Acquisition Application	Applicant Institution	Forward the application through the respective Ministry
Section 2 Direction	Ministry of Land and Land Development	Grant authority to enter the land and the decision of Minister that the particular land is needed for a public purpose.
Section 2 Notice Sinhala, English, Tamil	Divisional Secretary	Publish the notice in the surrounding area.
Advance Tracing		Superintendent of Surveys
Section 4 Direction	Ministry of Land	Inviting objections from the land owners and decision of the Minister for investigation
Section 4 Notice Sinhala, English, Tamil	Divisional Secretary	Publish the notice inviting objections
Objection Inquiry	Applicant Ministry	Forward recommendations after conducting investigations on objections
Section 5 Declaration	Ministry of Land and Land Development	Decision of the Hon. Minister of Lands that the land is to be acquired
Section 5 Notice Sinhala, English		
Final plan		Superintendent of Survey

Section 7 Gazette Notice Sinhala, English	Divisional Secretary/ Government Printer	Invitation notice to investigate the title of the land.
Section 9 Inquiry into Title	Divisional Secretary	Investigating title
Section 10 Decision on Title Notice, Forward to Court	Divisional Secretary	Determine the title
Valuation	Valuation Department	
Section 17 Awarding Compensation	Divisional Secretary	
Payment of Compensation	Divisional Secretary	Allocate financial provisions from the Ministry of Lands or the relevant Institution and make payments to the land owner
Gazetting 38 Order	Ministry of Land and Land Development	Take over the land's possession to the Government
Taking undisturbed possession	Divisional Secretary	Take over the procession and hand it over to the applicant institution
Section 44 Vesting Certificate/Registration of State Ownership	Divisional Secretary/Registrar General	Issue vesting certificate to the Institution concerned, after payment of compensations to the land owners

(Source: "Acquisition Process", Homepage of Ministry of Lands, July 14, 2015)

11.4.2.2. National Involuntary Resettlement Policy (NIRP) of Sri Lanka

The Government of Sri Lanka has adopted the National Involuntary Resettlement Policy (NIRP) in 2001.

It was established not as an act but a policy. A move to legalize this policy is in process. Currently, however, it has not become law, and there are no provisions for its implementation.

Currently, NIRP goes beyond the Land Acquisition Act, and takes into account not just acquisition (which is all the Land Acquisition Act deals with) but also the planning and the resettlement and restoration post acquisition.

NIRP does not include a method for compensation calculation but it states that compensation for loss of land, structures, other assets and income should be paid. This should include transaction costs.

The NIRP is based on twelve principles. Overall it encourages developers to avoid involuntary resettlement wherever policy and to plan resettlement as part of the development activity. It aims to:

- ✓ Provide land for land as an option
- ✓ Pay compensation at full replacement cost given promptly

- ✓ Assist affected households to reestablish their livelihoods and improve their quality of life
- ✓ Bear the cost of the resettlement process
- ✓ Provide common property resources, community and public services

The NIRP principles include also those that govern consultation of all stakeholders and the participation of affected people in decisions relating to resettlement and restoration. It provides for:

- ✓ Participation of people affected in decisions relating to the resettlement options such as Compensation, selection of land etc.
- ✓ Just and fair treatment of vulnerable people and non-title holders
- ✓ Inclusion of local authorities in the process
- ✓ A participatory process to integrate the affected people with their new host communities

The NIRP emphasizes that affected people also need to be helped in restoring sourced and livelihood at least, to the level that prevailed prior to the loss of land and physical relocation.

11.4.2.3. JICA Guidelines

The policy of JICA Guidelines on land acquisition and involuntary resettlement is summarized below.

1) Involuntary resettlement and loss of means of livelihood are to be avoided when feasible by exploring all viable alternatives.

2) When, population displacement is unavoidable, effective measures to minimize the impact and to compensate for losses should be taken.

3) People who must be resettled involuntarily and people whose means of livelihood will be hindered or lost must be sufficiently compensated and supported, so that they can improve or at least restore their standard of living, income opportunities and production levels to pre-project levels.

4) Compensation must be based on the full replacement cost as much as possible.

5) Compensation and other kinds of assistance must be provided prior to displacement.

6) For projects that entail large-scale involuntary resettlement, resettlement action plans must be prepared and made available to the public. It is desirable that the resettlement action plan include elements laid out in the World Bank Safeguard Policy, OP 4.12, Annex A.

7) In preparing a resettlement action plan, consultations must be held with the affected people and their communities based on sufficient information made available to them in advance. When consultations are held, explanations must be given in a form,

manner, and language that are understandable to the affected people.

8) Appropriate participation of affected people must be promoted in planning, implementation, and monitoring of resettlement action plans.

9) Appropriate and accessible grievance mechanisms must be established for the affected people and their communities.

Above principles are complemented by World Bank OP 4.12, since it is stated in JICA Guideline that "JICA confirms that projects do not deviate significantly from the World Bank's Safeguard Policies". Additional key principle based on World Bank OP 4.12 is as follows.

1) Affected people are to be identified and recorded as early as possible in order to establish their eligibility through an initial baseline survey (including population census that serves as an eligibility cut-off date, asset inventory, and socioeconomic survey), preferably at the project identification stage, to prevent a subsequent influx of encroachers of others who wish to take advance of such benefits.

2) Eligibility of Benefits include, the PAPs who have formal legal rights to land (including customary and traditional land rights recognized under law), the PAPs who don't have formal legal rights to land at the time of census but have a claim to such land or assets and the PAPs who have no recognizable legal right to the land they are occupying.

3) Preference should be given to land-based resettlement strategies for displaced persons whose livelihoods are land-based.

4) Provide support for the transition period (between displacement and livelihood restoration.

5) Particular attention must be paid to the needs of the vulnerable groups among those displaced, especially those below the poverty line, landless, elderly, women and children, ethnic minorities etc.

6) For projects that entail land acquisition or involuntary resettlement of fewer than 200 people, abbreviated resettlement plan is to be prepared.

In addition to the above core principles on the JICA policy, it also laid emphasis on a detailed resettlement policy inclusive of all the above points; project specific resettlement plan; institutional framework for implementation; monitoring and evaluation mechanism; time schedule for implementation; and, detailed Financial Plan etc.

11.4.2.4. Comparison with JICA Guideline and Sri Lanka Legislation in land acquisition and involuntary resettlement

Table 11.4-2 shows gaps of policies between the JICA Guidelines and Sri Lanka Legislation in land acquisition and involuntary resettlement.

Table 11.4-2 Gaps of Policies between the JICA Guidelines and Sri Lanka Legislation in Land Acquisition and Involuntary Resettlement

No.	JICA Guidelines/World Bank	Laws of Sri Lanka	Gaps between JICA Guidelines and Laws of Sri Lanka/
1	Involuntary resettlement and loss of means of livelihood are to be avoided when feasible by exploring all viable alternatives. (JICAGL)	National Involuntary Resettlement Policy (NIRP, 2001)	(NIRP Principle) Involuntary resettlement should be avoided or reduced by reviewing alternative project options. (basically there is no gap)
2	People who must be resettled involuntarily and people whose means of livelihood will be hindered or lost must be sufficiently compensated and supported, so that they can improve or at least restore their standard of living, income opportunities and production levels to pre-project levels.(JICAGL)	NIRP (2001)	(NIRP Principle) Where unavoidable, project affected persons should be assisted to re-establish and improve the quality of life. (basically there is no gap)
3	Compensation must be based on the full replacement cost as much as possible. (JICAGL)	NIRP (2001)	(NIRP Principle) Compensation for fixed structures, other assets and income including transaction costs, should be based on full replacement cost. (basically there is no gap)
		Land Acquisition Act (LAA) No. 9 (1950/1956)	The Act provides for the payment of compensation on the basis of "market value" defined as the amount which the land might be expected to have realized if sold by a willing seller in the open market. (basically there is no gap)
4	Compensation and other kinds of assistance must be provided prior to displacement. (JICAGL)	NIRP (2001)	NIRP mentions that compensation should be paid promptly. (There is a little gap. The policy for the Project follows JICA GL)
5	In preparing a resettlement action plan, consultations must be held with the affected people and their communities based on sufficient information made available to them in advance. (JICAGL)	NIRP (2001)	Selection of resettlement sites, livelihood compensation and development options should be explored with the participation of the affected persons. (basically there is no gap)
6	Appropriate and accessible grievance mechanism must be established for the affected people and their communities. (JICAGL)	LAA No. 9 (1950/1956)	The Act provides a limited grievance redress mechanism whereby certain grievances of the affected persons relating to compensation can be referred to the Board of Review established under the Act. (basically there is no gap)
		NIRP (2001)	The NIRP recommends Grievances redress mechanism formally instituted by the project authorities with the support of the Divisional Secretaries of the project area. (There is a little gap. The policy for the Project follows JICA GL)
7	Eligibility of benefits includes, the PAPs who have formal legal rights to land (including customary and traditional land rights recognized under law), the PAPs who don't have formal legal rights to land at the time of census but have a claim to such land or assets and the PAPs who have no recognizable legal right to the land they are occupying. (WB OP4.12 Para.15)	NIRP (2001)	Affected persons who do not have documented title to land should be treated fairly and justly. (basically there is no gap)
8	Particular attention must be paid to the needs of the vulnerable groups among those displaced, especially those below the poverty line, landless, elderly, women and children, ethnic minorities, etc. (WB OP4.12 Para.8)	NIRP (2001)	Vulnerable groups should be identified and given assistance to improve their living standards. (basically there is no gap)

(Source: Prepared by the Team tabulated based on Land related laws of Sri Lanka and JICA Guidelines (2010.4) and World Bank OP 4.12.)

11.4.2.5. Electricity Act

Sri Lanka Electricity Act (No. 20 of 2009) was acted in 2009 and provides the regulations of the generation, transmission, distribution, supply and use of electricity in Sri Lanka.

The Public Utilities Commission of Sri Lanka (hereinafter referred to as the "Commission") established by the Public Utilities Commission of Sri Lanka Act, No. 35 of 2002, shall exercise, perform and discharge all the powers, functions and duties as are conferred on or assigned to the Commission by or under this Act.

In terms of Section 2A (1) (b) of the Sri Lanka Electricity Act, No. 20 of 2009 as amended by the Act, No.31 of 2013, the Commission may delegate any power conferred on it by items 3, 4, 5 and 6 of Schedule I of that Act to any Divisional Secretary (ANNEX 1 of the Electricity Act <DIVISIONAL SECRETARIES BY THE PUBLIC UTILITIES COMMISSION OF SRI LANKA (17th October 2013)>).

The licensees (CEB for the Project) and the Divisional Secretaries are expected to discharge their respective powers and duties under the said Act.

The Electricity Act is the core law for compensation issue relating to wayleave clearance.

In the Act, there are two types of compensation. One is land acquisition and another is for compensation for other than land acquisition. There is no description for item word "involuntary resettlement".

If a planned project requires land acquisition, the procedure of land acquisition and compensation are implemented according to the land acquisition act. Practical procedure of compensation for wayleave clearance other than land acquisition is stipulated in the "Guidelines on Wayleave and Felling or Lopping of Trees".

<< GUIDELINES ON WAYLEAVE AND FELLING OR LOPPING OF TREES (17th October 2013)>>

The guidelines are prepared in terms of the Sri Lanka Electricity Act, No. 20 of 2009 (as amended) and approved by the Commission on 17th October 2013. Then the guidelines became ANNEX 2 of the Electricity Act. However, policy or principle of compensation is not described not so in detail as the Land Acquisition Act and National Involuntary Resettlement Policy.

The guidelines mainly intend to:

- ✓ guide the licensees, who will be the applicants to the Divisional Secretaries requesting authority;

(i) to install or keep installed an electric line on, under or over any land;

(ii) to fell or lop a tree or cut back its roots that obstruct or interfere with the installation, maintenance or working of an electric line or plant, or constitute an unacceptable cause of danger.

- ✓ guide the Divisional Secretaries, who are delegated powers by the Commission conferred on it by items 4 of Schedule I of the Electricity Act:

(i) to determine the amount of compensation that a landowner may recover from the licensee in respect of grant of wayleave

(ii) to determine the amount of compensation that a person may recover from the licensee for any disturbance caused to his or her enjoyment of any land or movables in consequence of the exercise of any right conferred by a wayleave

<Compensation with respect to Grant of a Wayleave>

1) Where a wayleave is granted to a licensee under item 3 of Schedule I of the Electricity Act (by way of authority granted by the Divisional Secretary or acquisition under the Land Acquisition Act), the owner of the land may recover from the licensee reasonable compensation in respect of the grant as may be determined by the Divisional Secretary. Hence, the Divisional Secretary shall give due consideration for the amount of compensation claimed by the owner of the land (as part of the terms and conditions subject to which he or she is prepared to grant the wayleave) at any inquiry being held in response to an application made by a licensee requesting authority.

2) If any damage is caused to land or to movables in the exercise of any right conferred by a wayleave, any person interested in such land or movables may recover reasonable compensation in respect of that damage from the licensee.

3) If a person is disturbed in his or her enjoyment of any land or movables in consequence of the exercise of a right conferred by a wayleave, he or she may recover compensation in respect of that disturbance, of such amount as may be determined by the Divisional Secretary, from the licensee.

4) The Divisional Secretary may on its own motion or on the application of a person affected, conduct such inquiries as may be necessary to determine whether a licensee is liable to pay any person any compensation under paragraphs 1), 2) and 3) above.

5) Upon deciding whether any compensation is payable and, if so, the amount of compensation payable by the licensee, at the conclusion of any inquiry conducted under paragraph 4) above, the Divisional Secretary will communicate such decision in writing to the licensee and to any person who has applied for, or was awarded, compensation. The Divisional Secretary in that communication will clearly indicate the basis for his or her decision on compensation.

<Guidelines on felling or lopping trees>

In this part, detailed official procedure for felling (removal) or lopping (cutting) and compensation for these action by a project are described.

And forms of documents used in the procedure for felling or lopping and compensation are attached as Appendix of the guidelines (for example: NOTICE REQUIRING WAYLEAVE,

GRANT OF WAYLEAVE, WAYLEAVE AGREEMENT, APPLICATION REQUIRING AUTHORITY TO INSTALL/KEEP INSTALLED AN ELECTRIC LINE, NOTICE REQUIRING TO FELL OR LOP A TREE)

11.4.3. Scale and Scope of Land Acquisition and Involuntary Resettlement

11.4.3.1. Scope of Affected Subject

Table 11.4-3 shows scale and scope of land acquisition and involuntary resettlement

Table 11.4-3 Scope of Land Acquisition and Involuntary Resettlement

	Affecting action	Subject to be affected Trees/Paddy Land/Household	Average quantity of unit per one tower	
			400 kV T/L	220 kV T/L
1	-Cutting/Removal of trees of home garden	Trees in home garden Total numbers of trees	227	6
		Species of trees	Coconut and others	Coconut
		Number of home garden = Number of PAHs	24	1
2	-Farming restriction of paddy land used by construction of tower foundations -Farming restriction of paddy land used by construction of temporal access roads	Unit area of affected by construction of tower foundations in paddy land m^2/tower (tentative estimation)	1,000m^2 foundation: 400 m^2 access road: 400 m^2 stock yard: 200 m^2	900m^2 foundation: 300 m^2 access road: 400 m^2 stock yard: 200 m^2
		Number of towers (tentative estimation)	80	60
		Number of affected land owners (assumed to be almost same as number of towers)	80	60
		Total area of affected in paddy land (tentative estimation)	80,000 m^2=8 ha	54,000 m^2=5.4 ha
		Affected period	one season (double cropping)	one season (single cropping)
3	-Farming restriction of paddy land used by tower footings	Unit area of affected by using of tower footings in paddy land m^2/tower (tentative estimation)	2 m^2/ one pole(footing) →8 m^2/ one tower	
		Number of towers (tentative estimation)	80	60
		Number of affected land owners (assumed to be almost same as number of towers)	80	60
		Total area of affected in paddy land (tentative estimation)	640 m^2	420m^2
		Affected period	50years=100seasons(double cropping)	50years=50seasons (single cropping)

(Source: Prepared by the Team)

11.4.3.2. Estimation of number of land owner affected by tower construction in the paddy land

1) 400 kV T/L

Number of towers located on paddy land was estimated to about 80 by overlaying position of planned towers and land use on Google image map.

Assuming that the average area of paddy land per owner is less than 1 ha (100m X 100m). The one side length of owned land along transmission line is less than 100m. In addition, distance between adjacent two towers is considered to be from 300m to 400m in average. Thus, it is unlikely that one demarcated paddy land stride with more than the width of the two towers. Therefore, number of land owners is considered to be mostly equal to number of towers, i.e. about 80.

2) 220kV T/L

Total number of towers erected for the 220kV T/L is 113. 52% of T/L passes through paddy land. Number of towers located on paddy land was estimated to about 60. (113 X 0.52=58.8)

Assuming that the average area of paddy land per owner is less than 1 ha (100m X 100m). The one side length of owned land along transmission line is less than 100m. In addition, distance between adjacent two towers is considered to be from 300m to 400m in average. Thus, it is unlikely that one demarcated paddy land stride with more than the width of the two towers. Therefore, number of land owners is considered to be mostly equal to number of towers, i.e. about 60.

Table 11.4-4 and Table 11.4-5 show owner list of affected land in 400 kV T/L area.

