PART - II

FACILITY DESIGN FOR THE HIGHEST PRIORITY PROJECT

CHAPTER I

OVERVIEW OF THE FACILITY DESIGN

Chapter 1 Overview of the Facility Design

1.1 Selection of Facilities

The transmission line system for the Pakxan - Thakhek - Pakbo section (hereinafter referred to "the Project" was selected as the highest priority project for structuring the optimum domestic-use transmission network in the country, as discussed in detail in the foregoing Part I of this report. This Project is for extending the power system from Central 1 region to the Central 2 region.

The current Central 1 region has sufficient electricity from Nam Ngum 1 and Nam Leuk hydropower stations. The surplus energy after domestic consumption in this region is exported to Thailand. Most of new power stations for domestic supply as well as IPP facilities are planned by MIH/EDL to be developed in the Central 1 region. While, the Central 2 region has no power stations at present except the export purposed IPP Theun Hinboun hydropower station, and no interconnection system with the Central 1 region has been developed. Development of IPP Nam Theun 2 hydropower station only is planned in the Central 2 region in the next decade. Accordingly, the Central 2 region has been obliged to import energy from Thailand at Thakhek and Savannakhet (Pakbo SS) for meeting its growing demand. Completion of the Project will directly contribute to save the imported energy and from the broad point of view to jump-start the formulation of national power network.

Scope of the Project is construction of transmission lines and substations in the section of Pakxan SS - Pakbo SS. The Project is outlined as below:

(a) Construction of 115 kV transmission line facilities with double circuits of ACSR 240 mm^2 for the section of the existing Pakxan substation to the new Thakhek substation to be constructed under the IDA fund by the year 2004,

(b) Construction of 115 kV transmission line facilities with double circuits of ACSR 240 mm^2 for the section of the new Thakhek substation to the existing Pakbo substation,

(c) Extension of the existing 115/22 kV Pakxan substation,

(d) Extension of the newly constructed 115/22 kV Thakhek substation, and

(e) Extension of the existing 115/22 kV Pakbo substation.

1.2 Design Policy

1.2.1 Design Principle

Design of the project facilities was conducted principally pursuant to the standards established by the STEP team of JICA and referring to IEC standards as well as common practices adopted by international consultants to the similar facilities in Lao PDR. This subsection states the basic criteria applied for design of the project facilities that were determined through discussions with EDL and the JICA STEP team as discussed in chapter 7 of Part I.

1.2.2 Locations of Substations

Locations of the substations for the Project were determined through map studies and site investigation of the team and EDL.

For developing the interconnection system to deliver electricity from the Nam Ngum 1 and Nam Leuk power stations in the Central 1 region to the Central 2 region, the existing Pakxan substation located in Bolikhamxai province connecting with those 2 hydropower power stations was selected for an originating of interconnection. The Pakxan substation exports energy to EGAT's Bungkhan substation in Thailand on a single circuit of 115 kV transmission line. This substation is to be extended with new transformers under the IDA fund for completion target of the year 2004 for its growing local power demand. A new 115 kV transmission line toward Thakhek is to outgo from newly extended transmission line bays in this substation.

There is no 115 kV substation in the Thakhek area at present. A new 115/22 kV substation is to be constructed in the suburb of Thakhek town by the year 2004 under the IDA fund. Sufficient land for the new substation has been acquired by EDL. For easy and stable operation and maintenance of the substation, the 115 kV transmission line from the Pakxan substation will be connected to this substation with extension of transmission line bays.

The 115/22 kV Pakbo substation exists in the suburb of Savannakhet town. With extension of transmission line bays in the substation, the 115 kV line from the Thakhek substation will be connected for delivery energy from the Thakhek substation into this area.

1.2.3 Selection of Transmission Line Routes

Subsection 6.6 of Part I of this report stated the selection of the transmission line routes for the Pakxan - Thakhek section and the Thakhek - Pakbo section. The team with EDL counterparts visited the sections during June 2002. During the site visit, the team got from EDL branch offices various

information regarding the local features, city and regional development plans, their proposed power system extension plans, etc. The branch offices also gave the team adequate route of the line for each section. Based on those information and recommendation of the branch offices and results of the team's examination on Environmental law, NBCA (National Bio-diversity and Conservation Area), land acquisition and compensation, and other factors, the recommended line routes as shown on the enclosed maps were selected.

Connections of the incoming and outgoing transmission lines at each substation were also recommended in this Part II taking into account easiness of the future expansion of the system. Those details are discussed in Subsection 2.1 of Part II.

1.2.4 Climatic Conditions

Climatic conditions collected from the local authorities were examined in detail by the team. The conditions for facility design of the Project were discussed in Subsection 7.1 of Part-1. Following are summary of the climatic design criteria for the facilities.

(a) Atmospheric Temperatures

Maximum air temperature:	45 ^{o}C
Minimum air temperature:	0 ^{o}C
Annual mean air temperature:	25 ^{o}C

(b) Air Density

Basic air density to be applied for insulation design in the country was presumed to be 0.12, which should vary upon altitude of the project land.

(c) Wind velocity

Records of wind velocity in the country were analyzed in detail. The maximum gust in the past 36 years was 40 m/s recorded in Pakse. Based on IEC 60826 and CIGRE AC 22 WG06-2000, 10 minutes mean wind velocity for applying the facility design was computed to be 35 m/s. From the velocity, the basic wind pressures were determined as follows:

Conductors and groundwires:	720 N/m^2
Insulator sets:	1,010 N/ m^2
Steel towers:	2,100 N/ m^2 including pressure to real structure

(d) Annual Rainfall

The country is characterized by a tropical climate with two distinct seasons; the rainy season from the beginning of May to the end of September and the dry season from October through April. Maximum annual rainfall in the country is 4,000 mm, and that in the project area is

4,000 mm in Pakxan, 3,050 mm in Thakhek and 1,920 mm in Savannakhet. Such rainfall in the rainy season was in particular taken into account for examining the construction schedule.

(e) Lightning (Isokeraunic Level)

Maximum and mean thunderstorm days per year in the project areas are recorded respectively as 40 and 28 against maximum 141 days recorded over the country. The isokeraunic level in the project area is however assumed to be 140 for safety design and taken into account for the insulation design of the facilities.

(f) Seismic

Lao PDR is not seismically active country. Besides, wind load is heavier for structures than seismic load. Then, seismic load is not considered for design of the facilities of the Project.

(g) Other Conditions

For designing conditions, maximum humidity is assumed to be 100 %, and pollution level to be light.