Table 11.4-4 Owner list of affected land in 400 kV T/L area (Kantale area)

	Land owner	**Land type**	**DS Division**	**Angle Point**
1	A	Home garden	Kantale	AP24-AP25
2	B	Home garden	Kantale	AP24-AP25
3	C	Home garden	Kantale	AP24-AP25
4	D	Forest area	Kantale	AP24-AP25
5	E	Home garden	Kantale	AP25-AP26
6	F	Home garden	Kantale	AP25-AP26
7	G	Home garden	Kantale	AP25-AP26
8	F	Home garden	Kantale	AP26-AP27
9	H	Home garden	Kantale	AP26-AP27
10	I	Home garden	Kantale	AP26-AP27
11	J	Home garden & Paddy	Kantale	AP26-AP27
12	K	Home garden	Kantale	AP27-AP28
13	L	Home garden	Kantale	AP27-AP28
14	M	Paddy	Kantale	AP27-AP28
15	N	Cultivated Land	Kantale	AP27-AP28
16	O	Home garden	Kantale	AP27-AP28
17	P	Home garden	Kantale	AP23-AP24
18	Q	Home garden	Kantale	AP23-AP24

Note: Land owner identified until middle August 2015 by CEB
(Source: CEB)

Table 11.4-5 Owner list of affected land in 400 kV T/L area (Habarana & Hataraskotuwa deviation)

	Land owner	Land type	DS Division	Angle Point
1	A	Home garden	Palugaswewa	AP3-AP4
2	B	Home garden	Palugaswewa	AP3-AP4
3	C	Home garden	Palugaswewa	AP3-AP4
4	D	Home garden	Palugaswewa	AP3-AP4
5	E	Home garden & paddy	Palugaswewa	AP4-AP5
6	F	Home garden	Palugaswewa	AP4-AP5
7	G	Home garden	Palugaswewa	AP5-AP6
8	H	Home garden	Hingurakgoda	AP11-AP12
9	I	Home garden	Hingurakgoda	AP11-AP12

Note: Land owner identified until middle August 2015 by CEB

(Source: CEB)

11.4.4. Specific Policy and Framework for Compensation of the Project

11.4.4.1. Policy for Compensation

CEB set the policy for compensation and support as follows.

- ✓ In the National Policy on Involuntary Resettlement (NPIR, May 2001), it is described as one of the policies that "Compensation for fixed structures, other assets and income including transaction costs, should be based on full replacement cost which should be paid promptly". The policy is applied to the Project, and all compensation shall be based on the full replacement cost at the market value of the object to be compensated.

- ✓ Compensation will be paid by CEB for income loss due to construction of towers and creation of access roads in paddy land. In few situations where farmers' fences in paddy fields, paths to paddy fields and any other structures do get damaged, CEB shall recover to their original condition. If necessary, compensation shall be paid to those farmers who are affected.

- ✓ Compensation amount will be decided as per the assessment by the relevant Divisional Secretary. Compensation for removed/cut trees will be paid by CEB at a fair market rate based on tree type, tree age and expected income from the trees. The assessment of the value will be made by the Divisional Secretary.

- ✓ Compensation will be paid by cash or in kind.

11.4.4.2. Entitlement Matrix

An entitlement matrix serves as a tool for evaluating the possible losses caused by the Project, namely it identifies eligibility of PAPs and provides a basis for necessary compensation the PAPs. Table 11.4-6 summarizes the Entitlement Matrix designed for this Project.

Table 11.4-6 Entitlement Matrix

<table>
<tr><th>Type of Losses</th><th>Level of Impact</th><th>Entitled Person (s) (Project Affected Person(s))</th><th>Contents of compensation</th><th>Implementation Issues/Guidelines</th><th>Responsible Organization</th></tr>
<tr><td colspan="6">1. Trees (in home gardens)</td></tr>
<tr><td>(1) Loss of source of net income due to cutting/removal</td><td>Temporal and partial loss of valuable trees in home garden</td><td>Individual(s) who has ownership of affected home garden</td><td>Provide cash compensation which equals to net income loss due to restriction of cultivating paddy land during construction of tower foundation and access roads</td><td>a. Assessment of quantity and quality of trees
b. Assessment of Cash Compensation under Law(Electricity Act)
c. Assessment of Market Value by Land Market Survey
d. Updating of title of the affected persons
e. Payment of Cash Compensation under Law
f. APs will be fully informed of the entitlements and procedures regarding payments</td><td>a. Divisional Secretary (DS)
b. DS
c. DS
d. DS
e. CEB
f. DS/CEB</td></tr>
<tr><td colspan="6">2. Paddy land (Agricultural land)</td></tr>
<tr><td>(2) Loss of source of net income due to cultivating restriction of paddy land</td><td>Temporal cultivating restriction on partial paddy land caused by construction of tower foundation and access roads</td><td rowspan="2">Individual(s) who has ownership of affected paddy land</td><td>Provide cash compensation which equals to net income loss due to restriction of cultivating paddy land during construction of tower foundation and access roads (during one cultivating season)</td><td rowspan="2">a. Assessment of loss of income
b. Assessment of Cash Compensation under Law(Electricity Act)
c. Updating of title of the affected persons
d. Payment of Cash Compensation under Law
e. APs will be fully informed of the entitlements and procedures regarding payments</td><td rowspan="2">a. Divisional Secretary (DS)
b. DS
c. DS
d. CEB
e. DS/CEB</td></tr>
<tr><td>(3) Loss of source of net income due to cultivating restriction of paddy land</td><td>Long term cultivating restriction on partial on paddy land caused by construction of four tower footings</td><td>Provide cash compensation which equals to net income loss due to restriction of cultivating paddy land during construction of four tower footings (during ten years)</td></tr>
</table>

11.4.5. Estimation of Compensation Amounts

11.4.5.1. Compensation for Cutting/Removal of Trees in Home Garden

1) 400 kV T/L

Table 11.4-7 Estimated Compensation Amount for Cutting/Removal of Trees in Home Gardens (400 kV T/L)

Trees	Unit Number of Trees in affected home garden	Unit rate of compensation LKR/ tree	Amount of Estimation LKR
Jak, Teak	10	20,000	200,000
Other Timber	33	4,000	132,000
Coconut tree	48	30,000	1,440,000
Other fruit tree	13	7,500	97,500
Ayuruvedic Plant	123	3,000	369,000
Total	227		2,238,500

(Source: Prepared by the Team estimated with referring to some recent examples of IEE and Resettlement Plan prepared by CEB (Green power development and energy efficiency improvement investment program (tranche 1) Part2 – Transmission infrastructure capacity enhancement project - Bidding Document for Procurement, Annex 1: IEE, October 2014, Annex 2: Resettlement Plan October 2014))

Note: * Number of trees cutting/removal is estimated on the assumption that minimum ground clearance is 8.5m. However, recently CEB decided the minimum ground clearance from 8.5m to 15m. Thus, number of trees cutting/removal will be considerably decreased.

2) 220 kV T/L

Table 11.4-8 Estimated Amount for Cutting/Removal of Trees in Home Gardens (220 kV T/L)

Trees	Unit Number of Trees in affected home garden	Unit rate of compensation LKR/ tree	Amount of Estimation LKR
Coconut tree	6	30,000	180,000
Total	6		180,000

(Source: Prepared by the Team estimated with referring to some recent examples of IEE and Resettlement Plan prepared by CEB (Green power development and energy efficiency improvement investment program (tranche 1) Part2 – Transmission infrastructure capacity enhancement project - Bidding Document for Procurement, Annex 1: IEE, October 2014, Annex 2: Resettlement Plan October 2014))

Actual compensation amounts are decided as per the assessment of the relevant Divisional Secretaries according to Electricity Act 2009 (including all the latest amendments and relevant regulations). According to the Act Divisional Secretaries are delegated powers from the Public Utilities Commission (multi-sector regulator to regulate certain physical infrastructure industries) of Sri Lanka.

11.4.5.2. Estimation of compensation amounts for loss of net income that the land owner can get from the paddy land without restriction of paddy farming by the Project.

1) Farming restriction of paddy land used by construction of tower foundation/footings and temporal access roads

Compensation amount is estimated as follows.

$$(Loss\ of\ income) = (A) \times (B)$$

A: Affected area

B: Income obtained from paddy farming per unit area

Estimated compensation amount is as follows.

Rice cultivation is carried out for two seasons per year (double-crop farming) in the area. However, period of construction work for tower footings will take only one season. Therefore, affected period is considered as one season.

(i) 400 kV T/L

Rice cultivation is carried out for two seasons per year (double-crop farming) in the area. However, period of construction work for tower footings will take only one season. Therefore, affected period is considered as one season. Therefore, affected period is considered as one season.

Table 11.4-9 Compensation Amount for Loss of Temporal Net Income during Construction of Tower Foundations (400 kV T/L)

Item	Value	Notes
Net income obtained from paddy farming per unit area	35,000 LKR/acre/season (8.6 LKR/m^2/season)	Reference: (1) 35,000 LKR/ acre/ season by CEB, Moragolla Hydropower Project Feasibility Study, Volume3 EIA Study, November 2012 (2) 35,600 LKR/ acre/season by W.C Gamawelagedara1, et al., "Impact of rice processing villages on household income of rural farmers in Anuradhapura District", The Journal of Agricultural Sciences, 2011, vol. 6, no2
Affected area per each tower	1,000 m^2	Tower footing area: 400 m^2 Temporal access road: 400 m^2 Stock yard/ work space: 200 m^2
Estimated number of towers in paddy land	80 units	
Total compensation amount	688,000 LKR	

(Source: Prepared by the Team)

(ii) 220 kV T/L

Rice cultivation is mainly carried out for once per year in the area. As period of construction work for tower footings will take in half a year, affected period is considered in half a year.

Paddy lands are owned by small scale farmers as well as large scale land owners. Some belong to Kovil (Hindu temples). Therefore, this has to be considered when evaluating compensation amount.

Table 11.4-10 Compensation Amount for Loss of Temporal Net Income during Construction of Tower Foundations (220 kV T/L)

Item	Value	Notes
Net income obtained from paddy farming per unit area	35,000 LKR/acre/season (8.6 LKR/m^2/year)	Reference:
Affected area per each tower	900 m^2	Tower footing area: 300 m^2 Temporal access road: 400 m^2 Stock yard/ work space: 200 m^2
Estimated number of towers in paddy land	60 units	
Total compensation amount	464,400 LKR	

(Source: Prepared by the Team)

Any other damages and/or disturbance to the cultivation would be compensated as per the valuations of relevant Divisional Secretary.

Actual compensation process will be conducted by Divisional Secretary. Compensation amount is determined by the Divisional Secretary based on survey and assessment of affected paddy land. The process can start after final fixation of location and area necessary to be used for construction of towers and access roads.

The method of compensation is making payment for loss of net income that the land owner can get from the paddy land without restriction of paddy farming by the Project.

2) (Operation phase) Farming restriction of paddy land for the areas

(About two square meters x 4 poles) for four tower footings

Compensation amount is estimated as follows.

(Loss of income) = (A) x (B)

A: Affected area

B: Income obtained from paddy farming per unit area

Since rice cultivation in paddy field is carried out two seasons per year (double-crop farming) in the area, affected period is two seasons x 40 years

(i) 400 kV T/L

Table 11.4-11 Compensation Amount for Loss of Long Term Net Income during Using of Tower Footings (400 kV T/L)

Item	Value	Notes
Net income obtained from paddy farming per unit area	35,000 LKR/acre/season (8.6 LKR/m^2/season)	Reference: (1) 35,000 LKR/ acre/ season by CEB, Moragolla Hydropower Project Feasibility Study, Volume3 EIA Study, November 2012 (2) 35,600 LKR/ acre/season by W.C Gamawelagedara1, et al., "Impact of rice processing villages on household income of rural farmers in Anuradhapura District", The Journal of Agricultural Sciences, 2011, vol. 6, no2
Restriction Term	2 seasons x 50 years	
Affected area per each tower	2 m^2 x 4 Poles	Tower footing area: 2 m^2 *4 Pole
Estimated number of towers in paddy land	80 units	
Total compensation amount	550,400 LKR	

(Source: Prepared by the Team)

(ii) 220 kV T/L

Table 11.4-12 Compensation Amount for Loss of Long Term Net Income during Using of Tower Footings (220 kV T/L)

Item	Value	Notes
Net income obtained from paddy farming per unit area	35,000 LKR/acre/season (8.6 LKR/m^2/season)	Reference: (1) 35,000 LKR/ acre/ season by CEB, Moragolla Hydropower Project Feasibility Study, Volume3 EIA Study, November 2012 (2) 35,600 LKR/ acre/ season by W.C Gamawelagedara1, et al., "Impact of rice processing villages on household income of rural farmers in Anuradhapura District", The Journal of Agricultural Sciences, 2011, vol. 6, No2
Restriction	1seasons x 50 years	
Affected area per each tower	2 m^2 x 4 Poles	Tower footing area: 2 m^2 x 4 Pole =8 m^2
Estimated number of towers in paddy land	60 units	
Total compensation amount	206,400 LKR	

(Source: Prepared by the Team)

Any other damages and/or disturbance to the cultivation would be compensated as per the valuations of relevant Divisional Secretary.

Actual compensation process will be conducted by Divisional Secretary. Compensation amount is determined by the Divisional Secretary based on survey and assessment of affected paddy land. The process should be finalized before the start of construction work.

11.4.6. Grievance Redress Mechanism

The basic point of Grievance redress system for the Project is as follows.

1) To establish an accessible, fair and transparent grievance redress system by the basis of JICA Guidelines and relevant regulations in Sri Lanka.

2) The expenses relating to grievance redress activities burden on CEB.

3) CEB will maintain an ongoing interaction with Project Affected Persons (PAPs) to identify problems and will undertake appropriate remedial measures.

For this purpose CEB will put the person in charge of grievance redress (Grievance redress officer: GRO).

- ✓ GRO shall be easily accessible for PAPs by oral or verbal communication.
- ✓ It is important that GRO always presents in the CEB office during the process of compensation, and addresses any queries, disputes and complains that may arise.
- ✓ Determination in correspondence should be given as soon as possible when after receiving any grievances.
- ✓ GRO must records all complains and respective actions.

4) For issues that cannot be processed by GRO, the officer requests the correspondence and the resolution to the relevant Divisional Secretary.

11.4.7. Organizations with Responsibility for Implementation of Compensation Process

Organizations with responsibility for implementation of compensation process in the Project are shown in Table 11.4-13.

Table 11.4- 13 Organizations with Responsibility for Implementation of Compensation Process in the Project

Responsible Organization	Responsibility for Implementation of Compensation Process
CEB	Application to Division Secretary (1) to install electric lines (2) to fell or lop a tree or cut back its roots that obstruct or interfere with the installation, maintenance or working of an electric line or plant, or constitute an unacceptable cause of danger.
Divisional Secretaries	By delegated powers by the Commission conferred on it by items 4 of Schedule I of the Electricity Act: (1) to determine the amount of compensation that a landowner may recover from CEB in respect of grant of wayleave (2) to determine the amount of compensation that a person may recover from CEB for any disturbance caused to his or her enjoyment of any land or movables in consequence of the exercise of any right conferred by a wayleave (3) to conduct inquiries, on its own motion or on the application of a person affected, to determine whether a licensee is liable to pay any person any compensation under (1) and (2) above; provide information to the owners and occupiers of lands and the general public on granting or not granting of wayleave (including related procedures) and felling or lopping of trees by CEB

(Source: Prepared by the Team)

11.4.8. Implementation Schedule

Figure 11.4-1 shows implementation schedule.

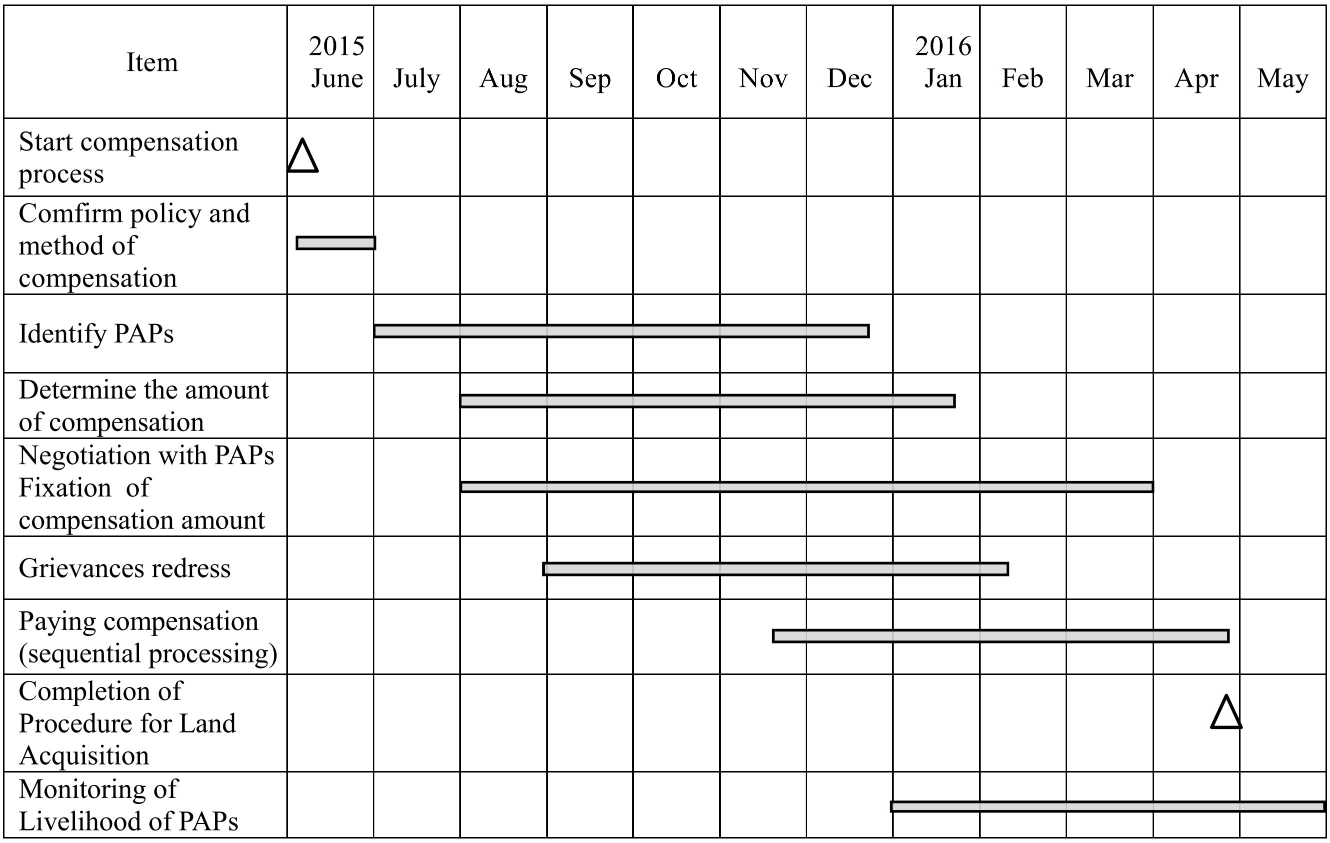


Figure11.4-1 Implementation Schedule

11.4.9. Compensation Cost Estimates and Source of Funds

Table 11.4-14 shows estimated budget of compensation by CEB in the Project.

Table 11.4-14 Estimated Budget of Compensation by CEB in the Project

No.	Description	Unit	Quantity	Rate (thousand LKR) /Unit)	Amount (thousand LKR)
1	Compensation cost (A)	Lump sum	1	4,328	4,328
2	Miscellaneous compensation relating cost (registration tax, remittance, etc.)	5 % of (A)			216
3	Activities direct cost (transportation, office supplies, etc.)	Lump sum	1	600	600
Subtotal Total (B)					5,144
4	General and administrative cost & Contingency (C)	15 % of (B)			772
Total					5,916

(Source: Prepared by the Team)

11.4.10. Stakeholders Meeting

11.4.10.1. 400 kV T/L

- ✓ Stakeholders meeting were held twice as follows.
- ✓ Prior publicity and notice for stakeholders meeting
- ✓ In both meeting any objection against the proposed project plan was not given from participants.
- ✓ Prior provision and publicity for stakeholders meeting were as follows:

  CEB, as a proponent explained to Divisionary Secretary (DS) the project plan and importance of stakeholders meeting to disclose information and to collect opinions and comments from local people including possible PAPs.

  Then DS informed local people to hold stakeholder meeting by District officers verbally and/or using message board several days in advance.

1) 1st Stakeholders Meeting

(i) Date and Time:

March 25, 2015, 10:30 AM

(ii) Venue

Kantale Divisional Secretariat Auditorium

(iii) Participants

Mr. Premadasa	Divisional Secretary of Kantale
Mr. P.A.B.C Kumarasiri	Project Engineer (TCPP*) - CEB
Mr. S. Padmasiri	Public Relations Officer (TCPP) - CEB
Mr. B.G.R Perera	Electrical Superintendents (TCPP) - CEB
Mr. K.N Chamara	Electrical Superintendents (TCPP) – CEB
Inhabitants	13 Persons (Male 5, Female 8)

Note: TCPP means Trincomalee Coal Power Project

(iv) Minutes of the Meeting

- ✓ Outline of the Project and Selection of the Sampoor -Habarana 400 kV transmission line route

  Mr. Kumarasiri (Project engineer - CEB) & Mr. Padmasiri (Public Relations Officer -CEB) explained about the outline of this Project and the importance of this Sampoor- Habarana 400 kV transmission line.

  - Transmission line route in Kantale area using satellite images
  - Wayleave clearances

- Safety clearances according to the conditions
- Lightning protection
- Tower foundations & tower heights
- Tower constructions using images & videos
- Effect on Paddy fields and crops and home gardens
- Impacts on Forest area and wild life

✓ Q & A Session

After the explanation and by CEB, questions were asked by stakeholders relevant to following items and CEB officers answered and explained the facts as follows.

<u>'How the transmission line route was identified? and 'Why this particular route?</u>

CEB officers explained using satellite images, how transmission line traverses in Kantale area. Since CEB officers explained showing roads and landmarks in this area, inhabitants could identify their houses and lands and could get very clear idea about the affected area for the transmission line and the location of angular points. CEB officers also explained that other alternative routes which has larger impacts on forest areas or on houses.

<u>Questions on affected houses</u>

It was explained that in Kantale area there are no houses within a band of 26 m on either side of the center line.

<u>Questions on the methodology of marking for the Wayleave clearances</u>

Tall trees or trees that eventually grow high, within a band of 26 m on either side of the line (52 m band), will be removed. During the survey trees in the center will be marked using 20 mm red color paint band and other trees with in the 52 m band will be marked using 20 mm yellow color paint band.

<u>What are the Steps of the compensating procedure?</u>

Marked trees in relevant land will be tagged & checked with the GramaNiladari. Then valuation will be prepared according to recommendations of the Divisional Secretary.

When there is a tower in a land, compensations will be paid for the area occupied for construction of towers according to recommendations of the Divisional Secretary. Compensation will be also paid to the damaged crops during construction if any.

<u>What are the impacts on coconut cultivation?</u>

In this area only one coconut cultivating land will be affected. The transmission line route has been selected to traverse the edge of this land in order to minimize the impact. For the affected coconut trees, compensations will be paid according to recommendations of the Divisional Secretary.

End of the meeting

The participants thanked the CEB officers for the explanations given and expressed that they expect that CEB will pay the compensation as explained. Information for contacting with CEB officers was given.

End of the meeting: 1.30 p.m.

Figure 11.4-2 Photo of Stakeholders Meeting in Kantale

2) 2nd Stakeholders Meeting

(i) Date and Time

March 26, 2015, 10:15 am

(ii) Venue

Palugasweva Divisional Secretariat Auditorium

(iii) Participants

Mr. R.Ranesh	Additional Divisional Secretary of Palugasweva Government
Mr. K.S.S Kumara	Project manager (TCPP) - CEB
Mr. Rohitha Gunawardhana	Head of Environment Unit-CEB
Mr. S. Padmasiri	Public Relations Officer (TCPP) - CEB
Mr. B.G.R Perera	Electrical Superintendents (TCPP) - CEB
Mr. K.N Chamara	Electrical Superintendents (TCPP) – CEB
Mr. T. Tanaka	Member of the Team
Inhabitants	28 Persons (Male 16, Female 11)

Note: TCPP means Trincomalee Coal Power Project

(iv) Minutes of the meeting

- ✓ Outline of the Project and selection of the Sampoor-Habarana 400 kV transmission line route

  Mr. Kumara (Project manager of TCPP) and Mr. Rohitha (Head of Environmental Unit) explained about the main section of this Project and the importance of this Sampoor - Habarana 400 kV transmission line.

  - Transmission line route using satellite images
  - Wayleave clearances
  - Safety clearances according to the conditions
  - Lightning protection
  - Tower foundations & tower heights
  - How the line route was planned avoiding/ minimizing the environmental and social impacts
  - Compensation procedure including assessment and payment

- ✓ Question and Answer Session

  After the explanation by CEB, questions were asked by stakeholders relevant to following items and CEB officers answered and explained the facts as follows.

  <u>Marking for the Wayleave clearances</u>

  Tall trees or trees that eventually grow high, within a band of 26 m on either side of the line (52m band), will be removed. During the survey for affected land, trees in the center of T/L line will be marked using 20 mm red color paint band and other trees within the 52m band will be marked using 20 mm yellow color paint band.

  <u>The steps of the compensating procedure</u>

  Marked trees in relevant land will be tagged & checked with the Grama Niladari. Then valuation will be prepared according to assessment of the Divisional Secretary. When towers or temporal access roads will be constructed in farm land, according to the recommendations of the Divisional Secretary, compensations will be paid for the income loss due to the construction activities.

  <u>Possibility to build a house under the transmission line</u>

  In populated areas height of 15m from ground to the sag point of the line is kept. With this height of the line, strength of the electromagnetic field in ground level and upper floor level will be under the public exposure limit. Therefore it is possible to build even a two storied house under the transmission line, if required.

  <u>Impacts to cultivations</u>

Cultivations below 3m height can be carried out under the transmission line. Cultivation in paddy fields can be continued under the towers after the construction period.

Lightning protection

Towers will be built to act as a lightning conductor as well. So houses near the towers will get an extra protection from lighting. The tower will ground the lighting before strike to lower houses or buildings.

End of the meeting: 1.00 p.m.

Figure 11.4-3 Photo of Stakeholders Meeting in Habarana

During the community consultation, a large number of farmer organizations were consulted. They opinioned that the CEB should give adequate compensation in case CEB require a portions of the paddy lands for the project, as the paddy lands are the sole source of income for the majority of the farming communities. In addition, the transmission line will require maintaining the way leave of 35 m for 220 kV line (which is 17.5 m either side of the center line of the line routes).

11.4.10.2. 220 kV T/L

Prior provision and publicity for stakeholders meeting were as follows:

Under the comprehension of CEB, consultants on behalf of CEB officer explained Divisionary Secretary (DS) the project plan and importance of stakeholders meeting to disclose information and to collect opinions and comments from local people including possible PAPs.

Then DS informed local people to hold stakeholder meeting by District officers verbally and/or using message board several days in advance.

1) Stakeholders Meeting (1)

Sampoor South GN (Grama Niladhari) Divisions: with representing farmers affected from AP 1 to AP2 of the T/L which will cross the paddy land:

(i) Date and Time

August 25, 2015, 4:00 PM

(ii) Meeting Place

Sampoor South (new resettlement area)

(iii) Participants

Name	No. of family members	Extent of land owned by them
Mr. A	5 members in the family	4 acres of land with ability to cultivate two times from the tank water
Mr. B	5 members in the family	1 1/2 acres of paddy land with ability to cultivate two times per year
Mr. C	4 members in the family	3 acres of paddy land with ability to cultivate two times per year
Mrs. D	3 members in the family	5 acres of paddy land with ability to cultivate two times per year
Mr. E	3 members in the family	1 1/2 acres of paddy land with ability to cultivate two times per year

(iv) Minutes of the Meeting

- ✓ They are using water from the small tank nearby to cultivate paddy lands. Farmer organization members help each other to pump water from that small and utilize the water for cultivating near land also. Woman and other family members also support to them in the cultivating and harvesting periods.

- ✓ They are not willing that the APs or Suspension towers to occupy their small paddy lands. However when explaining that there will be compensation paid for the land that will be purchased by the CEB for the towers, they showed willingness to consult their family members and to provide a positive response thereafter.

Figure 11.4-4 Stakeholders Meeting in Sampoor South, August 25, 2015

2) Stakeholders Meeting (2)

With People Amman Nagar of Pallikudiyuruppu GN Division Muthur DS Secretariat.

Location of this village is along the Ring Road opposite of AP-6.

(i) Date and Time

August 25, 2015, 11.20 A.M.

(ii) Place of the Meeting

Sannathawattai (222-Kattaiparichan South GN Division)

(iii) Participants

GN-Mr.Dineswaran

Community members : Mr. A, Mr. B, Mr. C, Mr. D, and Mrs. E

(iv) Minutes of the Meeting

- ✓ The Transmission line passes opposite side of their village but is about 200 meters far away.
- ✓ These people own small extent of high land (not used for Paddy cultivation) with each family having average ½ acre given by the government on Jaya Boomi land alienation program. They use the land for building houses and the rest for chena cultivation.
- ✓ Within the families, only part of the family is residing in the makeshift houses. Others are still kept outside with host families as proper housing and sanitation facilities were not adequately yet available. Average family members in family is 5. Main income generating activity is cultivation small household farming.
- ✓ They are concerned that land boundary marks have already been placed by the CEB for another T/L project and that if the 220 kV line will be crossing the same area too, they will not have land for cultivation. It is understood through observation that boundary marks have already been placed either for the Road construction or for the Forest boundaries or for Sampoor/ Habarana 400 kV line which the CEB had already placed.
- ✓ Divisional Secretary was also aware of this issue and he was concerned that people should not be impacted by aligning the line to disturb the community settlement. However, the 220 kV line is passing opposite the village and that they will not be directly affected. They will be affected when the construction work will be in progress.

Figure 11.4-5 Stakeholders Meeting in Amman Nagar of Pallikudiyuruppu GN Division, August 25, 2015

3) Stakeholders Meeting (3)

With farmer organizations

Name of the Farmer Organization: Sammanthuraively Vivasaya sangam

(i) Date and Time

August 27, 2015, 11.45 A.M.

(ii) Place of the Meeting

Thampalakamam South GN office

(iii) Participants (including President)

Mr. A, Mr. B, Mr. C, Mr. D, Mr. E, Mr. F, Mr. G, Mr. H
Their paddy lands will be affected when the line crosses AP 13, 14 & 15.

(iv) Minutes of the Meeting

- ✓ There are 103 members in farmer organization who are cultivating 465 acres of paddy land at least two times a year using irrigation waters from Kantale Tank. Membership of the FO is open to those farmers living within 1-2 km radius of the village. The farmer organization collect fee from each farmer as membership fee Rs 100 and monthly payment of Rs 10. Nearly 340 acres paddy lands (which can be cultivated two times per year is held by the Hindu Kovil (Temple). This portion of land is given to tenant farmers who earn seasonal cultivation right through a bidding process. The value of the paddy lands is rated from Rs 50,000 to Rs 60,000.

- ✓ Farmers on average harvest 45-50 packs of paddy per acre with one pack containing 50 kg. They invest machineries for harvesting as the land sizes are large. Approximate cost of production of paddy for one acre stands around Rs

30,000-Rs 40,000, with cost for tilling using machinery for one acre at Rs 10,000, seeds, chemicals and fertilizer Rs 12,000 harvesting Rs 7,000 and the rest for transporting and storage.

- ✓ The farmers face some major problems such as marketing, irrigation water and other infrastructure. The farmers produce 2,250 kg to 2,500 kg per acres but the government purchases only 2,000 kg of paddy at certified rates (Rs 45 per kg) forcing the farmers selling the rest to private buyers only for Rs 28 to 30. There are no proper irrigation systems in these areas reducing the potential income from cultivation. Farmers' organization does not have a permanent building.

- ✓ Overall there is no objection that towers are erected on the paddy fields, but they request compensation for the land areas occupied by the towers.

Figure 11.4-6 Stakeholders Meeting with Farmer Organizations

Chapter 12. Sampoor Coal-fired Power Plant

12.1. Development Plan and Progress of the Sampoor Coal-fired Power Plant

12.1.1. Administrative Organization

The Sampoor coal-fired power plant project shall be implemented by TPCL. TPCL, incorporated on 6th September 2011, is an independent power producer and a joint venture company between CEB and NTPC of India (both have a 50% share in TPCL). Various agreements for the plant (including a power purchase agreement (PPA), an implementation agreement, a board of investment agreement, a land lease agreement and a coal supply agreement) were signed on 07 October 2013 by the relevant parties including the Government of Sri Lanka, CEB and TPCL. TPCL shall implement the preparation work, construction work and O&M for the Sampoor coal-fired power plant. CEB shall purchase electric power from TPCL and provide agreed preliminary designs based on the PPA. NTPC shall work as the engineering consultant for TPCL. The Sampoor coal-fired power plant project organization is shown in Figure 12.1-1.

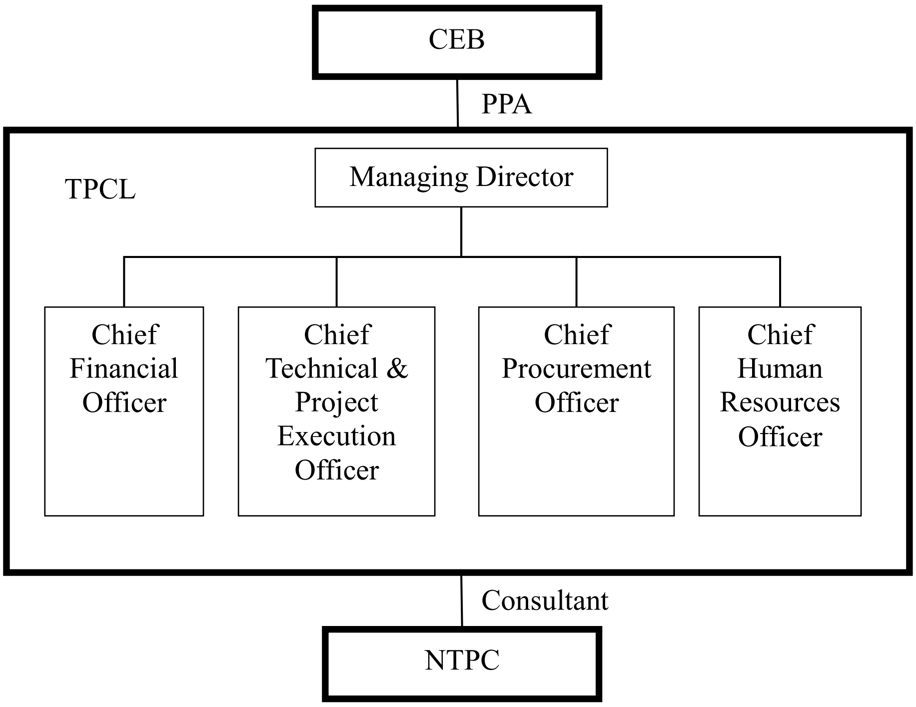


Figure 12.1-1 Organization Chart

CEB and NTPC shall provide a 30% investment in the project costs. The remaining part must be arranged by an EPC contractor to be chosen on a tender basis.

12.1.2. Development Plan

The area for the Sampoor coal-fired power plant is state-owned land with no residents and an area of 204.4 ha. The Sampoor coal-fired power plant project intends to install two (2) generation units – the gross output power for each generation unit is 250 MW and the net output is 227 MW. The Sampoor coal-fired power plant shall be operated as base load plant.

The point of interconnection between the generation switchyard and CEB system shall be the 220 kV GIS to AIS bushing of the 220 kV GIS line bay at CEB GIS S/S. CEB GIS S/S shall be installed close to the Sampoor coal-fired power plant.

The circulating sea water system is a once through type, with sea water to be taken from Trincomalee bay and discharges to be made at the mouth of the bay, the discharged water will be approximately 7°C higher than at the intake water temperature. Fresh water - which is required amongst other things for potable supplies, service water systems, boiler feed water, fire-fighting, ash handling, HVAC - shall be supplied from sea water that is desalinated in a desalination plant.