1.2.5 Environment

The Government of Lao PDR enacted the environmental law, and MIH establishes the environmental regulations for the facilities of power sector. In selecting the line routes and in designing the facilities, those law, regulations and international environmental practices were taking into account. Before implementation of the Project and after the transmission line routes are finalized, EA (Environmental Assessment) and its succeeding assessment, if necessary should be carried out by EDL and its associated institutions. After the government's approval to environmental assessment of the Project, EDL will negotiate to procure or compensate the project land.

Although UXO is not anticipated in the project area, careful investigations on it should be carried out before field activities will start along the line routes and its related places.

1.2.6 Stability of System Operation

The Project is to constitute an important part of the future national power network. Design criterion of N-1 was applied for maintaining continuously stable operation of the network. The facilities under the Project were, however, designed for the least cost system aiming at the horizon year of 2020.

Substation facilities under the Project are to be constructed in the premises of the existing substations. New facilities and their functions were determined so as to be with full coordination of the existing facilities and to be adequate for the future extension of substations. Therefore, the layout of facilities was designed so as to coordinate the existing facilities and incoming/outgoing transmission and

distribution line feeders.

Routes of the new transmission lines were selected from viewpoints of security of the national network and easy maintenance of the facilities in accordance with various advice of EDL for stable operation and fast restoration of troubles on the facilities in case.

In addition, principal plans for O & M works of the new facilities were recommended.

1.2.7 Results of Facility Design

Facility design of the selected project was achieved on the basis of the above-mentioned design policy during the 5th site study period (May to July 2002) and the 3rd study in Japan (August 2002). During the 5th site study period, the study team and the counterparts visited the selected project site for obtaining further detailed information and for discussing the facility design with the EDL's branch offices in the project area. EDL's information and advice given to the team during the site visit were useful for the design. Fully reflecting detailed investigation of the site visit, the facility design was conducted. Results of the facility design are stated in the succeeding chapters in this Part II.

1.3 Basic Plan of the Project Implementation

1.3.1 Rationale of the Project Implementation

Through formulation of the master plan study for the optimum power system detailed in Part I of this report, the Project for the section of Pakxan - Thakhek - Pakbo was selected and agreed by MIH/EDL as the highest priority to be implemented.

In consideration of the government's power plant development program, rural electrification program, and the present progress of various electrification projects, the Project that aims at interconnection of domestic power grid and saving of the imported energy is expected to be implemented as earliest as possible.

Following TOR of the Master Plan Study, the study team achieved facility design of the project for a step of an instant implementation of the Project. Facility design of the project has been achieved on the assumption of ICB (International Competitive Bidding) base for both equipment/materials and local installation including commissioning tests.

1.3.2 Procedures for Implementation

For acceleration of the project implementation to be completed by 2005 as a step for the main purpose

of this Project stated above, following programs are recommended to be urgently taken by MIH/EDL.

(1) Environmental Assessment (EA) and Other Procedures for obtaining Environmental Certificate by STEA[1]

Necessary procedures shall be made immediately following articles of "Regulation on Implementing Environmental Assessment (EA) for Electricity Projects in Lao PDR" issued on 20 Nov. 2001 by MIH. Most materials required for the documents are available in this report. In case that further assessment will be required to proceed as results of the EA, it will take minimum 192 days for obtaining a final decision of the project development according to the regulation. Additional examination or assessment, if required, should be achieved by MIH/EDL before commencement of the project implementation.

(2) Financial Arrangement for the Project

MIH/EDL shall arrange foreign and local financial resources required for implementing the selected project. This JICA report provides such all materials for preparing the proposal for seeking the financial source as necessity of the project, effects of the project, budget of the project, evaluation of the project, implementation schedule, and others. It is recommended to take necessary procedure for the arrangement as early as possible.

(3) Additional Studies of the Project

Following studies will be further required prior to actual construction of the Project. These will be conducted by MIH/EDL themselves or international institutions to assist the Project.

(a) Detailed design of the project facilities,
(b) Environmental assessment if further studies will be required,
(c) Investigation of UXO circumstances for confirming the safety in the project area,
(d) Transmission line route survey for finalizing quantities of required facilities and for the project preparatory works by MIH/EDL, a project consultant or others,
(e) Land acquisition and compensation for the transmission line routes (by EDL as an implementation agency),
(f) Preparation of bidding documents, and
(g) Appointment of procurement committee, project implementation committee, management committee, etc. by MIH/EDL.

[1] STEA: Science, Technology, and Environmental Agency

(4) Implementation Schedule and Project Budget

Implementation schedule of the Project should be prepared taking into account periods required for additional studies, bid floating, bid evaluation, contract negotiation and approval, manufacturing of equipment/materials, transportation, and local construction works. Local particularity in the wet season affecting the field construction works was carefully examined. Budget for implementation of the Project was estimated on the ICB base referring to the recent world market prices, the latest contract prices under the PTD/SPRE projects and costs estimated for newly planned similar projects in Lao PDR.

The schedule examined by the team and the project budget estimated by the team are detailed in Chapter 6 of Part II.

CHAPTER II

TRANSMISSION LINES

Chapter 2 Transmission Lines

2.1 Transmission Line Route

2.1.1 Outline of Line Route

The team had the field investigation for Pakxan SS - Thakhek SS - Pakbo SS section and discussed with EDL branch offices in early June 2002. As results of the investigation and discussion, the team selected the transmission line route for the section to be along with Route No. 13 for reasons of less inhabited areas, easy construction and convenience for maintenance work. The selected line route is shown on Figure 2.1-1. The route is aligned behind villages where habitats exist. Terrain surrounding the route is mostly flat or very gently waved and covered by bushes, paddy field, cropland or thin forest.

The line section of Pakxan SS - Thakhek SS was selected on the north side of Route 13 (in its first half section) and on the east side of the road (in its latter half section). The reasons are higher level land, less trees, less flood from the Mekong River due to high bank of the road comparing with other sides of the road.

In the line section of Thakhek SS - Pakbo SS there is another existing road along the Mekong River. The line route along the River is slightly shorter than the line route along Route 13. However, there are 22 kV distribution systems expanded from both 22 kV Thakhek and Pakbo substations. While, area along Route 13 has a potential of regional development in future.

(1) Pakxan SS - Thakhek SS (Figure 2.1-2, Photo No.01～Photo No.13)

The existing Pakxan substation is located on the north side of Route 13, from which a 115 kV international interconnection line crosses over the Mekong River to Thailand. Overview of the selected transmission line route is as follow:

(a) The transmission line route avoids inhabited area near the substation, and runs over about 4.5 km forward the north-east through areas gently sloped and covered by open forest and bushes. It turns toward the east and runs 4 km through bushes and paddy field till reaching the Nam Xan River. Photo No.01 shows the view from crossing point over the Nam Xan River to orientation of alignment.

(b) Then the line runs toward the southeast over about 6 km and approaches to Route 13. This section is aligned on the north side of Route 13 in paddy field and bush land for about 30 km.

About 1 km of the last section will be on foot of ridges behind houses as shown in Photo No.02. The line then reaches the Nam Kading River.

(c) The line crosses over 400 m wide the Nam Kading River and Route 13 by crank route or diagonal route near bridge. Photo No.03 shows a tower position at an end of bridge. Photo No. 04 shows the right bank of the Nam Kading River, and Photo No.05 shows a candidate tower position for the river crossing. Span length of the river crossing will be 500 m in crank route and 750 m in diagonal route. The route should be decided at detail design in coordination with the conditions of tower design. Proposed route of this section is shown in Figure 2.1-3

(d) After crossing the river, the line is aligned on foot of mountain range shown in Photo No.06 for about 10 km and turns to the east following Route 13 over about 10 km (Photos No.07 to No.09). The line is further aligned on the east side of Route 13 for advantage to flood for 28 km.

(e) In order to bypass a rocky peak at Pha Som village, the route changes to the west side of Route 13 over about 4.5 km. After the diversion, the line returns to the east side of the road. Photo No.10 shows paddy field at road crossing for the return. The line passes through bush, short treed land and paddy field in slightly undulated area over about 52 km.

(f) After the Pakan River crossing, the line crosses under 230 kV Theun Hinboun - Thakhek Line. The 115 kV 2 cct towers in the crossing section will be modified on their conductor arrangement from vertical to horizontal position so that sufficient clearance from both of 230 kV conductors and ground surface can be maintained. Photo No.11 shows the prospective crossing section under 230 kV line.

(g) The line continues along Route 13 over 25 km and crosses over the Nam Don River. Then, the route passes in a narrow space between Route 13 and meander of the Nam Don River. Photo No.12 is the landscape behind a school between the Nam Don River and Route 13. Then the line runs over 10 km passing behind a small teak plant that is prohibited being clear.

(h) The line crosses over Route 12 at about 1.5 km east from junction of Routes 12 and 13, and runs detouring around densely populated Thakhek town over 3 km. Photo No.13 is for crossing point over Route 12. The last 4.5 km of the line runs in parallel to the planned 115 kV Nam Theun 2 - Thakhek line to the newly planned 115 kV Thakhek substation.

(2) Thakhek SS - Pakbo SS (Figure 2.1-4, Photo No. 14～Photo No. 24)

(a) New 115 kV Thakhek substation is planned at about 3.5 km south of the town center. The line route of Thakhek - Pakbo line runs toward the east through paddy field over about 5.5 km, and turns to the south east along Route 13, mainly in paddy field or bush over about 17 km. Photo No. 14 was taken at the road to Ban Gnangkom branched out from Route 13 at 9.5 km far from Thakhek junction.

(b) The line then turns toward the south and runs for about 22 km in paddy field, bush or forest along Route 13 and crosses over the Xe Bangfai River. Photos No.15 to No.17 are the

sceneries of this section, and Photo No. 18 shows the Xe Bangfai River.

(c) The line continues toward the south passing through mainly bush over about 29 km and comes to the Nam Thahao River. Photo No.19 shows paddy field near Ban Laofay in this section.

(d) After about 11 km from Nam Thahao, the line turns toward the southwest and gets away from Route 13. Photo No.20 shows landscape of this section. Then, the line of about 22 km long heads Pakbo substation located nearby the bank of the Mekong River and 7 km north from Savannakhet town crossing over a provincial road three times in this section. The land is covered by bush or paddy field on flat land as shown in Photos No.21 to No.24.

2.1.2 Land and Environment

(1) Geology

Geological and Mineral Occurrence Map prepared by the Department of Geology and Mines is shown on Figure 2.1-5. Following are general geological conditions along the line route.

(a) About 10 km of Pakxan area is covered unconsolidated gravels, sands, silts and clays mostly of fluvial origin, with some basaltic lava flows, ash and loess of Neogene in Tertiary Period.

(b) Next 20 km area along Route 13 is mostly covered red continental sandstone and clays, with lagoonal mudrocks in the upper levels bearing evaporite units of halite and gypsum of Cretaceous in Mesozoic period.

(c) Geology of the next 10 km is again unconsolidated gravels, sands, silts and clays of Neogene in Tertiary Period.

(d) About 25 km around the crossing section over Nam Kading River is mostly covered by red continental sandstone and clays, with lagoonal mudrocks in the upper levels bearing evaporite units of halite and gypsum of Cretaceous in Mesozoic period.

(e) Geology of the north side and south side of Route 13 over about 40 km in the next section is defined as unconsolidated gravels, sands, silts and clays of Neogene in Tertiary Period.

(f) The next section of about 25 km where route runs on the north side of Route 13 is sandstone, siltstone and shale of Permian and Carboniferous in Palaeozoic Period. Geology of the next 15 km is continental red clayey arenites in Triassic and Jurassic of Mesozoic Period.

(g) About 20 km after crossing of the Nam Hinboun River is again sandstone, siltstone and shale of Permian and Carboniferous in Palaeozoic Period. Successive about 5 km is unconsolidated gravels, sands, silts and clays of Neogene in Tertiary Period. About 30 km area around Thakhek is covered by continental red clayey arenites in Triassic and Jurassic of Mesozoic Period.

(h) Entire route of Thakhek SS - Pakbo SS line is defined mostly to be red continental sandstone and clays, with lagoonal mudrocks in the upper levels bearing evaporite units of halite and gypsum

of Cretaceous in Mesozoic period except the section from 20 km to 25 km from Thakhek SS is unconsolidated gravels, sands, silts and clays of Neogene in Tertiary Period.

(2) Topography and Land Items

The terrain in the entire line route is flat, open, or gently undulated. Land items for Pakxan SS - Thakhek SS line approximately consists of bush land 68%, paddy field with mosaic of cropland 17%, forest 14% and glass land 1%. Thakhek SS - Pakbo SS line is covered by bush 66%, paddy field with mosaic of cropping 25% and forest 9%.