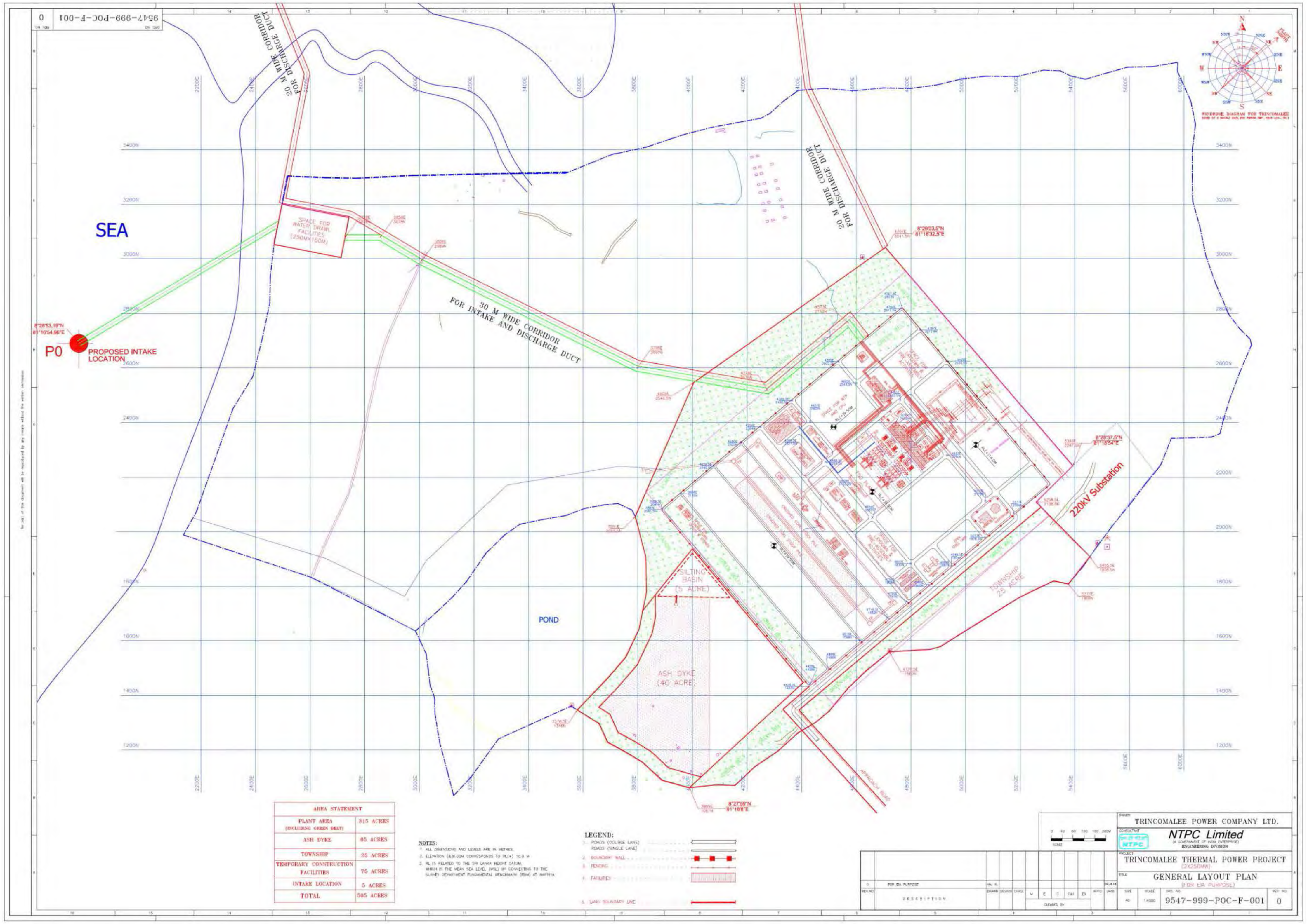
The main fuel for the plant shall be imported coal and the coal unloading jetty shall be installed inside Trincomalee bay. Belt conveyors which shall be installed from unloading jetty to coal stockyards will transport the coal. A fuel oil (Light Diesel Oil (LDO) and High Speed Diesel (HSD)) firing facility shall be provided to cater for the boiler Cold-start up, the warm-ups and the flame stabilization under low load operation. The fuel oil shall be transported by road tankers.

The boiler shall be a direct pulverized coal-fired sub-critical steam pressure type and the stack shall be 135 m. A sea water based Flue Gas Desulfurization system (FGD) shall be installed in and around the stack area to limit the SOx emissions to the atmosphere. Also, and Electrostatic Precipitator (ESP) shall be installed to limit the emissions of particulate matter from the flue gas. NOx reduction shall be facilitated through a coal-firing system. Table 12.1-1 shows the specifications for the Sampoor coal-fired power plant specifications, and Figure 12.1-2 shows the general layout plan of the Sampoor coal-fired power plant.

Table 12.1-1 The Sampoor Coal-fired Power Plant Specifications

Item	Specification	Remarks
Mode of Operation	Base Load	
Number of generation units	2	
Gross output	250 MW	
Net output	227 MW	
Output voltage	220 kV	
Land requirement	204.4 Hectares	
Main Fuel	Imported Coal	
Auxiliary Fuel	LDO/HSD	
Stack height	135 m	
Steam temperature of SH/RH	540 / 540 °C	(Boiler outlet)
Steam pressure of SH	155 kg/cm^2	(Boiler outlet)
Flue Gas Desulfurization system	Sea water type	
Circulating water system	Once through type	
Temperature rise of circulating water	7 °C (Max)	Deferential of intake and discharge water
Estimated Project Cost excluding IDC	513 Million US $	
Estimated Project Cost including IDC & WCM	615 Million US $	

(Source: Feasibility Report “Trincomalee Thermal Power Project (2x250 MW)” and EIA Report for Trincomalee Thermal Power Project (2 x 250 MW))



(Source: EIA report)

Figure 12.1-2 General Layout Plan of the Sampoor Coal-fired Power Plant

12.1.3. Progress

The Sampoor coal-fired power plant project was planned over three periods – the preliminary, construction and operational periods.

CEB by letter "Extension of Preliminary Period of PPA dated October 7, 2014" to TCPL, extended the preliminary period of the PPA for the Sampoor coal-fired power plant project until 31 December 2015 TCPL is due to issue the construction notice to CEB by this extended date. However, as CEB expects to obtain the EIA approval in May 2015 - it originally expected in March - there is a possibility that the preliminary period may be extended for a further two (2) months or more by CEB.

The construction period – expected to be 48 months – shall commence on the date the construction notice is issued. Following this, the operational period is intended to start on the operation date and expire on 25 years after this date.

After the EIA approval, TPCL shall run the EPC contractor tenders during the preliminary period. The tender shall be divided in 3 portions – leveling work, housing work, and power plant facilities work. The leveling work and housing work shall be assigned to local companies, and power plant facilities work to an international company. The basic design criteria, which form the basis of the tender documentation, has already been prepared by TPCL and agreed by CEB.

The scheduled initial operation date is the planned completion date of the first generation unit construction, which is 44 months after the date the construction notice is issued.

The scheduled operation date is the planned completion date of the second generation unit construction, which is 48 months after the date the construction notice is issued.

Thus, TPCL is expected to commence the commercial operation of the first generating unit within 44 months of the construction notice being issued; likewise, it shall start the commercial operation of the second generating unit within 48 months of the construction notice being issued.

For the purpose of testing and commissioning of the Sampoor coal-fired power plant, CEB shall supply electricity from the its 220 kV system at the interconnection point at least 360 days prior to the scheduled initial operation date – 34 months from the date of the construction notice was issued.

Figure 12.1-3 shows the Sampoor coal-fired power plant project schedule.

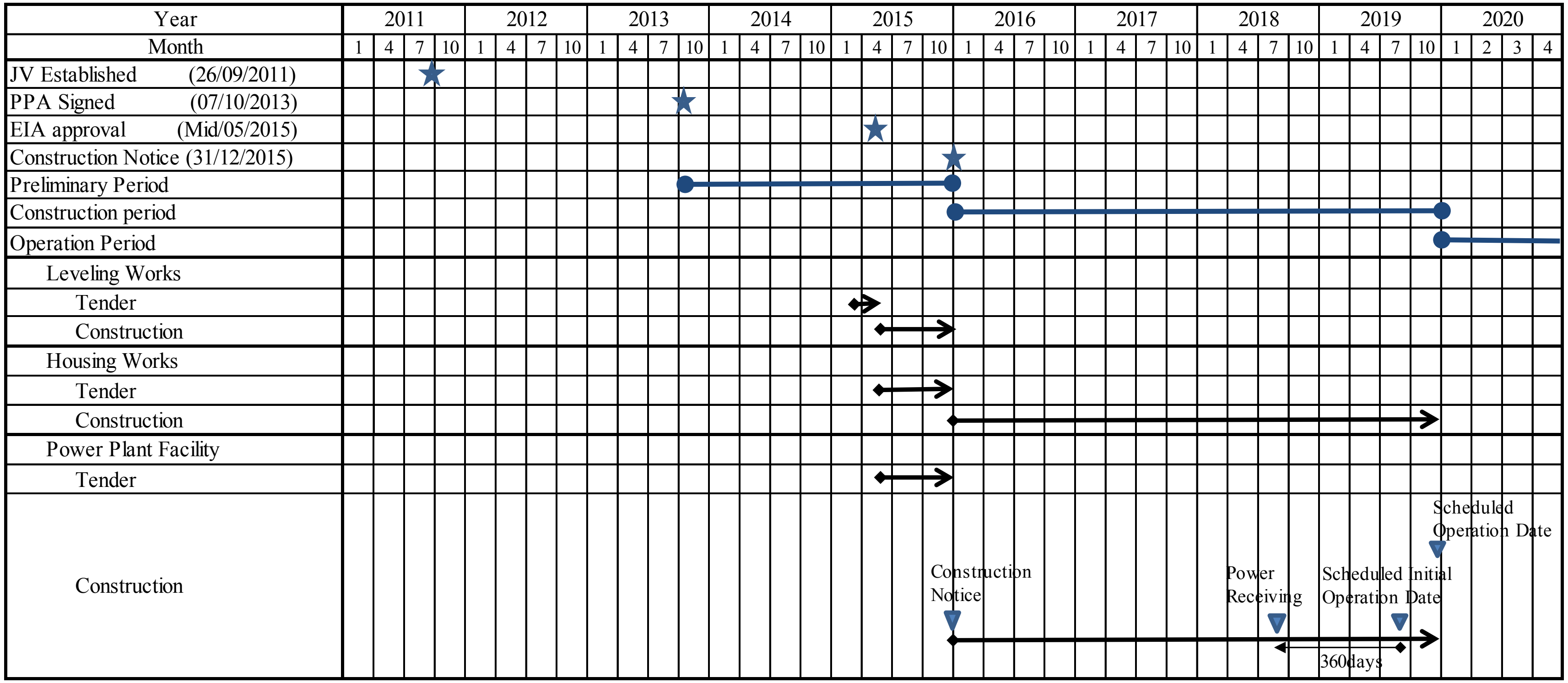


Figure 12.1-3 The Sampoor Coal-fired Power Plant Project Schedule

12.2. Environmental and Social Considerations for the Sampoor Coal-fired Power Plant

12.2.1. EIA requirements for Thermal Power Plants

In accordance with the Sri Lanka Gazette (in particular Gazette no. 772/22 of 24 June 1993, 859/14 of 23 February 1995, 1104/22 of 5 November 1999, and 1108/1 of 29 November 1999), the proposed thermal power plants that have a generation capacity exceeding 25 megawatts at a single location are subject to the EIA requirements.

12.2.2. Status of EIA procedure for the Sampoor Coal-Fired Power Plant

The EIA report entitled "Environmental Impact Assessment for Trincomalee Thermal Power Project (2 x 250 MW), January, 2015" was submitted to CEA on 9 February 2015 by TPCL under section 23 BB (1) of the National Environmental Act (no. 47 of 1980 as amended by acts no. 56 of 1988 and no. 53 of 2000).

The EIA report was opened to the public in three languages (Sinhala, Tamil and English) on the CEA website. The paper advertisement for the public consultations was published in newspapers by CEA on 13 February 2015. Furthermore, the EIA report had been available for inspection by the public at the following locations between 8.45 am and 4.15 pm for a period of 30 days from the date of the advertisement (except weekends and public holidays). Notifications of the public disclosure are shown in Annex 12.2-1.

- District Secretariat/ Trincomalee
- Divisional Secretariat/ Mutur
- Pradeshiya Sabha/ Mutur
- Eastern Provincial Council/ Kanniya Road, Varothayanagar, Trincomalee
- Eastern Provincial Office/ Central Environmental Authority/ Priyantha Mawatha/ Kanthale
- Library/ Central Environmental Authority/104, Denzil Kobbekaduwa Mawatha/ Battaramulla
- CEA Website

(Source: CEA Website
http://www.cea.lk/web/?option=com_content&view=article&layout=edit&id=173 (Accessed 13 February 2015))

Subsequent to the public participation period, PAA will prepare its own comments on the EIA report in light of the public opinions. The project proponent(s) should then prepare their responses to these comments. Upon receipt of the project proponent(s) written response, PAA should evaluate this before the approval process. According to an interview with CEB Environmental Unit, it is likely that CEB will grant its approval to the EIA report from July 2015 onwards.

Chapter 13. Economic and Financial Analysis

13.1. Analysis Assumptions

This is a transmission line construction project. In general, transmission lines or transmission network construction projects tend to consist of the replacement of old transmission lines and/or the construction of bypass transmission lines. Usually, the main benefits to accrue coming from these projects are the reduction of transmission line losses. The reduction of transmission line losses is calculated by subtracting the predicted new transmission line losses from the present transmission line losses.

However, the Project aims to construct completely new transmission lines in order to provide electricity from new coal power plant to connection point of existing transmission network. There are no existing transmission lines in the Project area. Therefore, it is impossible to calculate the transmission line losses of the existing network.

The Project can be thought as a part of the construction of new power plant in a sense that most of power generation is evacuated through this transmission line except for the local demand consumption. With these new transmission lines a lot more electricity is expected to reach the existing transmission network.

The main benefits of the Project shall come from providing generated electricity through the new transmission lines, as the main role of these is to provide generated power to the existing transmission network.

On the other hand, the CEB and the NTPC established TPCL as new joint venture (their equity shares are 50% each). TPCL shall own new power plant and will operate coal power plant also.

CEB and TPCL projects shall be evaluated separately. In other words, the benefits and costs inherent to construction of new coal power plant shall be excluded from the EIRR and FIRR calculations. There are several reasons for this. TPCL is not a subsidiary of CEB and is considered as substantially independent from CEB. This Project shall be financed by a JICA ODA loan; thus, it is important for JICA as the lender to properly verify the Project's profitability and value as well as CEB's ability to repay the loan.

Considering above situations, the Team regards relationship between CEB and TPCL as one of business. CEB shall purchase power from TPCL and the benefits of the Project shall accrue from such electricity trade. TPCL profits and costs shall be included in the purchase price. Thus, the benefit, costs and other factors inherent to TPCL can be excluded from the IRR calculations.

13.2. Implementation Schedule and Costs

13.2.1. Implementation Schedule

The schedule of consulting services, construction of transmission lines, and construction of switching station works for the Project is indicated in the Figure 7.3-1. The whole Project is scheduled to be carried out over 24 months (further details below).

- ✓ Commencement of consulting services: estimated as January 2017
- ✓ Commencement of construction works: estimated as January 2017
- ✓ Completion of construction works (up to the issuance of the taking over and acceptance certificate (TOAC)): estimated as December 2019)
- ✓ Warranty period: 12 months from when the TOAC issued

13.2.2. Implementation Costs

An economic and financial analysis for the Project has been conducted using estimated construction costs as described in Table 13-2-2. In this analysis a conservative view has been taken of the consultant service costs that are included in the implementation costs.

1) Conditions of Costs

The costs of the implementation work for the project were estimated in consideration of the following:

Implementation schedule:	From 2017 to 2018
Taxes:	Value added tax 12.0%, and Import Tax 7% are considered
Price escalation:	2.0% for foreign currency and 3.8% for local currency are considered
Foreign currency exchange rate:	1 USD = 130.2 LKR 1 USD = 107.1 JPY 1 LKR = 0.823 JPY
Administration costs	5.0% of the project costs
Physical contingency:	Construction 5% Consultant 5%
Interest during construction	Construction 0.3% Consultant 0.01%
Front end fee	0.2% of loan
Base year for evaluation	2020 for costs and benefits

Based on the above conditions, the following ratios of the costs allocation shown in Table 13-2-1 are applied to this analysis.

Table 13.2-1 Allocation Rate of Costs

Category	2015	2016	2017	2018
Package 01: Construction of transmission lines	-	-	50%	50%
Package 02: Construction of switching station	-	-	50%	50%
Consulting services	-	-	43%	57%
Non eligible portion	1%	9%	45%	45%

(Source: Prepared by the Team based on provided data)

2) Breakdown of the Implementation Costs

The implementation costs and those arranged per year are presented in Tables 10.5-2 and Table 10.5-4, respectively.

Based on the above conditions, the following ratios of the costs allocations shown in Table 13.2-2 are applied to this analysis.

Table 13.2-2 Allocation of Costs

(in million. JPY)

Items	Currency	2015	2016	2017	2018
Total Cost	FC	28	-	4,927	5,054
	LC	24	295	3,490	3,551
Total	-	51	295	8,417	8,605

(Source: Prepared by the Team based on provided data)

13.3. Costs during the Operation Period

The Project costs consist of the initial implementation costs and the costs during the operation period. The latter costs consist of the energy purchase costs and the O&M costs.

13.3.1. Power Purchase Costs

CEB will purchase power from TPCL after operation commences at the Trincomalee coal power plant. On October 9 2013 CEB and TPCL entered into the PPA (entitled: “Power Purchase Agreement for the Boo Development of a Coal-Fired Power Facility at Trincomalee”). No tariff rates are stipulated in the PPA, but the formula to calculate tariffs are stipulated in schedule 9. The Team has estimated the power tariffs and power purchase costs based on this schedule 9.

NTPC is CEB’s joint venture partner for TPCL, and is the consultant for the Trincomalee coal fired power plant construction project. NTPC conducted a feasibility study on this project (entitled “Trincomalee Coal Power Co. Ltd. Feasibility Report”) and submitted it to CEB in October 2013. NTPC estimated the power tariff to CEB in this report and the calculation methods are the same as the calculation formula in the PPA. Therefore, conditions of calculation in the T-FR can be utilized for these calculations.

13.3.1.1. Capacity Charge and Energy Charge

Payments to the TPCL comprise two distinct elements, a capacity charge element and an energy charge, each of which is sub-divided into a number of components as follows:

- The capacity charge was computed for available capacity.
- The energy charge represents the payment for net electrical output and was computed on the basis of the coal energy rate, which reflects the costs of the energy content of coal and the secondary fuel.

13.3.1.2. Calculation of the Capacity Charge

1) Calculation Formula for the Capacity Charge

In this section the following definitions shall be applied in relation to the calculations.

	Description	clause
AAYA	actually achieved yearly availability	2)
DOM	US dollar component of the operation and maintenance costs	9)
DPR	US dollar component of the depreciation	8)
FCCP	foreign currency component of the capacity charge payable	11)
IOD	US dollar component of the interest on debt	7)
IWC	interest on the working capital	10)
RCCP	Sri Lankan rupee component of capacity charge payable	11)
RIOD	Sri Lankan rupee component of the interest on debt	7)
ROE	return on equity	6)
ROM	Sri Lankan rupee component of the operation and maintenance cost	9)
RPR	Sri Lankan rupee component of the depreciation	8)
TA	target availability	2)

The Team employed three formulas for this calculation. The normal calculation formula shall be adopted for the year if TA exceeds AAYA or TA is equal to AAYA. The ceiling capacity charge formula and Additional Capacity Charge formula shall be applied for the year if AAYA exceeds TA.