(3) Environmental Impact

The line route is selected avoiding houses and villages including urban areas of Pakxan, Thakhek, and Pakbo substations. Habitats are scattered very scarcely along the line route. The line is aligned possibly close to Route 13 diverting small villages so that resettlement could be avoided. Towns of Pakxan and Thakhek are quite densely populated, and the line is aligned detouring such habitat areas.

Since the line route is selected close to and along with Route 13, access road for construction and maintenance purpose will not be required much, and environmental impact to wildlife habitat is very limited, accordingly. Remarkable forest is not encountered on the line and vegetation clearing in the right of way for the line will be for mainly bush.

None of NBCA, national park, historic spots, cultural heritages, scenic areas or particular development area exist in the Project area, according to information from EDL branch offices. Significant influence to existing infrastructures also will not be found. Since the route is aligned at several hundred meters to 1 km apart from the Route 13, and also bushes and trees along the road will interfere the line facilities from passengers' vision, a visual impact of the Project facilities should be less.

Thus, synthetically environmental impact to the circumstances would be small and special mitigation measures for environmental protection will not be required. However, the procedure concerning environmental assessment required in "Regulation on Implementing Environmental Assessment for Electricity Projects in Lao PDR", regulated on 20 Nov. 2001, should be taken prior to implementation of the Project.

2.2 Design of Transmission Lines

Design of transmission lines for the Project is carried out in the following flow, in conformity with on the selected line route and the conceptual design described in Chapter 7 of Part I. The Laotian

Electric Power Technical Standard (LEPTS) prepared by JICA STEP team was also based.

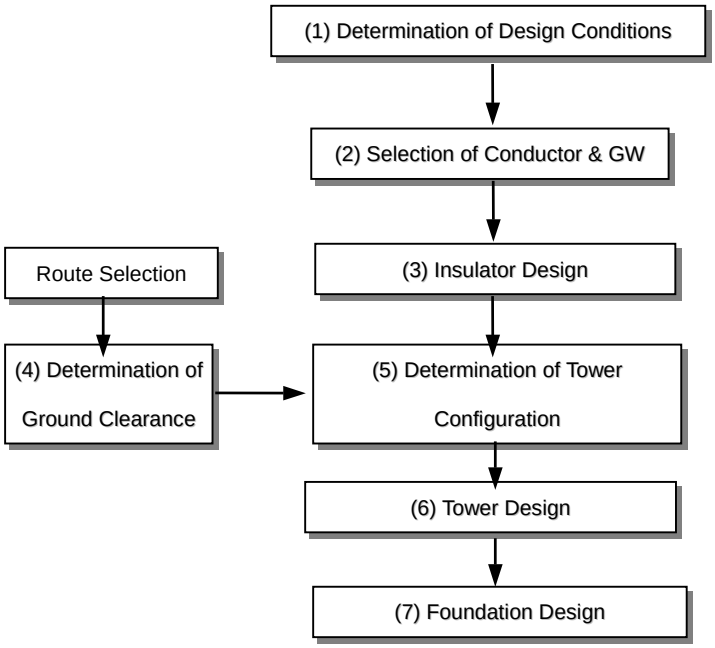


Figure 2.2-1 Flow of Design for the Project

2.2.1 Determination of Design Conditions

In addition to the climate conditions described in Chapter 1 of Part II, the following conditions were applied to the design for the Project.

(1) Stringent Condition and EDS (Every Day Stress) Condition

Condition	Temperature	Wind
Stringent	10 ℃	35 m/s
EDS	25 ℃	Still air

(Meteorological observation data in Laos)

(2) Pollution Level

Light Pollution (IEC60071-2 Table Ⅰ)

(3) Safety Factors

Required minimum safety factors for the Project are determined complying with LEPTS as follows:

(a) Conductor/Ground-wire

2.5 to UTS (Ultimate Tensile Strength) in stringent condition

5.0 to UTS for EDS condition at supporting point

(b) Insulator string

2.5 to RUS (Rated Ultimate Strength) for maximum working tension at supporting point

(c) Tower

Normal condition = stringent condition: 1.5 to yield strength of materials

Broken-wire condition = normal condition + breakage of one ground-wire or one phase conductor: 1.0 to yield strength of materials

(d) Foundation

Normal condition = stringent condition: 2.0 to yield strength of foundations

Broken-wire condition = normal condition + breakage of one ground-wire or one phase conductor: 1.33 to yield strength of foundations

2.2.2 Conductor and Ground-wire Design

Design conditions of the conductor and ground-wire for the Project are as below:

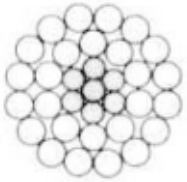
Table 2.2-1 Design Conditions of Conductor and Ground-wire

Loading condition	Wind velocity	Wind pressure	Conductor temperature	Safety factors
Stringent condition	35 m/sec	790 N/ m^2	10 ℃	2.5 (40%UTS)
EDS condition	0 m/sec	0 N/ m^2	25 ℃	5.0 (20%UTS)

(1) Conductor and Ground-wire

ACSR 240 mm^2 (ASTM: Hawk) and GSW 50 mm^2 (ASTM: GSW 3/8) are applied for the whole line section.

Table 2.2-2 Conductor and Ground-wire

Type	Conductor ACSR 240 mm^2 (ASTM: Hawk)	Ground-wire GSW 50 mm^2 (ASTM: GSW 3/8)
Figure		
Component of stranded wires	Al: 26/3.439 mm St: 7/2.675 mm	St: 7/3.05 mm
Total area of aluminum wires	280.8 mm^2	51.05 mm^2
Overall diameter	21.78 mm	9.144 mm
Weight	976.5 kg/km	406 kg/km
Ultimate tensile strength	86.7 kN	48.1 kN
Modulus of elasticity	82,000 N/ mm^2	189,300 N/ mm^2
Coefficient of linear expansion	19.0*10^{-6}/℃	11.5x10^{-6}/℃
DC resistance at 20℃	0.1196 Ω/km	-
Allowable current	484 A	-

(2) Maximum Working Tension and Every Day Stress (EDS)

As a maximum span length is measured to be 500 m on 1:100,000 map at the crossing point of the Nam Kading River, the maximum design span length is assumed to be 600 m in consideration of difference in elevation between two adjacent towers at that crossing section. Therefore, the maximum tension of conductor and ground-wire for the Project will occur in 600 m span. The values of the maximum working tensions and EDS of both conductor and ground-wire satisfy the determined safety factors as shown in Table 2.2-3.

Working tension of ground-wire is determined so that its sag becomes to be less than 80% of the conductors' sag under EDS condition at the standard span length (350 m) for avoiding a reverse flashover from ground-wire to the conductors and direct lightning stroke to conductors.