(i) The calculation formula for the yearly normal capacity charge can be summarized as follows:

$$\mathrm{FCCP} = \frac{\mathrm{AAYA}}{\mathrm{TA}} * (\mathrm{ROE}+\mathrm{IOD}+\mathrm{DPR}+\mathrm{DOM})$$

$$\mathrm{RCCP} = \frac{\mathrm{AAYA}}{\mathrm{TA}} * (\mathrm{RIOD}+\mathrm{RPR}+\mathrm{IWC}+\mathrm{ROM})$$

Note: Formula is converted into a yearly basis (original formula applied a monthly basis).

(ii) The calculation Formula for the ceiling capacity charge is:

Ceiling foreign currency component (CFCC) = (ROE+IOD+DPR+DOM)
Ceiling Sri Lankan rupee component (CRC) = (RIOD+RPR+IWC+ROM)

(iii) Calculation formula for the capacity charge payable beyond target availability:

$$\text{Foreign currency component} = \frac{AAYA}{TA} * \frac{PHb}{PHy} * (ROE+IOD+DPR+DOM)$$

$$\text{Sri Lankan Rupee component} = \frac{AAYA}{TA} * \frac{PHb}{PHy} * (RIOD+RPR+IWC+ROM)$$

The above formula can be summarized as follows:

$$\text{Additional capacity charge} = \frac{AAYA}{TA} * \frac{PHb}{PHy} * (CFCC+CRC)$$

PHb = Number of hours in which the facility has been dispatched by CEB

PHy = Number of hours in a year: 8,760

2) AAYA and TA

AAYA is measurable after the operation of the power plant, and AAYA shall be estimated based on some assumptions before the plant operation commence. TA is the agreed planned capacity from the view of the facility. Therefore, TA is one of candidate of AAYA. On the other side, CEB estimate the future generation quantity for each plant based on the estimated power demand. A new power plant shall be operated more than TA if the generation forecast of a certain year is greater than the generation at TA. AAYA shall be computed from the generation forecast if the generation quantity is the greater than generation at TA.

TA is stipulated in schedule 8 of the PPA and the initially agreed TA, expressed in percentages, is set out in Table13.3-1.

Table 13.3-1 Target Availability

Year	TA (%)	Year	TA (%)	Year	TA (%)	Year	TA (%)	Year	TA (%)
1	75	6	80	11	85	16	80	21	80
2	75	7	85	12	80	17	80	22	80
3	80	8	85	13	85	18	80	23	75
4	80	9	80	14	80	19	80	24	75
5	80	10	85	15	80	20	80	25	75

(Source: Schedule 8 Actual Available Capacity 8.5 Target Availability)

Calculation of AAYA

Table 13.3-2 Comparison between CC and TA

Year	PGQ (GWh)	NDC (MW)	PHy	CC	TA
2020	3,360	455	8,760	84.30%	75.00%
2021	3,381	455	8,760	84.83%	75.00%
2022	3,400	455	8,760	85.30%	80.00%
2023	3,416	455	8,760	85.70%	80.00%
2024	3,425	455	8,760	85.93%	80.00%
2025	3,432	455	8,760	86.11%	80.00%
2026	3,435	455	8,760	86.18%	85.00%
2027	3,437	455	8,760	86.23%	85.00%
2028	3,438	455	8,760	86.26%	80.00%
2029	3,438	455	8,760	86.26%	85.00%
2030	3,438	455	8,760	86.26%	85.00%
2031	3,439	455	8,760	86.28%	80.00%
2032	3,439	455	8,760	86.28%	85.00%

(Source: Prepared by team based on provided data)

PGQ: planned generation quantity
NDC: net dependable capacity
CC: computed capacity

In the CEB Generation Plan of October 2013, CEB described the power generation plan of the Sampoor coal-fired power plant estimated based on the electricity demand forecast and power plant construction plan. The plant planned to start generation from 2018 in the CEB Generation Plan but this has now been postponed to 2020. However, generation in first two years shall be cut because the plan was prepared based on the power demand forecast and the operation start year of each power plant shall be affected by the power demand forecast.

CC is greater than TA in every year of the CEB Generation Plan period. Therefore, CC shall be adopted for AAYA during the plan period. After 2033 TA shall be adopted for AAYA because there are no estimations for the generation after 2033.

Table 13.3-3 Value of AAYA

	Year	AAYA		Year	AAYA		Year	AAYA
1	2020	84.3%	11	2030	86.3%	21	2040	80.0%
2	2021	84.8%	12	2031	86.3%	22	2041	80.0%
3	2022	85.3%	13	2032	86.3%	23	2042	75.0%
4	2023	85.7%	14	2033	80.0%	24	2043	75.0%
5	2024	85.9%	15	2034	80.0%	25	2044	75.0%
6	2025	86.1%	16	2035	80.0%	26	2045	75.0%
7	2026	86.2%	17	2036	80.0%	27	2046	75.0%
8	2027	86.2%	18	2037	80.0%	28	2047	75.0%
9	2028	86.3%	19	2038	80.0%	29	2048	75.0%
10	2029	86.3%	20	2039	80.0%	30	2049	75.0%

(Source: Prepared by the Team based on provided data)

3) Adoption of formula

AAYA is estimated to be greater than TA from 2020 to 2032 and AAYA shall be the same as TA after 2033. Therefore, the ceiling capacity charge formula and additional capacity charge formula shall be applied from 2020 to 2032 and the normal capacity charge formula shall be adopted after 2033. The calculated value of the normal capacity charge shall be same as the calculated value of the ceiling capacity charge after 2033 because AAYA/TA shall be one. Consequently, the ceiling capacity charge formula shall be applied throughout the Project period and the additional capacity charge formula shall be applied from 2020 to 2032.

4) Project Costs and Financing of the Trincomalee coal power plant

According to the T-FR, the foreign currency portion of the Project costs are estimated as 330.62 million USD and the local currency portion of this as 32,313.88 LKR million (284.36 million USD). The Team estimated the construction costs of the Trincomalee coal power plant at 2020 based on the T-FR.

Table 13.3-4 Conversion of the Project Costs

	FC	LC
Project cost (mil USD)	330.62	284.36
Price escalation (mil USD)	59.51	97.25
Total cost (Mil USD)	390.13	381.61
Total cost (Mil JPY)	41,783	40,871

(Source: Prepared by the Team based on provided data)

The Project costs shall be divided according to the method of financing by either equity finance or long term loans. The T-FR stipulates that 30% of the foreign currency component shall be financed by equity and with the remainder to be financed by loans. The Team adopted the conditions stipulated in the T-FR.

Table 13.3-5 Division of the Project Costs

	FC	LC
Equity (FC) (Mil JPY)	12,535	－
Loan (FC) (Mil JPY)	29,248	－
Loan (LC) (Mil JPY)	－	40,871
Total (Mil JPY)	41,783	40,871

(Source: Prepared by team based on provided data)

5) Calculation of ROE

The return ratio is set at 18%.

Return on Equity = 18% of Equity

Equity	12,535	Mil JPY
Rate	18%	
ROE	2,256	Mil JPY

6) Calculation of IOD and RIOD

As the actual loan conditions were not available at the time of this analysis, IOD and RIOD were calculated based on the loan conditions stipulated in the T-FR (apparently these are the only documents which refer to the loan conditions for the Project). Thus, here the applicable interest rate was 13.89% with a payment schedule of 8 years and a 3 year moratorium.

Table 13.3-6 Calculation of IOD and RIOD

(Mil JPY)

	Year	Loan Balance		Interest rate %	Interest amount	
		FC	DC		IOD	RIOD
	2019	29,248	40,871	-	-	-
1	2020	25,592	35,762	13.89	3,809	5,322
2	2021	21,936	30,653	13.89	3,301	4,613
3	2022	18,280	25,544	13.89	2,793	3,903
4	2023	14,624	20,436	13.89	2,285	3,193
5	2024	10,968	15,327	13.89	1,777	2,484
6	2025	7,312	10,218	13.89	1,270	1,774
7	2026	3,656	5,109	13.89	762	1,064
8	2027	0	0	13.89	254	355

(Source: Prepared by the Team based on provided data)

7) Calculation of DPR and RPR

In the T-FR the depreciation conditions were calculated using the straight line method with a yearly depreciation rate of 7.5% and the depreciation applicable for up to 90% of the investment. Thus, the depreciation period was set at 12 years.

Table 13.3-7 Calculation of DPR and RPR

	DPR	RPR	Total	
Capital cost	41,783	40,871	82,654	Mil JPY
Rate	7.5%	7.5%	7.5%	
DPR	3,134	3,065	6,199	Mil JPY

(Source: Prepared by the Team based on provided data)

8) Calculation of DOM and ROM

The calculation formula for DOM and ROM was “Unit price (UP) * NDC *(1-AUX)”

UP: USD 45 per KW for DOM and LKR 1,850 per KW for ROM

NDC (net dependable capacity): 455 MW

AUX (auxiliary energy consumption): 0.09

Table 13.3-8 Calculation of DOM and ROM

	DOM	ROM	Total	
UP	45	1,850	-	USD/KW LKR/KW
Escalation	8	632	-	USD/KW LKR/KW
UP at 2020	53	2,482	-	USD/KW LKR/KW
UP in JPY	6	2	8	Mil JPY/MW
NDC	455	455	455	MW
AUX	0.09	0.09	0.09	
OM	2,838	1,021	3,859	Mil JPY

(Source: Prepared by the Team based on provided data)

9) Calculation of IWC

(i) Composition of working capital

Working capital is composed of following:

a) Delivered cost of coal for two months

b) Delivered cost of secondary fuel for two months

c) DOM and ROM for one month

d) Receivables for two months

e) 30% of O&M costs for spare parts

(ii) Calculation of energy cost for two months (a)+b))

The coal energy rate reflects the costs of the energy content of coal and the secondary fuel. The Team interpreted “a) Delivered cost of coal for two months + b) Delivered cost of secondary fuel for two months” as the energy charge corresponding to TA for two months.

The calculation formula:

a) + b) = Generation at TA * CER

Generation at TA = TA (%) * NDC (MW) * 8760 (h)

Value of each parameter

TA: See 3)

CER: 5.22 JPY/kWh (please refer to 13.3.2.3 for details on the calculation of the energy charge)

NDC: 455MW

Table 13.3-9 Calculation of Energy for Two Months a) + b)

(Million JPY)

	Year	TA (%)	Generation at TA (GWh)	CER JPY/kWh	a)+b)
1	2020	75%	2,989	5.22	2,602
2	2021	75%	2,989	5.22	2,602
3	2022	80%	3,189	5.22	2,775
4	2023	80%	3,189	5.22	2,775
5	2024	80%	3,189	5.22	2,775
6	2025	80%	3,189	5.22	2,775
7	2026	85%	3,388	5.22	2,949
8	2027	85%	3,388	5.22	2,949
9	2028	80%	3,189	5.22	2,775
10	2029	85%	3,388	5.22	2,949
11	2030	85%	3,388	5.22	2,949
12	2031	80%	3,189	5.22	2,775
13	2032	85%	3,388	5.22	2,949
14	2033	80%	3,189	5.22	2,775
15	2034	80%	3,189	5.22	2,775
16	2035	80%	3,189	5.22	2,775
17	2036	80%	3,189	5.22	2,775
18	2037	80%	3,189	5.22	2,775
19	2038	80%	3,189	5.22	2,775
20	2039	80%	3,189	5.22	2,775
21	2040	80%	3,189	5.22	2,775
22	2041	80%	3,189	5.22	2,775
23	2042	75%	2,989	5.22	2,602
24	2043	75%	2,989	5.22	2,602
25	2044	75%	2,989	5.22	2,602
26	2045	75%	2,989	5.22	2,602
27	2046	75%	2,989	5.22	2,602
28	2047	75%	2,989	5.22	2,602
29	2048	75%	2,989	5.22	2,602
30	2049	75%	2,989	5.22	2,602

(Source: Prepared by team based on provided data)

(iii) Calculation of O&M related c) and e)

c) DOM and ROM for one month and e) 30% of O&M Cost for spare parts can be computed by DOM and ROM.

Calculation formula:

c) = (DOM + ROM)/12

e) = (DOM + ROM) * 0.3

Value of parameters

DOM: 2,838

ROM: 1,021

Calculation results

c) = (2,838+1,021) / 12 = 322 mil JPY

e) = (2,838+1,021) * 0.3 = 1,158 mil JPY

(iv) Calculation of receivables (d))

Two months receivables are equivalent to the power purchase costs (PPC) for the past two months. One sixth of PPC (capacity charge + energy charge) was adopted for this estimation. In order to avoid circular reference the calculated value may be a little bit different from a 1/6 of the total charge amounts.

Table 13.3-10 Calculation of Receivables for Two Months (d)

(Mil JPY)

	Year	PPC	d)
1	2020	42,906	7,151
2	2021	41,787	6,964
3	2022	39,382	6,564
4	2023	38,240	6,373
5	2024	37,013	6,169
6	2025	35,758	5,960
7	2026	33,618	5,603
8	2027	32,375	5,396
9	2028	32,491	5,415
10	2029	31,753	5,292
11	2030	31,753	5,292
12	2031	32,501	5,417
13	2032	25,336	4,223
14	2033	23,878	3,980
15	2034	23,878	3,980
16	2035	23,878	3,980
17	2036	23,878	3,980
18	2037	23,878	3,980
19	2038	23,878	3,980
20	2039	23,878	3,980
21	2040	23,878	3,980
22	2041	23,878	3,980
23	2042	22,789	3,798
24	2043	22,789	3,798
25	2044	22,789	3,798
26	2045	22,789	3,798
27	2046	22,789	3,798
28	2047	22,789	3,798
29	2048	22,789	3,798
30	2049	22,789	3,798

(Source: Prepared by the Team based on provided data)

(v) Calculation of IWC

The calculation formula for IWC is “working capital * interest rate”.

The working capital was financed by short term loans from private banks and the interest rates were based on the actual interest rate according to the CEB project director of the Trincomalee Coal Power project. According to CEB annual reports from 2009 to 2012, the interest rates for the said short term private bank loans were between 10% and 17%. Thus, based on this, the Team adopted 13.5% – the mid-value of the past interest rates – as the interest rate for its calculations.

Table 13.3-11 Calculation of Working Capital and IWC

(Mil JPY)

	Year	Working Capital					Interest Rate	IWC
		a)+b)	c)	d)	e)	Total		
1	2020	2,602	322	7,151	1,158	11,232	13.5%	1,516
2	2021	2,602	322	6,965	1,158	11,046	13.5%	1,491
3	2022	2,775	322	6,564	1,158	10,818	13.5%	1,460
4	2023	2,775	322	6,373	1,158	10,628	13.5%	1,435
5	2024	2,775	322	6,169	1,158	10,423	13.5%	1,407
6	2025	2,775	322	5,960	1,158	10,214	13.5%	1,379
7	2026	2,949	322	5,603	1,158	10,031	13.5%	1,354
8	2027	2,949	322	5,396	1,158	9,824	13.5%	1,326
9	2028	2,775	322	5,415	1,158	9,670	13.5%	1,305
10	2029	2,949	322	5,292	1,158	9,720	13.5%	1,312
11	2030	2,949	322	5,292	1,158	9,720	13.5%	1,312
12	2031	2,775	322	5,417	1,158	9,671	13.5%	1,306
13	2032	2,949	322	4,223	1,158	8,651	13.5%	1,168
14	2033	2,775	322	3,980	1,158	8,234	13.5%	1,112
15	2034	2,775	322	3,980	1,158	8,234	13.5%	1,112
16	2035	2,775	322	3,980	1,158	8,234	13.5%	1,112
17	2036	2,775	322	3,980	1,158	8,234	13.5%	1,112
18	2037	2,775	322	3,980	1,158	8,234	13.5%	1,112
19	2038	2,775	322	3,980	1,158	8,234	13.5%	1,112
20	2039	2,775	322	3,980	1,158	8,234	13.5%	1,112
21	2040	2,775	322	3,980	1,158	8,234	13.5%	1,112
22	2041	2,775	322	3,980	1,158	8,234	13.5%	1,112
23	2042	2,602	322	3,798	1,158	7,879	13.5%	1,064
24	2043	2,602	322	3,798	1,158	7,879	13.5%	1,064
25	2044	2,602	322	3,798	1,158	7,879	13.5%	1,064
26	2045	2,602	322	3,798	1,158	7,879	13.5%	1,064
27	2046	2,602	322	3,798	1,158	7,879	13.5%	1,064
28	2047	2,602	322	3,798	1,158	7,879	13.5%	1,064
29	2048	2,602	322	3,798	1,158	7,879	13.5%	1,064
30	2049	2,602	322	3,798	1,158	7,879	13.5%	1,064

(Source: Prepared by the Team based on provided data)

10) Calculation of the Yearly Capacity Charge

Table 13.3-12 Calculation of Capacity Charge Payable

(Mil JPY)

	Year	ROE	IOD	DPR	DOM	FCCP	ROD	PRP	IWC	ROM	RCCP
1	2020	2,256	3,809	3,134	2,838	12,037	5,322	3,065	1,516	1,021	10,925
2	2021	2,256	3,301	3,134	2,838	11,529	4,613	3,065	1,491	1,021	10,190
3	2022	2,256	2,793	3,134	2,838	11,021	3,903	3,065	1,460	1,021	9,450
4	2023	2,256	2,285	3,134	2,838	10,513	3,193	3,065	1,435	1,021	8,715
5	2024	2,256	1,777	3,134	2,838	10,006	2,484	3,065	1,407	1,021	7,978
6	2025	2,256	1,270	3,134	2,838	9,498	1,774	3,065	1,379	1,021	7,240
7	2026	2,256	762	3,134	2,838	8,990	1,064	3,065	1,354	1,021	6,505
8	2027	2,256	254	3,134	2,838	8,482	355	3,065	1,326	1,021	5,768
9	2028	2,256	-	3,134	2,838	8,228	-	3,065	1,305	1,021	5,392
10	2029	2,256	-	3,134	2,838	8,228	-	3,065	1,312	1,021	5,399
11	2030	2,256	-	3,134	2,838	8,228	-	3,065	1,312	1,021	5,399
12	2031	2,256	-	3,134	2,838	8,228	-	3,065	1,306	1,021	5,392
13	2032	2,256	-	-	2,838	5,094	-	-	1,168	1,021	2,189
14	2033	2,256	-	-	2,838	5,094	-	-	1,112	1,021	2,133
15	2034	2,256	-	-	2,838	5,094	-	-	1,112	1,021	2,133
16	2035	2,256	-	-	2,838	5,094	-	-	1,112	1,021	2,133
17	2036	2,256	-	-	2,838	5,094	-	-	1,112	1,021	2,133
18	2037	2,256	-	-	2,838	5,094	-	-	1,112	1,021	2,133
19	2038	2,256	-	-	2,838	5,094	-	-	1,112	1,021	2,133
20	2039	2,256	-	-	2,838	5,094	-	-	1,112	1,021	2,133
21	2040	2,256	-	-	2,838	5,094	-	-	1,112	1,021	2,133
22	2041	2,256	-	-	2,838	5,094	-	-	1,112	1,021	2,133
23	2042	2,256	-	-	2,838	5,094	-	-	1,064	1,021	2,085
24	2043	2,256	-	-	2,838	5,094	-	-	1,064	1,021	2,085
25	2044	2,256	-	-	2,838	5,094	-	-	1,064	1,021	2,085
26	2045	2,256	-	-	2,838	5,094	-	-	1,064	1,021	2,085
27	2046	2,256	-	-	2,838	5,094	-	-	1,064	1,021	2,085
28	2047	2,256	-	-	2,838	5,094	-	-	1,064	1,021	2,085
29	2048	2,256	-	-	2,838	5,094	-	-	1,064	1,021	2,085
30	2049	2,256	-	-	2,838	5,094	-	-	1,064	1,021	2,085

(Source: Prepared by the Team based on provided data)

11) Calculation of the Additional Capacity Charge

Please refer to section 13.3.1.2 1) iii for the calculation formula for the additional capacity charge.

$$\text{Additional capacity charge} = \frac{AAYA}{TA} * \frac{PHb}{PHy} * (CFCC+CRC)$$

The values of the parameters for the formula are already stated above except for PHb. PHb shall be computed from planned the generation quantity, for which the formula is:

PHb = PGQ (GWh) / NDC (MW) – PHy * TA

Table 13.3-13 Calculation of Additional Capacity Charge

	Year	AAYA (%)	TA (%)	PHb (h)	PHy (h)	CFCC (Mil JPY)	CRC (Mil JPY)	ACC (Mil JPY)
1	2020	84.3%	75%	815	8,760	12,037	10,925	2,399
2	2021	84.8%	75%	861	8,760	11,529	10,190	2,413
3	2022	85.3%	80%	465	8,760	11,021	9,450	1,157
4	2023	85.7%	80%	500	8,760	10,513	8,715	1,174
5	2024	85.9%	80%	519	8,760	10,006	7,978	1,145
6	2025	86.1%	80%	535	8,760	9,498	7,240	1,099
7	2026	86.1%	85%	103	8,760	8,990	6,505	185
8	2027	86.2%	85%	108	8,760	8,482	5,768	178
9	2028	86.2%	80%	548	8,760	8,228	5,392	918
10	2029	86.2%	85%	110	8,760	8,228	5,399	174
11	2030	86.2%	85%	110	8,760	8,228	5,399	174
12	2031	86.2%	80%	550	8,760	8,228	5,392	922
13	2032	86.2%	85%	112	8,760	5,094	2,189	95

(Source: Prepared by the Team based on provided data)

13.3.1.3. Calculation of the Energy Charge

1) Calculation Formula

The formula for the energy charge is: “production * CER”

The formula for CER is: CER = 1 / (1-AUX) * ((Pc * HRc) + (Po*HRs))

The formula for HRc is: HRc = GHR – (GCV * HRs)

CER: coal energy rate
Pc : price of coal in JPY per KJ
Po : price of secondary fuel in JPY per liter
HRc : normative quantity of coal required for generation of one kWh
HRs : normative consumption of secondary fuel in liters per kWh
GHR: gross station heat rate in KJ per kWh
GCV: gross caloric value of secondary fuel in KJ per liter

2) Calculation of Pc and Po

Recently, the prices of coal and crude oil have been unstable and often fluctuate. The tables below illustrate these past price trends.

Table 13.3-14 International Prices of Coal and Oil

	2010	2011	2012	2013	2014
Coal (USD/Ton)	106.04	130.12	103.25	90.6	75.12
Brent (USD/Barrel)	79.63	110.95	111.96	108.85	98.94

(Source: http://ecodb.net/pcp/imf_usd_poilwti.html)

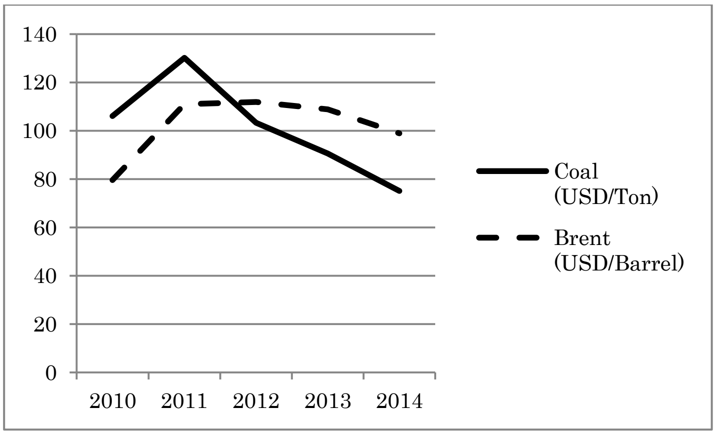


Table 13.3-15 Monthly Coal Price USD/Ton and Brent Price USD/Barrel

Month	Coal ($/Ton)	Brent ($/Barrel)
06/2014	76.59	111.87
07/2014	73.66	106.98
08/2014	73.86	101.92
09/2014	70.65	97.34
10/2014	68.26	87.27
11/2014	67.02	78.44
12/2014	66.68	62.16
01/2015	66.54	48.42
02/2015	65.79	57.93

(Source: http://www.indexmundi.com)

Table 13.3-14 shows that coal prices have been influenced and correlated with the oil price. Table 13.3-15 shows that coal prices and especially oil prices have drastically fallen being around half the price it was six months ago. Various reasons are likely for these falls, including the effect of the European economic crisis, the impact of shale energy, and speculation by institutional investors. It is unclear to which level oil prices will recover and also to future price levels. Thus, in light of this and taking a relatively conservative viewpoint, to eliminate temporary fluctuations the Team decided to adopt the 5 year oil price average from 2010 to 2014.

Pc shall be 101 USD/Ton
Po shall be 102 USD/Barrel

3) Calculation of HRc

The formula for HRc is: HRc = GHR – (GCV * HRs)

The values of the relevant parameters are:

GHR (kJ/kWh) = 10,886
GCV (kJ/Liter) = 42,000
HRs (Liter/kWh) = 0.002

Thus, HRc is 10,802

4) Calculation of CER

The formula for CER is: CER = 1 / (1-AUX) * ((Pc * HRc) + (Po*HRs))

The values of the relevant parameters are:

AUX: 0.09
1 kg = 25.7 MJ =25,700 KJ
1 Barrel = 158.987 Liter

1 / (1 - 0.09) * ((101*107.1/25.700) * 10,802 + 86.238*107.1*158.987 * 0.002)

CER: 5.2218 (JPY/kWh)

5) Calculation of the Energy Charge

Table 13.3-16 Calculation of Energy Charges

(Mil JPY)

	Year	Production (GWh)	CER (JPY/kWh)	Energy Charge
1	2020	3,360	5.22	17,545
2	2021	3,381	5.22	17,655
3	2022	3,400	5.22	17,754
4	2023	3,416	5.22	17,838
5	2024	3,425	5.22	17,885
6	2025	3,432	5.22	17,921
7	2026	3,435	5.22	17,937
8	2027	3,437	5.22	17,947
9	2028	3,438	5.22	17,953
10	2029	3,438	5.22	17,953
11	2030	3,438	5.22	17,953
12	2031	3,439	5.22	17,958
13	2032	3,439	5.22	17,958
14	2033	3,189	5.22	16,650
15	2034	3,189	5.22	16,650
16	2035	3,189	5.22	16,650
17	2036	3,189	5.22	16,650
18	2037	3,189	5.22	16,650
19	2038	3,189	5.22	16,650
20	2039	3,189	5.22	16,650
21	2040	3,189	5.22	16,650
22	2041	3,189	5.22	16,650
23	2042	2,989	5.22	15,610
24	2043	2,989	5.22	15,610
25	2044	2,989	5.22	15,610
26	2045	2,989	5.22	15,610
27	2046	2,989	5.22	15,610
28	2047	2,989	5.22	15,610
29	2048	2,989	5.22	15,610
30	2049	2,989	5.22	15,610

(Source: Prepared by the Team based on provided data)

13.3.1.4. Calculation of the Power Purchase Costs

Payments to the TCPL comprise two distinct elements, a capacity charge and an energy charge. The capacity charge consists of FCCP, RCCP, and ACC.

Table 13.3-17 Calculation of Power Purchase Costs (PPC)

(Mil JPY)

	Year	FCCP	RCCP	ACC	Energy charge	PPC
1	2020	12,037	10,925	2,399	17,545	42,906
2	2021	11,529	10,190	2,413	17,655	41,787
3	2022	11,021	9,450	1,157	17,754	39,382
4	2023	10,513	8,715	1,174	17,838	38,240
5	2024	10,006	7,978	1,145	17,885	37,013
6	2025	9,498	7,240	1,099	17,921	35,758
7	2026	8,990	6,505	185	17,937	33,618
8	2027	8,482	5,768	178	17,947	32,375
9	2028	8,228	5,392	918	17,953	32,491
10	2029	8,228	5,399	174	17,953	31,753
11	2030	8,228	5,399	174	17,953	31,753
12	2031	8,228	5,392	922	17,958	32,501
13	2032	5,094	2,189	95	17,958	25,336
14	2033	5,094	2,133	-	16,650	23,878
15	2034	5,094	2,133	-	16,650	23,878
16	2035	5,094	2,133	-	16,650	23,878
17	2036	5,094	2,133	-	16,650	23,878
18	2037	5,094	2,133	-	16,650	23,878
19	2038	5,094	2,133	-	16,650	23,878
20	2039	5,094	2,133	-	16,650	23,878
21	2040	5,094	2,133	-	16,650	23,878
22	2041	5,094	2,133	-	16,650	23,878
23	2042	5,094	2,085	-	15,610	22,789
24	2043	5,094	2,085	-	15,610	22,789
25	2044	5,094	2,085	-	15,610	22,789
26	2045	5,094	2,085	-	15,610	22,789
27	2046	5,094	2,085	-	15,610	22,789
28	2047	5,094	2,085	-	15,610	22,789
29	2048	5,094	2,085	-	15,610	22,789
30	2049	5,094	2,085	-	15,610	22,789

(Source: Prepared by the Team based on provided data)

13.3.2. O&M Costs

Two types of O&M costs were adopted for this IRR calculation. No electricity will be provided to new transmission lines before operation of the new power plant, so no benefits will be gained. Therefore, only the O&M costs of newly constructed transmission lines were counted before operation. The O&M costs for after the power plant operation commences were calculated using the formula(s) below.

[For the O&M costs of the transmission division]

$$\frac{[O\&M\ costs\ of\ transmission\ division]}{[Total\ power\ sales]} \times [Power\ sales\ originated\ in\ Trincomalee]$$

[For the O&M costs of the distribution division]

$$\frac{[O\&M\ costs\ of\ distribution\ division]}{[Total\ power\ sales]} \times [Power\ sales\ originated\ in\ Trincomalee]$$

Power will be provided to the whole transmission distribution networks through the new transmission lines. As it is impossible to specify the places where the generated power shall be consumed, the total O&M costs shall be divided in accordance with above formula(s).

Construction of the transmission lines is expected to be completed in 2018 and plant is scheduled to start operation in 2020. Thus, the O&M costs of the newly constructed transmission lines were only adopted for 2019.

- ✓ O&M costs of newly constructed transmission lines: 1% of construction costs
- ✓ Average O&M costs of transmission division and distribution division

Table 13.3-18 Movement of Transmission and Distribution O&M Costs

	2005	2006	2007	2008	2009	2010	2011	2012	2013
TOMT(A)	746	971	1,005	1,153	1,678	1,521	1,733	4,154	3,940
TOMD (B)	5,540	7,026	7,614	6,956	6,369	6,874	7,723	15,454	15,855
TG (C)	5,338	5,961	5,941	5,787	5,450	6,386	6,552	6,162	8,808
UOMT A/C	0.1397	0.1629	0.1691	0.1992	0.3078	0.2382	0.2646	0.6741	0.4473
UOMD B/C	1.0379	1.1786	1.2815	1.2019	1.1686	1.0764	1.1787	2.5080	1.8001

(Source: Financial Statement of CEB)
TOMT (A): Total O&M Cost of Transmission (million LKR)
TOMD (B): Total O&M Cost of Distribution (million LKR)
TG (C): Total Generation (GWh)
UOMT A/C: Unit O&M Cost of Transmission (Mil LKR/GWh)
UOMD A/B: Unit O&M Cost of Distribution (Mil LKR/GWh)

Slope unit transmission:	0.0307	Increase ratio:	0.0933
Slope unit distribution:	0.0698	Increase ratio:	0.0526

The increase ratio of the transmission division's unit O&M costs are more than the predicted increase ratio of the consumer price index. The increase ratio of 0.0933 shall be applied from a conservative point of view. The increase ratio of the distribution division's unit O&M costs is less than the increase ratio of the consumer price index. The consumer price index of 0.065155 shall be applied.

Table 13.3-19 Estimation of Unit O&M Costs in 2020

	2014	2015	2016	2017	2018	2019	2020	Rate	JPY
UOMT	0.4972	0.5471	0.5970	0.6469	0.6968	0.7467	0.7966	0.82	0.6556
UOMD	1.9118	2.0236	2.1354	2.2471	2.3589	2.4707	2.5824	0.82	2.1253

(Source: Prepared by team based on provided data)

Table 13.3-20 O&M Costs

		PGQ GWh	UOMCT Mil JPY	OMCT Mil JPY	UOMCD Mil JPY	OMCD Mil JPY	TOMC Mil JPY
1	2020	3,360	0.6556	2,203	2.1253	7,141	9,344
2	2021	3,381	0.6556	2,217	2.1253	7,186	9,402
3	2022	3,400	0.6556	2,229	2.1253	7,226	9,455
4	2023	3,416	0.6556	2,240	2.1253	7,260	9,500
5	2024	3,425	0.6556	2,245	2.1253	7,279	9,525
6	2025	3,432	0.6556	2,250	2.1253	7,294	9,544
7	2026	3,435	0.6556	2,252	2.1253	7,301	9,552
8	2027	3,437	0.6556	2,253	2.1253	7,305	9,558
9	2028	3,438	0.6556	2,254	2.1253	7,307	9,561
10	2029	3,438	0.6556	2,254	2.1253	7,307	9,561
11	2030	3,438	0.6556	2,254	2.1253	7,307	9,561
12	2031	3,439	0.6556	2,255	2.1253	7,309	9,564
13	2032	3,439	0.6556	2,255	2.1253	7,309	9,564
14	2033	3,189	0.6556	2,090	2.1253	6,777	8,867
15	2034	3,189	0.6556	2,090	2.1253	6,777	8,867
16	2035	3,189	0.6556	2,090	2.1253	6,777	8,867
17	2036	3,189	0.6556	2,090	2.1253	6,777	8,867
18	2037	3,189	0.6556	2,090	2.1253	6,777	8,867
19	2038	3,189	0.6556	2,090	2.1253	6,777	8,867
20	2039	3,189	0.6556	2,090	2.1253	6,777	8,867
21	2040	3,189	0.6556	2,090	2.1253	6,777	8,867
22	2041	3,189	0.6556	2,090	2.1253	6,777	8,867
23	2042	2,989	0.6556	1,960	2.1253	6,353	8,313
24	2043	2,989	0.6556	1,960	2.1253	6,353	8,313
25	2044	2,989	0.6556	1,960	2.1253	6,353	8,313
26	2045	2,989	0.6556	1,960	2.1253	6,353	8,313
27	2046	2,989	0.6556	1,960	2.1253	6,353	8,313
28	2047	2,989	0.6556	1,960	2.1253	6,353	8,313
29	2048	2,989	0.6556	1,960	2.1253	6,353	8,313
30	2049	2,989	0.6556	1,960	2.1253	6,353	8,313
Total		97,091	-	63,653	-	206,349	270,002

(Source: Prepared by team based on provided data)
PGQ: planned generation quantity
UOMCT: unit O&M costs of transmission
OMCT: O&M costs of transmission
UOMCD: unit O&M costs of distribution
OMCD: O&M cost of distribution
TOMC: total O&M cost

13.4. Economic Analysis

13.4.1. Economic Evaluation

The economic analysis appraises the Project under study in terms of an entire national economy by comparing and measuring its economic costs and benefits converted into international prices. In other words, the economic analysis is the process of evaluating the extent of economic effects on the national economy as result of the implementation of the Project.

The economic evaluation was conducted according to the following procedure:

- ✓ The definition and quantification of economic costs and benefits.
- ✓ The comparison of economic costs and benefits.
- ✓ The calculation and evaluation of the EIRR.

The comparisons were carried out by converting all the future economic costs and benefits emerging during the operational life of the Project into Net Present Values (NPV), by applying the discounted cash flow method. When the present value of the economic costs (C) are equal to the present value of the economic benefits (B), or B/C=1, the discount rate used to calculate these present values is known as the economic internal rate of return (EIRR).

In general, the discount rate (for capital establishment) used by multilateral development banks, such as the World Bank and the Asian Development Bank, as applied to developing countries is between 8% and 12%. The average value normally adopted as a reference is 10.0%.

The economic evaluation of this Project assumed that the discount rate in Sri Lanka was 10% taking into account the above-mentioned average value adopted by multilateral development banks and the past project evaluations by JBIC and JICA for Sri Lanka.

13.4.2. Economic Benefits and Costs

From the perspective of the national economy, the "economic benefits" of a power efficiency project are the output emerging from the implementation of the project, such as the increase of power sales.