Table 2.2-3 Maximum Working Tension and Every Day Stress (Span length = 600m)

Type	UTS	Tension		Safety Factors
ACSR 240 mm^2	86.7 kN	Maximum Tension	32.3 kN	2.68＞2.5
		EDS condition	16.4 kN	5.32＞5.0
GSW 50 mm^2	48.1 kN	Maximum Tension	16.4 kN	2.93＞2.5
		EDS condition	8.6 kN	5.59＞5.0

2.2.3 Insulator Design

Insulator type, number of insulator unit and insulator assembly for the Project are determined based on the preliminary design discussed in Section 7.2 of Part I.

(1) Insulator type and size

(a) Type:

The standard disc type porcelain insulator with ball and socket complying with IEC 60305 is applied to the transmission lines for the Project.

(b) Size:

Table 2.2-4 and Figure 2.2-2 show the selected insulator size and its strength, respectively.

Table 2.2-4 Insulator Size

Size	Height	Diameter	R.U.S.*
250 mm disc	146 mm	255 mm	120 kN (for ACSR 240 mm^2)

(*: RUS: Rated Ultimate Strength)

(2) Number of insulator unit

(a) Pollution level

Pollution level was assumed at "Light" classified in IEC 60071-2 (Table I). Required creepage

distance/phase to phase voltage for the "Light" level is 16mm/kV.

(b) Standard lightning impulse withstand voltage

Standard lighting impulse withstand voltage for 115kV equipment is 550 kV and the minimum clearance at 550 kV is 1,100 mm as classified in IEC 60071-2.

(c) Number of insulator units per string: 10 units

From the necessary creepage distance of insulators, number of insulator unit per string of the standard string is 7 units. While, from the standard lightning impulse withstand voltage, number of insulator unit per string of the standard set is 8 units. Therefore, number of insulator unit per string was determined to be 10 units adding 2 units for allowance to the maintenance. Standard insulator sets applied for the existing and planned 115 kV lines in Lao PDR have also 10 units per string.

(3) Insulator assembly

A single string of 120 kN insulator is applied to both suspension and tension insulator assembly for the Project. Insulator fittings also have to keep the same strength of insulators.

Table2.2-5 Insulator Assemblies

Conductor	Maximum Tension (Span length: 600 m)	Suspension and tension insulator assemblies	Safety factor
ACSR 240 mm^2	32.3 kN	Single strings of 120 kN	3.72＞2.5

However, in case transmission line for the Project crosses over national roads or wide rivers as shown in Table 2.2-6, 120 kN double insulator assemblies are applied to both towers in the crossing section (either suspension or tension tower) for safety reason.

Table 2.2-6 Important crossing section

Section	№	Important crossing point	Length from Pakxan SS
Pakxan – Thakhek	1	Nam Sane River	5 km
	2	Nam Kading River Route 13	44 km
	3	Route 13	67 km
	4	Route 13	95 km
	5	Route 13	100 km
	6	Nam Hinboun River	142 km
	7	Route 12	187 km
	8	new Route 13	191 km
	9	Route 13	192 km
Thakhek – Pakbo	10	Xe Bang Fai River	239 km

(4) Configuration of Insulator assembly

Tentatively designed dimension and configuration of insulator assemblies are shown in Table 2.2-7

and Figures 2.2-3 and 2.2-4.

Table 2.2-7 Size of Insulator Assembly

	Items	Values
Suspension Insulator Assembly	Number of 250 mm Insulator	Single: 10 units、Double: 20 units
	Length of 250 mm Insulator	1,460 mm
	Arcing Horn Gap	1,240 mm
	Single Insulator Assembly Length	1,960 mm
	Double Insulator Assembly Length	2,110 mm
Tension Insulator Assembly	Number of 250 mm Insulator	Single: 10 units、Double: 20 units
	Length of 250 mm Insulator	1,460 mm
	Arcing Horn Gap	1,240 mm
	Single Insulator Assembly Length	2,150 mm
	Double Insulator Assembly Length	2,500 mm

2.2.4 Ground Clearance

The most severe state for the ground clearance of conductors will occur when conductor's temperature rises 80℃ under still air condition. As for the Project, minimum height of conductor above ground is determined as below.

Table 2.2-8 Minimum Height of Conductor above Ground

Classification	Applied areas for the Project	Height	Reason
Areas where people rarely enter or will enter, such as mountains, forests, waste fields, etc.	Bush lands, forests, grass lands and narrow-rivers	7.0 m	5.0 m (LEPTS) +2.0 m (margin) = 7.0 m
Areas where people enter or will enter frequency	Paddy fields with mosaic of croplands, general roads and wide-rivers	8.0 m	6.0 m (LEPTS) +2.0 m (margin) = 8.0 m
Areas where distribution line exists or will be planned	National roads	9.5 m	2.36 m (LEPTS) *+5.0 m (Distribution Pole Height) +2.0 m (margin) 9.5 m

*: Clearance between 115 kV transmission line and 22 kV distribution line

2.2.5 Determination of Tower Configuration

Basic dimensions of suspension and tension type towers for the Project are decided in examining the conductor clearance diagrams based on the preliminary design described in Section 7.3 of Part I.

(1) Insulation design

Insulation gaps for standard and abnormal states are worked out as below. Those gap lengths are used for clearance between conductor and tower, between conductors, and between conductor and ground wire.

Table 2.2-9 Insulation Gaps

Characteristic	Items	Values	Reasons
Voltage	Nominal voltage	115 kV	Complying with IEC60038
	Highest voltage	123 kV	Complying with IEC60038
Lightning Impulse	Length of 250 mm insulator	1,460 mm	146 mmx10 units=1,460 mm
	Arcing horn gap	1,240 mm	Insulator strings length*0.85 1,240 mm (85% of length of insulator string)
	Standard insulation gap	1,400 mm	Arcing horn gap x 1.115 1,400 mm (111.5% of arcing horn gap)
Commercial frequency	Abnormal state insulation gap	200 mm	Complying with IEC60071-1, 60071-2
	Abnormal state phase gap	400 mm	Complying with IEC60071-1, 60071-2

(2) Clearance design

(a) Clearance between conductor and tower

Lengths of cross-arms and vertical separation between cross-arms are determined from conductor clearance diagrams applying values in Table 2.2-11 and Figure 7.2-2 of Part I.