In line with the above interpretation and from the perspective of the national economy, the "economic costs" of such power transmission projects are all costs associated with the implementation of the project, including operation, maintenance, and administration costs as well as fuel expenses.

The economic benefits and economic costs of this study are as follows:

- ✓ Economic benefits: Power sales increase
- ✓ Economic costs: Costs for implementation of this project

13.4.3. Project Life and Operation Period

The economic costs and benefits were calculated over the whole life of the Project. The first year is assumed as the first allocation of the Project costs for the installation of equipment and machinery. The final year of the Project refers to when the O&M of the Project facilities comes to an end.

The average operation period of the equipment and systems for this Project is assumed to be 30 years (2020 to 2049), beginning from when the Sampoor coal-fired power plant comes into operation.

13.4.4. Scope and Objectives of the Economic Evaluation

The construction of the switching station and the construction of the transmission lines under this Project will simply be regarded as one part in the overall national power transmission system for Sri Lanka. Thus, it is generally difficult to define the benefits associated with the implementation of only one power transmission project of this kind.

13.4.5. Economic Benefits

The increase in power sales is calculated using this formula:

$$[Generation\ quantity\ (GWh)] \times [Sales\ Ratio\ (\%)] \times [Power\ Tariff\ (mil.JPY)]$$

(i) Generation Quantities

Generation forecasts in the CEB Generation Plan were applied for the years 2020 to 2032. Thus, the generation quantities were computed from TA after 2033.

Generation = TA * NDC * PHy

Table 13.4-1 Calculation of Generation from 2033 to 2049

	Year	TA (%)	EGQ (GWh)
14	2033	80%	3,189
15	2034	80%	3,189
16	2035	80%	3,189
17	2036	80%	3,189
18	2037	80%	3,189
19	2038	80%	3,189
20	2039	80%	3,189
21	2040	80%	3,189
22	2041	80%	3,189
23	2042	75%	2,989
24	2043	75%	2,989
25	2044	75%	2,989
26	2045	75%	2,989
27	2046	75%	2,989
28	2047	75%	2,989
29	2048	75%	2,989
30	2049	75%	2,989

(Source: Prepared by the Team based on provided data)

(ii) Sales Ratio

Sometimes CEB will not be able to sell all of its generated power to customers. For example, some of this power may be lost through passing through the transmission and distribution lines; some may even be stolen from these lines. Table 13.4-2 illustrates the difference between the generated power volume and the power sales volume.

Table 13.4-2 Power Sales (GWh) vs Generation (GWh)

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Power Sales	6,667	7,225	7,832	8,276	8,417	8,441	9,268	10,023	10,474	10,621
Generation	8,043	8,769	9,389	9,814	9,901	9,882	10,714	11,528	11,801	11,962
Sales Ratio	82.89%	82.39%	83.42%	84.33%	85.01%	85.42%	86.50%	86.94%	88.76%	88.79%

(Source: CEB stat 2005 to 2013)

As a result of CEB's continuous efforts to reduce losses, sales ratio has been increasing for the past 10 years. However, sooner or later the sales ratio will reach a natural ceiling because transmission and distribution line losses can never be reduced to zero and it is also tough for CEB to completely prevent the theft of electricity. It is difficult for the Team to forecast when the sales ratio will reach its ceiling; thus, we took a conservative outlook and adopted the 2013 sales ratio of 88.79% for this calculation.

(iii) Power Tariffs for Consumer

Consumer tariff rates differ depending on the type of customer and quantity of electricity consumed, so the Team adopted a weighted average price for this calculation. The average consumer power tariffs calculated for the last 10 years are shown in Table 13-4.3.

Table 13.4-3 Average Consumer Tariffs

Power Sales Quantity by Tariff in GWh

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
TOTAL	6,667	7,225	7,832	8,276	8,417	8,441	9,268	10,023	10,474	10,621

Power Sales Amount by Tariff in Mil LKR

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
TOTAL	51,076	55,927	70,408	87,400	110,896	110,551	120,780	132,373	162,956	190,488

Average Sales Price LKR/kWh

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
TOTAL	7.66	7.71	8.99	10.56	13.17	13.10	13.03	13.21	15.56	17.94

(Source: CEB stats 2005 to 2013)

Average Sales Price Increasing Ratio (%)			
Slope:	1.0656	Increase ratio:	0.0594

To obtain a conservative estimate of the 2020 tariff rate, the Team adopted an inflation rate of 3.8% for the Project. We feel that as the inflation rate in Sri Lanka has been declining in recent years the adopted rate of 3.8% is likely to accurately reflect the economic conditions of the country. On the other hand, in order to at least maintain profitability companies must increase their selling prices in line with the consumer price index.

Table 13.4-4 Estimation of Average Tariff up until 2020

Year	Tariff
2014	18.62
2015	19.30
2016	19.98
2017	20.66
2018	21.34
2019	22.02
2020	22.71
Rate	0.82
JPY	18.69

(Source: Prepared by the Team based on provided data)

(iv) Sales Increase Amounts

The power sales increase amounts were computed based on the above-stated generation, sales rate and consumer tariff as shown in Table 13.4-5.

Table 13.4-5 Power Sales Amounts

	Year	Generation GWh	Sales rate %	Tariff Mil JPY	Sales Amounts Mil JPY
1	2020	3,360	88.79%	18.69	55,749
2	2021	3,381	88.79%	18.69	56,097
3	2022	3,400	88.79%	18.69	56,413
4	2023	3,416	88.79%	18.69	56,678
5	2024	3,425	88.79%	18.69	56,827
6	2025	3,432	88.79%	18.69	56,944
7	2026	3,435	88.79%	18.69	56,993
8	2027	3,437	88.79%	18.69	57,027
9	2028	3,438	88.79%	18.69	57,043
10	2029	3,438	88.79%	18.69	57,043
11	2030	3,438	88.79%	18.69	57,043
12	2031	3,439	88.79%	18.69	57,060
13	2032	3,439	88.79%	18.69	57,060
14	2033	3,189	88.79%	18.69	52,906
15	2034	3,189	88.79%	18.69	52,906
16	2035	3,189	88.79%	18.69	52,906
17	2036	3,189	88.79%	18.69	52,906
18	2037	3,189	88.79%	18.69	52,906
19	2038	3,189	88.79%	18.69	52,906
20	2039	3,189	88.79%	18.69	52,906
21	2040	3,189	88.79%	18.69	52,906
22	2041	3,189	88.79%	18.69	52,906
23	2042	2,989	88.79%	18.69	49,599
24	2043	2,989	88.79%	18.69	49,599
25	2044	2,989	88.79%	18.69	49,599
26	2045	2,989	88.79%	18.69	49,599
27	2046	2,989	88.79%	18.69	49,599
28	2047	2,989	88.79%	18.69	49,599
29	2048	2,989	88.79%	18.69	49,599
30	2049	2,989	88.79%	18.69	49,599
Total		97,091			1,610,921

13.4.6. Economic Costs

Since the local currency portion of the economic costs is not regarded as an accurate reflection of the attributes of the economy (due to several circumstances such as the effect of control and legislation on prices), this amount cannot be evaluated or used directly as an economic cost.

Therefore, for the purpose of the economic analysis, it is necessary to convert the national market costs to economic costs referenced to the international market, by applying conversion factors.

(v) Foreign Currency

The foreign currency portion of the implementation costs is expressed in terms of

CIF (cost, insurance, and freight) FOB (free on board prices, which can be included as economic costs since they are referenced to the international market. In the economic analysis of this project, the CIF prices are treated directly as international market prices.

(vi) Local Currency

As mentioned above, it is believed that the local market in developing countries is affected by several factors including internal price control, laws and regulations. This is the reason for the consideration that if the national market prices are treated as economic costs, they will not represent accurately those particularities of the economy applying to goods and services, such as for materials and consulting.

The Standard Conversion Factors (SCF) derived from ordinary import-export statistics are applied to costs of trading goods and used in the economic evaluation process in order to convert from national market prices into typical international market prices.

The SCF adopted for this analysis was 0.9. This factor was selected in consideration of the examples of projects from other countries.

The following costs were eliminated from economic and financial costs:

- ✓ For economic cost: price escalation and taxes
- ✓ For financial cost: price escalation and interest during implementation

The price escalation from 2015 to 2020 was added because the original base costs were calculated based on the 2014 price.

Table 13.4-6 summarizes the economic costs calculated according to the above conditions. The detailed annual breakdown of costs is stipulated in Table 13.4-7.

Table 13.4-6 Project Economic Costs

(in million Yen)

	2015	2016	2017	2018
Economic costs	60	350	7,795	7,790

Table 13.4-7 Economic Costs and Financial Costs

Item	Total			2015			2016			2017			2018		
	FC	LC	Total	FC	LC	Total	FC	LC	Total	FC	LC	Total	FC	LC	Total
A. ELIGIBLE PORTION	Mill JPY	Mill JPY	Mill JPY	Mill JPY	Mill JPY	Mill JPY	Mill JPY	Mill JPY	Mill JPY	Mill JPY	Mill JPY	Mill JPY	Mill JPY	Mill JPY	Mill JPY
Ⅰ) Procurement / Construction	9,761	3,926	13,687	0	0	0	0	0	0	4,832	1,926	6,758	4,929	1,999	6,928
1 Package 01: Construction of Transmission Lines	7,747	3,166	10,913	0	0	0	0	0	0	3,873	1,583	5,456	3,873	1,583	5,456
2 Package 02: Construction of Switching Station	1,100	239	1,339	0	0	0	0	0	0	550	120	670	550	120	670
3 Base cost for JICA financing	8,847	3,405	12,252	0	0	0	0	0	0	4,423	1,703	6,126	4,423	1,703	6,126
4 Price escalation	449	333	783	0	0	0	0	0	0	179	132	311	271	202	472
5 Physical contingency	465	187	652	0	0	0	0	0	0	230	92	322	235	95	330
Ⅱ) 6 Consulting services	159	14	173	0	0	0	0	0	0	75	7	81	84	7	91
7 Base cost	144	12	156	0	0	0	0	0	0	68	6	74	75	6	82
8 Price escalation	7	1	9	0	0	0	0	0	0	3	0	3	5	1	5
9 Physical contingency	8	1	8	0	0	0	0	0	0	4	0	4	4	0	4
Total (Ⅰ + Ⅱ)	9,920	3,940	13,859	0	0	0	0	0	0	4,907	1,933	6,839	5,013	2,007	7,020
B. NON ELIGIBLE PORTION	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
a Procurement / Construction	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10 Package 01: Construction of Transmission Lines	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11 Package 02: Construction of Switching Station	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12 Base cost for Borrower financing	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13 Price escalation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14 Physical contingency	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
b Land Acquisition	0	352	352	0	23	23	0	281	281	0	49	49	0	0	0
16 Base cost	0	322	322	0	21	21	0	258	258	0	43	43	0	0	0
17 Price escalation	0	13	13	0	0	0	0	10	10	0	3	3	0	0	0
18 Physical contingency	0	17	17	0	1	1	0	13	13	0	2	2	0	0	0
c 19 Administration cost	0	711	711	0	1	1	0	14	14	0	344	344	0	351	351
d 20 VAT	0	1,663	1,663	0	0	0	0	0	0	0	821	821	0	842	842
e 21 Import Tax	0	694	694	0	0	0	0	0	0	0	343	343	0	351	351
Total (a+b+c+d+e)	0	3,420	3,420	0	24	24	0	295	295	0	1,557	1,557	0	1,544	1,544
TOTAL (A+B)	9,920	7,359	17,279	0	24	24	0	295	295	4,907	3,490	8,397	5,013	3,551	8,564
		0			0			0			0			0	
C. Interest during Construction	61	0	61	0	0	0	0	0	0	20	0	20	41	0	41
22 Interest during Construction(Const.)	61	0	61	0	0	0	0	0	0	20	0	20	41	0	41
23 Interest during Construction (Consul.)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
D. Front End Fee	28	0	28	28	0	28	0	0	0	0	0	0	0	0	0
GRAND TOTAL (A+B+C+D) 24	10,009	7,359	17,368	28	24	51	0	295	295	4,927	3,490	8,417	5,054	3,551	8,605
		0			0			0			0			0	
E. JICA finance portion incl. IDC (A + C)	10,009	3,940	13,948	28	0	28	0	0	0	4,927	1,933	6,860	5,054	2,007	7,061
					0										
29 Financial Costs	9,490	7,012	16,502	28	24	51	0	285	285	4,725	3,354	8,080	4,737	3,349	8,086
Price Escalation 2015- 2020	1,139	1,599	2,738	3	5	9	0	65	65	567	765	1,332	568	764	1,332
Total Financial Costs	10,629	8,610	19,240	31	29	60	0	350	350	5,292	4,119	9,411	5,306	4,112	9,418
Note 24-4-8-13-17-22-23															
30 Economic Costs	9,552	4,314	13,866	28	24	51	0	285	285	4,746	2,020	6,765	4,779	1,986	6,764
Price Escalation 2015- 2020	1,146	984	2,130	3	5	9	0	65	65	569	461	1,030	573	453	1,026
Total Economic Costs	10,698	5,298	15,996	31	29	60	0	350	350	5,315	2,480	7,795	5,352	2,438	7,790
Nore: for FC=24-4-8-13-17-20-21															
for LC=(3+6)*SCF+5+9+14+18+19	SCF=	0.90													

(Source: Prepared by the Team based on provided data)

13.4.7. Economic Evaluation Results

The economic evaluation of the Project was based on the cash flow of the analyzed economic costs and benefits analyzed. The results are summarized in Table 13.4-8 and the outline is presented below.

In the economic analysis, the ratio between the benefits and costs (B/C) was estimated from the converted net present value of the benefits and the costs. The difference between the benefits and the costs (B-C) were also estimated in the same manner.

The EIRR was also calculated because it is regarded as an important indicator to assess the feasibility of the Project. This indicator is defined as follows:

$$\sum_{t=1}^{t=T} \frac{C_t}{(1+R)^t} = \sum_{t=1}^{t=T} \frac{B_t}{(1+R)^t}$$

Where:

T = last year of the Project life

Ct = annual cash flow of the economic cost for the Project at the year t

Bt = annual benefit from the alternative project at the year t (savings from the alternative project and sales income from the international interconnection)

R = EIRR

Total economic costs = costs for the implementation of the Project (such as construction of the transmission lines and switching station, contingency, consulting fee and administration fee) +power purchase costs+ maintenance costs for 30 years

Total economic benefits = Power sales increase

The EIRR was calculated as 32.58% for the base case, as indicated below.

Table 13.4-8 Economic Evaluation Results

Case	EIRR (%)	B/C ratio	B-C (mil. JPY)
Base case	32.58%	2.00	261,802

As indicated earlier, the discount rate (for capital establishment) used by multilateral development banks as applied to developing countries is generally between 8% and 12%. The average value normally adopted as reference is 10%.

From an economic perspective the Project is likely to be feasible, because the calculated EIRR (32.58%) is higher than the discount rate (for capital establishment) of 10% assumed for Sri Lanka. In other words, the Project should be feasibility from an economic perspective if the price variation is kept within about 10%.

Table 13.4-9 EIRR Calculation Sheet

Economic Internal Rate of Return EIRR= 32.58%

(Mil JPY)

Year		Cost				Benefit	Net Cash Balance (B-C)
	Year	Investment	Power Purchase Cost	O&M	Total Cost (C)	Power Sales (B)	
	2015	60		0	60		-60
	2016	350			350		-350
	2017	7,795		0	7,795		-7,795
	2018	7,790		0	7,790		-7,790
	2019			160	160		-160
1	2020		42,906	9,344	52,250	55,749	3,499
2	2021		41,787	9,402	51,189	56,097	4,908
3	2022		39,382	9,455	48,838	56,413	7,575
4	2023		38,240	9,500	47,740	56,678	8,938
5	2024		37,013	9,525	46,537	56,827	10,290
6	2025		35,758	9,544	45,302	56,944	11,641
7	2026		33,618	9,552	43,170	56,993	13,823
8	2027		32,375	9,558	41,933	57,027	15,093
9	2028		32,491	9,561	42,052	57,043	14,991
10	2029		31,753	9,561	41,314	57,043	15,729
11	2030		31,753	9,561	41,314	57,043	15,729
12	2031		32,501	9,564	42,064	57,060	14,996
13	2032		25,336	9,564	34,900	57,060	22,160
14	2033		23,878	8,867	32,745	52,906	20,160
15	2034		23,878	8,867	32,745	52,906	20,160
16	2035		23,878	8,867	32,745	52,906	20,160
17	2036		23,878	8,867	32,745	52,906	20,160
18	2037		23,878	8,867	32,745	52,906	20,160
19	2038		23,878	8,867	32,745	52,906	20,160
20	2039		23,878	8,867	32,745	52,906	20,160
21	2040		23,878	8,867	32,745	52,906	20,160
22	2041		23,878	8,867	32,745	52,906	20,160
23	2042		22,789	8,313	31,103	49,599	18,497
24	2043		22,789	8,313	31,103	49,599	18,497
25	2044		22,789	8,313	31,103	49,599	18,497
26	2045		22,789	8,313	31,103	49,599	18,497
27	2046		22,789	8,313	31,103	49,599	18,497
28	2047		22,789	8,313	31,103	49,599	18,497
29	2048		22,789	8,313	31,103	49,599	18,497
30	2049		22,789	8,313	31,103	49,599	18,497
Total		15,996	852,129	270,162	1,138,287	1,610,921	472,634

Condition of Discount Rate:	0.1		
Net Present Value:	261,263	523,066	
Benefit and Cost Ratio (B/C)			2.00206
Benefit and Cost Difference (B-C)			261,802

Coefficient to Cost: 1

13.4.8. Economic Sensitivity Analysis

A sensitivity analysis was conducted to study the effect of some assumed variations involving the costs of construction materials, which are highly related to the economic situation in Sri Lanka. In addition to the base case introduced above, a total of eight cases were analyzed where the economic costs rose by 5% and 10% and the economic benefits fell 5 and 10%.

Sensitivity analysis results are shown in Table 13.4-10.

Table 13.4-10 Results of EIRR Sensitivity Analysis

	Benefit		
Cost	Base case	-5%	-10%
Base case	32.58	26.94	20.78
+5%	27.24	21.36	15.78
+10%	21.88	16.52	11.53

In the cases where the benefits fell by 10% and the costs rose by 10% from the base case, the EIRR actually stayed higher than 10%; thus, further suggesting that the Project is economically feasible.