Table 2.2-10 Swinging Angle of Conductor and applied Clearance

Wind Velocity	10 m/sec	35 m/sec
Swinging angle of conductor	10 deg	60 deg.
Applied clearance	Standard clearance	Abnormal clearance

Table 2.2-11 Values of Clearance Diagram

Tower type	Item	Formulas and values
Suspension tower	Insulator assembly length	146 mmx10units+500 mm(Fitting length) 2,000 mm
Tension tower	Jumper conductor depth	1,240 mm (Arcing horn length)x1.2 + 100 mm (Margin for changing the shape of jumper conductor) 1,600 mm
Suspension and tension tower	Standard clearance (Swinging angle 10 deg)	1,400 mm (Standard insulation gap) + 150 mm (Step bolts length) = 1,550 mm
	Abnormal clearance (Swinging angle 60 deg)	200 mm (Abnormal state insulation gap) + 150 mm (Step bolts length) = 350 mm

(b) Separation between conductors and between conductor and ground-wire

Minimum separation between two conductors and between conductor and ground-wire are determined to satisfy the following values when conductors will swing by wind blow.

- Between two conductors: 450 mm
  (Abnormal state phase gap; 400 mm + Conductor's diameter; around 50 mm)
- Between conductor and ground wire: 250 mm
  (Abnormal state insulation gap; 200 mm + Conductor's and ground wire's diameter around; 50 mm)

(3) Insulation design of ground-wires

Number and shielding angle to conductors of ground-wire are determined as below:

Number: 1

Maximum shielding angle: 30deg.

(4) Tower configurations

Configurations of the following 7 standard types of towers are determined based on the above design conditions.

Table 2.2-12 Tower Configurations

Tower	Suspension Tower		Tension Tower				
Line Horizontal Angle	0～3°		0～15°	0～30°	0～90°		0～90° (Dead End)
Type	A1	A2	B1	C1	D1	D2	DE
Height [m]	32.9	37.9	32.8	33.3	34.0	39.0	34.0
Arm Length [m]	6.2	6.2	6.2	6.8	7.6	7.6	7.6
Width of tower [m]	6.0	7.2	7.0	7.0	7.0	8.4	7.0
Body Extension [m]	21.5	26.5	20.0	20.0	20.0	25.0	20.0
Conductor Height [m]	8.3	13.3	8.8	8.8	8.8	13.8	8.8
Applied Areas*	Ⅰ	Ⅱ	Ⅰ	Ⅰ	Ⅰ	Ⅱ	Ⅰ
Number of Figure	2.2-5	2.2-6	2.2-7	2.2-8	2.2-9	2.2-10	2.2-9

Area I: Except national roads (bush, forests, grass lands, paddy fields with mosaic of croplands, general roads and rivers)

Area II: National roads

Wider dimensions at ground level of towers are to produce lighter loads to the foundations. Lighter loads will result in smaller foundations. There seems no land issue along most section of the selected transmission line routes so that widths of towers at the ground level will be freely determined. The widths at ground level of standard towers modeled in Section 7.2 of Part-Ⅰ were spread for the Project by 1.0 m for suspension type towers and by 2.0 m for tension type towers for more economical foundations.

2.2.6 Tower Design

Towers for the Project were provisionally designed for estimation of tower weights and foundation loads. High tensile steels were also applied to towers and bolts, and all of tower members must be galvanized for preventing rusts.

(1) Tower design conditions

Tower design is carried out for the 7 standard towers classified in Table 2.2-12, based on the following design conditions and span length.

(a) Wind pressure

Conductor 790 N/m^2

Insulator strings 1,100 N/m^2

Tower 2,100 N/m^2 (including pressure on its rear structures)

(b) Standard span length and applied maximum span length

Table 2.2-13 Design Span Length

Tower	Type	Standard Span Length	Design Span Length
Suspension	A1	350 m	500 m
	A2	350 m	500 m
Tension	B1	350 m	500 m
	C1	350 m	500 m
	D1	350 m	600 m
	D2	350 m	600 m
	DE	350 m	400 m

(c) Loading conditions and safety factors

Table 2.2-14 Loading Conditions and Safety Factors

Loading conditions	Loads	Safety factor
Normal condition	Maximum load (35 m/sec)	1.5 to yield strength of material
Abnormal condition (Broken wire condition)	Maximum load + one ground wire or one phase conductor breakage load	1.0 to yield strength of material

(2) Results of tower design

Following is summary of the results of tower design.

Table 2.2-15 Tower Weights and Foundation Loads transferred from Towers

Tower	Suspension		Tension				
Line Horizontal Angle	0～3°		0～15°	0～30°	0～90°		0～90° (Dead End)
Type	A1	A2	B1	C1	D1	D2	DE
Weight [ton]	5.0	6.2	6.2	7.0	9.2	11.0	9.4
Foundation Compression Load [kN]: Normal load	182	192	252	344	543	552	596
Foundation Tensile Load [kN]: Normal load	148	152	211	299	486	486	532

2.2.7 Foundation Design

Transmission lines for the Project pass over firm soil areas such as "Sandstone, Siltstone and Shale", "Red Continental Sandstone and Clays", and "Unconsolidated Gravels, Sands, Silts and Clays" as shown in Figure 2.2-11 (1) which are defined by Geological and Mineral Occurrence Map issued by the Department of Geology and Mines. Seven soil boring data that were investigated at river bridge sites on Route 13 (between Nam Kading and Savannakhet) shown in Figure 2.2-11 (2) also shows existence of firm stratum. Therefore, it can be assumed that normal pad and chimney type foundations are applicable to all towers in the Project.

Dimensions, concrete volume, reinforcement volume, excavation volume and back-filling volume of pad and chimney type foundations were worked out on the basis of the loads transferred from towers shown in Table 2.2-15.

(1) Foundation design conditions

Foundation design was carried out for 7 standard towers classified in Table 2.2-15, based on the following design conditions.

(a) Soil conditions

Soil - I: Sandstone, siltstone and shale

Soil - II: Red continental sandstone and clays

Soil - II: Unconsolidated gravels, sands, silts and clays

(b) Loading conditions and safety factors

Table 2.2-16 Loading Conditions and Safety Factors

Loading conditions	Loads	Safety factor
Normal condition	Maximum load (35 m/sec)	2.0 to yield strength of foundation
Abnormal condition (Broken wire condition)	Above maximum load + one ground wire or one phase conductor breakage load	1.33 to yield strength of foundation

(2) Results of foundation design

Summary of the results of foundation design and tentative foundation configurations are as shown in Table 2.2-17 and Figure 2.2-12, respectively.