13.5. Financial Analysis

13.5.1. Financial Evaluation

A financial analysis appraises the degree of financial return of the Project under study that is expected to earn and is carried out in terms of profitability for the owner.

The amount invested for the Project is regarded as the “financial costs” and are evaluated in terms of market prices. Additionally, the benefits derived from the Project, which are also evaluated in terms of market prices, are regarded as the “financial benefits”.

The financial costs and benefits derived during the operational life of the Project are compared in terms of present values. When the present value of the financial costs (C) are equal to the present value of the financial benefits (B), or B/C=1, the discount rate used to calculate these present values is known as the financial internal rate of return (FIRR).

13.5.2. Financial Benefits and Costs

- ✓ Financial benefits: power sales increase
- ✓ Financial costs: Costs for implementation of this project

13.5.3. Project Life and Operation Period

The average operation period of the equipment and systems for this Project is assumed to be 30 years (2020 to 2049), beginning from when the Sampoor coal-fired power plant comes into operation.

13.5.4. Scope and Objectives of the Financial Analysis

The financial analysis was carried out in view of financial independence of the executing agencies; the analysis is usually focused on the cash flow {the relationship between the income (financial benefits) and the expenses (financial costs)}, the repayment of loans, and the balance sheet that summarizes the benefits and costs of the Project.

In the same manner as its economic counterpart, this financial analysis was carried out based on the IRR.

13.5.5. Financial Benefits

Power sales increase

Here the calculation method and calculated amounts are the same as those described in the economic benefits.

13.5.6. Financial Costs

The financial costs consisting of the total implementation and operation costs of the Project are indicated below.

(i) Implementation Costs

The financial costs are formed by those expenses directly related to the implementation costs (including skilled and unskilled labor), fuel, machinery, equipment, compensation fees, engineering fees, administration and operation fees, as well as technical contingency costs.

(ii) Administration Costs

The administration costs are executing agency's administrative costs for performing the Project.

(iii) VAT and Import Tax

VAT (sales tax) is applied to all goods and services, and its rate was assumed as 12%. The import tax consists of PAL and NBT. PAL is applied to imported goods, and its rate was assumed as 5%. NBT – levied in order to ensure the budget for rebuilding the infrastructure damaged by the civil war – is applied to entities whose turnover is more than 500,000 LKR in a quarter, and its rate is assumed as 2%.

(iv) Power Purchase Costs

The purpose of this Project is to construct new transmission lines that will supply the power generated at the Sampoor coal-fired power plant to the whole country. New power plant shall be developed by TPCL, and CEB will purchase generated power from TPCL.

(v) O&M Costs

The average unit costs of the transmission division and the distribution division shall be imposed as O&M costs in accordance with the purchased quantities. This is because it will be difficult to identify the consumers who consume power generated from the Sampoor coal-fired power plant and no one will be able to specify the source of the generated electricity that passes through the transmission and distribution lines.

Table 13.5-1 summarizes financial costs calculated according to the above conditions.

The detailed annual breakdown of the costs is stipulated in Table 13.4-7.

Table 13.5-1 Project Financial Costs

(in million Yen)

	2015	2016	2017	2018
Financial costs	60	350	9,411	9,418

13.5.7. Financial Evaluation Results

The financial evaluation of the Project was based on the cash flow of the analyzed financial costs and benefits. The results are summarized in Table 13.5-2 and the outline is presented below.

The relation between the benefits and the costs were used in the financial analysis – such as B/C and B-C – that compare the present values of the benefits and costs as a ratio and as a difference, respectively.

The FIRR, together with the NPV and the benefit-cost ratio (B/C), are important indicators to evaluate the financial feasibility of the Project. The FIRR is defined as follows:

$$\sum_{t=1}^{t=T} \frac{Cf_t}{(1+Rf)^t} = \sum_{t=1}^{t=T} \frac{Bf_t}{(1+Rf)^t}$$

Where:

T = last year of the Project life

Cft = annual cash flow of the financial cost for the Project at the year t

Bft = annual cash flow of the financial benefit for the Project at the year t (increase of electricity exchange income)

Rf = FIRR

Table 13.5-2 Financial Evaluation Results

Case	FIRR (%)	B/C ratio	B-C (mil. JPY)
Base case	29.50	1.23	61,173

The FIRR of 29.50% calculated for the Project is higher than the discount rate (for capital establishment) of 10%.

Table 13.5-3 FIRR Calculation Sheet

Financial Internal Rate of Return FIRR= 29.50%

(Mil JPY)

Year		Cost				Benefit	Net Cash Balance (B-C)
	Year	Investment	Power Purchase Cost	O&M	Total Cost (C)	Power Sales (B)	
-	2015	60			60	0	-60
-	2016	350			350	0	-350
-	2017	9,411			9,411	0	-9,411
-	2018	9,418			9,418	0	-9,418
-	2019			211	211	0	-211
1	2020		42,906	9,344	52,250	55,749	3,499
2	2021		41,787	9,402	51,189	56,097	4,908
3	2022		39,382	9,455	48,838	56,413	7,575
4	2023		38,240	9,500	47,740	56,678	8,938
5	2024		37,013	9,525	46,537	56,827	10,290
6	2025		35,758	9,544	45,302	56,944	11,641
7	2026		33,618	9,552	43,170	56,993	13,823
8	2027		32,375	9,558	41,933	57,027	15,093
9	2028		32,491	9,561	42,052	57,043	14,991
10	2029		31,753	9,561	41,314	57,043	15,729
11	2030		31,753	9,561	41,314	57,043	15,729
12	2031		32,501	9,564	42,064	57,060	14,996
13	2032		25,336	9,564	34,900	57,060	22,160
14	2033		23,878	8,867	32,745	52,906	20,160
15	2034		23,878	8,867	32,745	52,906	20,160
16	2035		23,878	8,867	32,745	52,906	20,160
17	2036		23,878	8,867	32,745	52,906	20,160
18	2037		23,878	8,867	32,745	52,906	20,160
19	2038		23,878	8,867	32,745	52,906	20,160
20	2039		23,878	8,867	32,745	52,906	20,160
21	2040		23,878	8,867	32,745	52,906	20,160
22	2041		23,878	8,867	32,745	52,906	20,160
23	2042		22,789	8,313	31,103	49,599	18,497
24	2043		22,789	8,313	31,103	49,599	18,497
25	2044		22,789	8,313	31,103	49,599	18,497
26	2045		22,789	8,313	31,103	49,599	18,497
27	2046		22,789	8,313	31,103	49,599	18,497
28	2047		22,789	8,313	31,103	49,599	18,497
29	2048		22,789	8,313	31,103	49,599	18,497
30	2049		22,789	8,313	31,103	49,599	18,497
Total		19,240	852,129	270,213	1,143,429	1,610,921	469,358

(Source: Prepared by team based on provided data)

Condition of Discount Rate:	0.1		
Net Present Value:	263,609	324,783	
Benefit and Cost Ratio (B/C)			1.23
Benefit and Cost Difference (B-C)			61,173

Coefficient to Cost: 1

13.5.8. Financial Sensitivity Analysis

Some variations are expected for the construction material costs and other items reflecting the economic situation in Sri Lanka. Consequently, the financial benefits calculated for the Project will obviously be affected by such variations.

Taking into account the above and in addition to the base case introduced earlier, a total of eight cases were analyzed where the financial benefits fell by 5% and 10%, and the financial costs rose by 5% and 10%.

The sensitivity analysis results are as follows.

Table 13.5-4 Results of FIRR Sensitivity Analysis

	Benefit		
Cost	Base case	-5%	-10%
Base case	29.50	24.08	18.30
+5%	24.36	18.85	13.31
+10%	19.35	14.07	8.76

In the cases where the benefits fell by 10% from the base case and the costs rose by 10% from the base case, the FIRR actually fell below 10%. Other than this case, the FIRR was always more than 10%, which may be interpreted as the Project is financially feasible.

Chapter 14. Calculation of the Reduction in Greenhouse Gas Emissions

14.1. Procedure for the Calculation of Greenhouse Gas Emission

14.1.1. 220 kV Sampoor – Kappalturai T/L

The procedure for calculating of the greenhouse gas emissions from the 220 kV Sampoor – Kappalturai T/L is as follows;

1) Amount of transmission loss when the Project is not implemented($TE_{PJ,y}$)

- ✓ Assumption of the Kappalturai load and the Trincomalee load is supplied by the existing 132kV T/L
- ✓ The maximum loss (MW) in 2020 will be calculated by transmission line resistance
- ✓ 58.2% of load factor (LF) (predicted for 2020) is applied
- ✓ Load loss factor (LLF) was calculated by the formula "0.2 x LF + 0.8 x LF^2" with the result of 0.387
- ✓ The amount of transmission loss after the completion of the Project is calculated by multiplying the maximum loss with the LLF and 8760 hours
- ✓ The T/L loss to the existing 132 kV T/L in 2020 is calculated to be 20,273 MWh/year

2) CO_2 emission factor (EF_{elec})

- ✓ 0.6674 t-CO_2/MWh (predicted for 2020) is applied

3) Amount of transmission loss after the completion of the Project ($TL_{PJ,y}$)

- ✓ The maximum loss (MW) in 2020 will be calculated by transmission line resistance
- ✓ 58.2% of LF (predicted for 2020) is applied
- ✓ Load loss factor (LLF) was calculated by the formula "0.2 x LF + 0.8 x LF^2" with the result of 0.387
- ✓ The amount of transmission loss after the completion of the Project is calculated by multiplying the maximum loss with the LLF and 8760 hours
- ✓ The T/L loss of the 220 kV Sampoor – Kappalturai T/L is calculated to be 339 MWh/year in 2020

14.1.2. 400 kV Sampoor – New Habarana T/L

The procedure for calculating the greenhouse gas emissions for the 400 kV Sampoor – New Habarana T/L is as follows;

1) Amount of electricity supply after the completion of the Project ($TE_{PJ,y}$)

- ✓ The supply of energy through the 220 kV lines connected to the Sampoor substation is deducted from the evacuated energy from the Sampoor coal-fired power plant
- ✓ The maximum load at the sending point in 2020 will be calculated by PSS/E
- ✓ The T/L loss in 2020 will be calculated by transmission conductor for ZEBRA type
- ✓ LF is calculated by the following formula;

$$[LF] = \frac{[Amount\ of\ electricity\ supply\ after\ the\ Project]}{[Max\ load\ at\ sending\ point\ in\ 2020\ ] \times 8760(hour)}$$

- ✓ LLF is calculated by the formula "0.2 x LF + 0.8 x LF^2"
- ✓ The amount of transmission loss after the completion of the Project is calculated by multiplying the maximum loss with the LLF and 8760 hours
- ✓ The Electricity loss of the 400 kV Sampoor – New Habarana T/L for ZEBRA is 18,352 MWh/year in 2020

2) CO_2 emission factor (EF_{elec})

- ✓ 0.6674 t-CO2/MWh (predicted for 2020) is applied

3) Amount of transmission loss after the completion of the Project ($TL_{PJ,y}$)

- ✓ The maximum load at the sending point in 2020 will be calculated by PSS/E.
- ✓ The T/L loss in 2020 will be calculated by transmission conductor for LL-ACSR type
- ✓ LF is calculated by the following formula;

$$[LF] = \frac{[Amount\ of\ electricity\ supply\ after\ the\ Project]}{[Max\ load\ at\ sending\ point\ in\ 2020\ ] \times 8760(hour)}$$

- ✓ LLF is calculated by the formula "0.2 x LF + 0.8 x LF^2"
- ✓ The amount of transmission loss after the completion of the Project is calculated by multiplying the maximum loss with the LLF and 8760 hours
- ✓ The Electricity loss of the 400 kV Sampoor – New Habarana T/L is 14,866 MWh/year in 2020

14.2. Results of the Calculation of Greenhouse Gas Emission

1) Baseline emission

The baseline emission is calculated by following formula.

$$BE_y = TE_{PLy} \times EF_{elec}$$

2) Project emission

The Project emission is calculated by following formula.

$$PE_y = TL_{PLy} \times EF_{elec}$$

3) Emission reduction

The Project emission is calculated by following formula.

$$ER_y = BE_y - PE_y$$

The result predicted of greenhouse gas emissions for each transmission lines in 2020 are shown in Table 14.2-1.

Table 14.2-1 Greenhouse Gas Emissions and Reductions

Name of Transmission Line	BE_y (t-CO_2)	PE_y (t-CO_2)	ER_y (t-CO_2)
220 kV Sampoor - Kappalturai T/L	13,530	226	13,304
400 kV Sampoor - New Habarana T/L	12,248	9,922	2,326

Note: 400kV Sampoor – New Habarana transmission line is operated by 220kV in 2020.

The symbol of formula are as follows:

ER_y : $Emission\ reduction$
BE_y : $Baseline\ emission$
PE_y : $Project\ emission$
$TE_{PJ.y}$: $T/L\ loss\ before\ the\ project\ implementation\ system\ in\ year\ "y"$
$TL_{PL.y}$: $T/L\ loss\ after\ the\ project\ implementation\ system\ in\ year\ "y"$
EF_{elec} : $CO2\ emission\ factor\ of\ electricity$

Chapter 15. Operation and Effect Indicators

15.1. Purpose of the Operation and Effect Indicators

The Project is a transmission line project associated with the Sampoor coal-fired power plant. Therefore, it is not necessary to set out the operation and effect indicators in accordance with reference to those published by JICA. However, the suitability of the Project facilities, such as the voltage, conductor number, conductor size, shall be confirmed, and the following indicators are set out for the post evaluation.

- ✓ Availability factor of the facilities
- ✓ Transmission losses

15.2. Formula for the Operation and Effect Indicators

15.2.1. Availability Factor of the Facilities

The target availability factor of the facilities is calculated with the following formula;

$$[Availability\ factor\ (\%)] = \frac{[Max\ load\ at\ sending\ point\ (MW)]}{[Capacity\ of\ T/L\ (MVA)] \times [Power\ factor]} \times 100$$

15.2.2. Transmission Losses

The actual transmission losses are calculated with the following formula by using the measurement energy at sending point and receiving point;

$$[Loss\ (\%)] = \frac{\{[Energy\ at\ sending\ point\ (MWh)] - [Energy\ at\ receiving\ point\ (MWh)]\}}{[Energy\ at\ sending\ point\ (MWh)]} \times 100$$

However, target of transmission loss is calculated not with the above formula but with the following one;

1) 220 kV Sampoor – Kappalturai Transmission Line

$$[Loss\ (\%)] = \frac{[Max\ loss\ (MW)] \times [LLF] \times 8760\ (hour)}{[Max\ load\ at\ sending\ point\ (MW)] \times [LF] \times 8760\ (hour)} \times 100$$

2) 400 kV Sampoor – New Habarana Transmission Line

$$[Loss\ (\%)] = \frac{[Max\ loss\ (MW)] \times [LLF\ for\ this\ TL] \times 8760\ (hour)}{[Energy\ from\ PS\ (GWh)] - [Energy\ to\ 220kV\ side\ (GWh)]} \times 100$$

15.3. Target of the Operation and Effect Indicators

Target of the operation and effect indicators is shown in Table 15.3-1.

Table 15.3-1 Target of the Operation and Effect Indicators

Item	Name of Transmission Line	Target 2020	Target 2022	Target 2024
Availability factor of facilities	220 kV Sampoor – Kappalturai T/L	7%	8%	10%
	400 kV Sampoor – New Habarana T/L (when operated at 220 kV)	17%	-	-
	400 kV Sampoor – New Habarana T/L (when operated at 400 kV)	-	22%	35%
Transmission losses	220 kV Sampoor – Kappalturai T/L	0.08%	0.09%	0.12%
	400 kV Sampoor – New Habarana T/L (when operated at 220 kV)	0.61%	-	-
	400 kV Sampoor – New Habarana T/L (when operated at 400 kV)	-	0.39%	0.57%

Chapter 16. Conclusions and Recommendations

16.1. Conclusions

16.1.1. Scope of the Transmission and Substation Facilities

The scope of the transmission and substation facilities is confirmed, as below, based on the results of power system analysis, site survey, and discussions with CEB;

1) Transmission Line

- ✓ 400 kV Sampoor – New Habarana T/L (4 x Low Loss Conductor (Zebra equivalent capacity), 95 km, 2 cct, Initially operate at 220 kV)
- ✓ 220 kV Sampoor – Kappalturai T/L (2 x Zebra, 45 km, 2 cct)

2) Switching Station at Sampoor

- ✓ 220 kV indoor GIS and one-and-half circuit breaker scheme

16.1.2. Environmental and Social Consideration

The two transmission line designs (400 kV and 220 kV) were carefully selected by considering various options to minimize the environmental and social impacts. CEB has extensively elaborated the potential negative impacts to the environment and social issues. These issues would be suitably managed by the mitigation measures shown in the IEE report.

The two IEE reports are fully compliant with the requirements of the JICA Environmental Guidelines.

16.1.3. Economic and Financial Analysis

The results of the economic and financial analysis under the base case and the sensitivity analysis are shown in Table 16.1-1, and it is confirmed that the Project is both economically and financially feasible.

Table 16.1-1 Results of Economic and Financial Analysis of the Project

Case	Economic Analysis		Financial Analysis	
	EIRR	B/C	FIRR	B/C
Base Case	32.58 %	2.00	29.50 %	1.23
Cost: +5 %, Benefit: 0 %	27.24 %	-	24.36 %	-
Cost: +10 %, Benefit: 0 %	21.88 %	-	19.35 %	-
Cost: 0 %, Benefit: -5 %	26.94 %	-	24.08 %	-
Cost: +5 %, Benefit: -5 %	21.36 %	-	18.85 %	-
Cost: +10 %, Benefit: -5 %	16.52 %	-	14.07 %	-
Cost: 0 %, Benefit: -10 %	20.78 %	-	18.30 %	-
Cost: +5 %, Benefit: -10 %	15.78 %	-	13.31 %	-
Cost: +10 %, Benefit: -10 %	11.53 %	-	8.76 %	-

16.2. Recommendations

16.2.1. Other Transmission and Substation Facilities

As a result of power system analysis, it is confirmed that it is necessary to reinforce some transmission lines and transformers. However, CEB is preparing demand forecast, generation plan at present. Therefore, it is recommended to prepare the master plan of transmission system after generation plan is determined.