Table 2.2-17 Results of Foundation Design

Soil	Type	Compression Load [kN]	Tensile Load [kN]	Applied Foundation Type	Applied C & T Load [kN]	Concrete /Tower [m^3]	Reinforcement /Tower [ton]	Excavation /Tower [m^3]	Back-filling /Tower [m^3]
I	A1	182	148	Pad-1	～200	2.4	0.2	13.6	11.2
	A2	192	152						
	B1	252	211	Pad-2	200～400	8.0	0.8	48.4	40.4
	C1	344	299						
	D1	543	486	Pad-3	400～600	20.4	2.0	112.8	92.4
	D2	552	486						
	DE	596	532						
II	A1	182	148	Pad-4	～200	3.6	0.4	25.2	21.6
	A2	192	152						
	B1	252	211	Pad-5	200～400	14.0	1.4	79.2	65.2
	C1	344	299						
	D1	543	486	Pad-6	400～600	35.2	3.5	167.6	132.4
	D2	552	486						
	DE	596	532						
III	A1	182	148	Pad-7	～200	6.0	0.6	56.8	50.8
	A2	192	152						
	B1	252	211	Pad-8	200～400	25.2	2.5	162.8	137.6
	C1	344	299						
	D1	543	486	Pad-9	400～600	62.4	6.2	310.8	248.4
	D2	552	486						
	DE	596	532						

2.2.8 Crossing Point with 230kV Theun Hinboun Line

(1) Crossing method and crossing point

The transmission line of the Project should cross the existing 230 kV Theun Hinboun transmission line. For the crossing, necessary clearance between the 230 kV line and the Project line should be maintained. Conductors of the Project line should be lowered for crossing under the 230 kV line but should also keep the minimum ground clearance as determined in Table 2.2-8. For the purpose, the vertical conductor arrangement on standard towers of the Project will be modified to horizontal arrangement on gantry type supports at both sides of crossing point. Double circuits on the standard towers will be separated into 2 separate single circuits. Two sets of gantry structure for a single circuit will be erected in the crossing point as shown in Figure 2.2-13. It is also assumed that the crossing will be made near the taller tower of the 230 kV line for crossing over Route 13.

(2) Structure of gantry

Gantries for 115 kV line applied for crossing under 230kV line will be same scale as the gantries for lead-in conductors at 115 kV substation. They will be provided with 90 degrees V-string insulator assemblies and single string tension insulator assemblies on both sides of their beams as shown in

Figure 2-2.13.

Configuration of gantries and the tentative layout of the Theun Hinboun line crossing are illustrated in Figures 2.2-14 and 2.2-15.

2.2.9 Quantities of Line Materials

Quantities of line materials are estimated from results of the above design for the Project.

(1) Number of towers and total weight of towers

As seen in the route map (Figure 2.2-1), various kinds of towers (type-B1, C1, D1, DE) are required for deviation of the line route. Proper tension type tower was located at every angle deviating points of the line route pursuant to its angle. Thus, number of tension type towers necessary for the line was firstly worked out. Suspension type towers are to be positioned between those tension towers. Number of suspension type tower (type-A1) was derived from a line distance between these tension towers divided by a standard span length of 350 m. For such sections as crossing over the national road, taller towers will be required for keeping necessary ground clearance of conductors. A2 and D2 type towers were applied for such section. Total number of towers required for the Project was thus worked out. Table 2.2-18 summarizes the number of towers and weight of towers for the Project.

Table 2.2-18 Number of Towers and the Total Weight of Towers

Type	Weight [ton]	Pakxan – Thakhek		Thakhek- Pakbo		Total Quantity	
		Towers [Units]	Total Weight [ton]	Towers [Units]	Total Weight [ton]	Towers [Units]	Total Weight [ton]
A1	5.0	490	2,450.0	275	1,375.0	765	3,825.0
A2	6.2	10	62.0	0	0.0	10	62.0
B1	6.2	21	130.2	8	49.6	29	179.8
C1	7.0	16	112.0	8	56.0	24	168.0
D1	9.2	15	138.0	7	64.4	22	202.4
D2	11.0	2	22.0	0	0.0	2	22.0
DE	9.4	4	37.6	2	18.8	6	56.4
Ga	1.5	4	6.0	0	0.0	4	6.0
Total		562	2,957.8	300	1,563.8	862	4,521.6

(2) Quantities of conductor and ground-wire

Quantities of conductors and ground-wires (GW) for the Project were computed by"Number of conductor or GW×Route Length [km]×1.05 (allowance for sag and margin for stringing works).

Table 2.2-19 Quantities of Conductor and Ground-wire

Type	Number [Units]	Pakxan – Thakhek		Thakhek- Pakbo		Total Quantity [km]
		Route Length [km]	Quantity [km]	Route Length [km]	Quantity [km]	
ACSR 240 mm^2	6	194.6	1,226.0	105.2	662.8	1,888.8
GSW 50 mm^2	1	194.6	204.3	105.2	110.5	314.8

(3) Quantities of insulators and insulator assemblies

Quantities of insulators and insulator assemblies for the Project were computed from number of suspension and tension towers, including number of double strings assemblies that are applied to important crossing sections as shown in Table 2.2-6.

Table 2.2-20 Quantities of Insulators and Insulator Assemblies

Type	Items	Unit Quantity [Units]	Pakxan - Thakhek		Thakhek - Pakbo		Total Quantity [Units]
			Tower [Units]	Total Quantity [Units]	Tower [Units]	Total Quantity [Units]	
Suspension	Insulators	60	486	29,160	273	16,380	45,540
	Single String Assemblies	6		2,916		1,638	4,554
	Insulators	120	14	1,680	2	240	1,920
	Double Strings Assemblies	6		84		12	96
Tension	Insulators	120	54	6,480	25	3,000	9,480
	Single String Assemblies	12		648		300	948
	Insulators	240	4	960	0	0	960
	Double Strings Assemblies	12		48		0	48
Gantry	Insulators	60	4	240	0	0	240
	Single String Assemblies	6		24		0	24
	Insulators	60	4	240	0	0	240
	V-string Assemblies	3		12		0	12
Total	Insulators			38,760		19,620	58,380
	Insulator Assemblies			3,732		1,950	5,682

(4) Quantities of fittings of conductor and ground-wire

Quantities of fittings of conductor and ground-wire for the Project were worked out as below.

(a) Vibration dampers of conductor and ground-wire

Two dampers are installed in each conductor and each GW in every span.

(b) Compression sleeve of conductor and ground-wire

- Number of compression sleeve of conductor＝Conductor quantities[km]／1.5 km (standard length of conductor per drum)

- Number of compression sleeve of GW＝GW quantities[km]／3.5 km (standard length of GW per drum)

(c) Ground-wire fittings

Suspension ground-wire fittings will be installed on suspension towers and tension ground-wire fittings will be installed on tension towers and gantries.

Table 2.2-21 Quantities of Fittings of Conductor and Ground-wire [Units]

Fittings	Pakxan - Thakhek	Thakhek - Pakbo	Total
Conductor Dampers	6,720	3,600	10,320
GW Dampers	1,120	600	1,720
Conductor Sleeves	817	442	1,259
GW Sleeves	68	37	105
Suspension GW Fittings	500	275	775
Tension GW Fittings	62	25	87

(5) Quantities of tower foundations

Quantities of 10 types of steel-reinforced concrete foundations including that for the gantry structures are summarized in Table 2.2-22 below.

Table 2.2-22 Quantities of Tower Foundations [Units]

Soil*	Type	Concrete Volume / tower	Pakxan - Thakhek	Thakhek - Pakbo	Total Quantity
I	Pad-1	2.4 [m^3]	115	0	115
	Pad-2	8.0 [m^3]	8	0	8
	Pad-3	20.4 [m^3]	6	0	6
II	Pad-4	3.6 [m^3]	234	261	495
	Pad-5	14.0 [m^3]	17	16	33
	Pad-6	35.2 [m^3]	12	8	20
III	Pad-7	6.0 [m^3]	151	14	165
	Pad-8	25.3 [m^3]	12	0	12
	Pad-9	62.4 [m^3]	3	1	4
For Ga	Pad-10	0.5 [m^3]	4	0	4
		Total	562	300	862

Soil - I: Sandstone, siltstone and shale

Soil - II: Red continental sandstone and clays

Soil - III: Unconsolidated gravels, sands, silts and clays

(6) Spare parts, tools and measuring instruments

Design specifications of transmission line for the Project are common to the whole line. Since maintenance work of the line after completion of the Project will be carried out by EDL branch offices, it is necessary to provide spare parts, tools and measuring instruments considering common stock among branch offices. Although items and quantities of them will be determined in the detail design stage of the Project, it is assumed that principal items of them will be as follows.

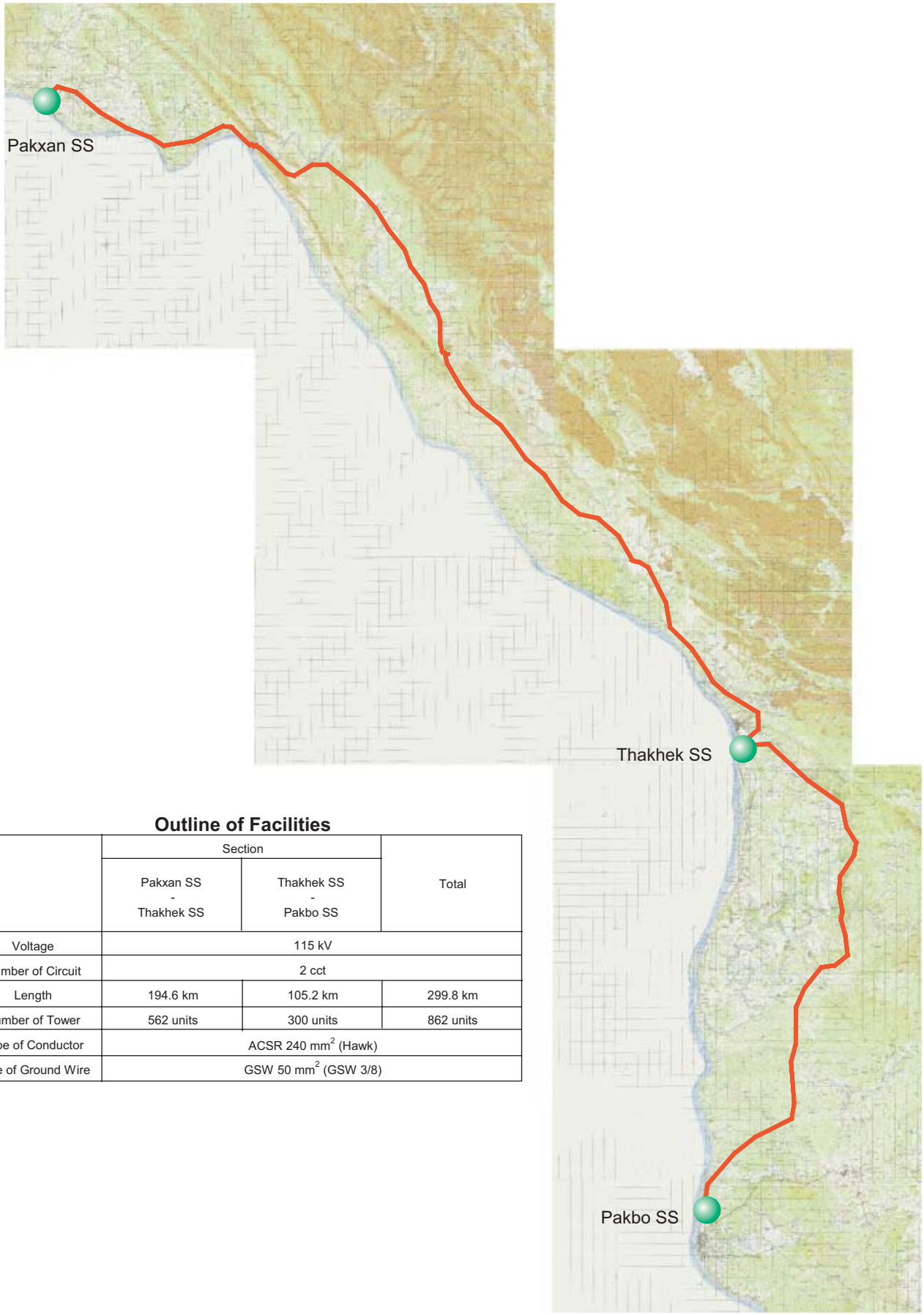
(a) Line materials for maintenance:

Complete set of standard towers, galvanized steel materials and bolts for replacement damaged members, spares of conductors / GWs and their fittings, insulators and their fittings, etc.

(b) Tools and measuring instruments:

Insulator replacing devices, tools for repairing works, insulated earthing rods, insulation resistance testers, equipment for maintenance staff, vehicles for inspection of facility, etc.

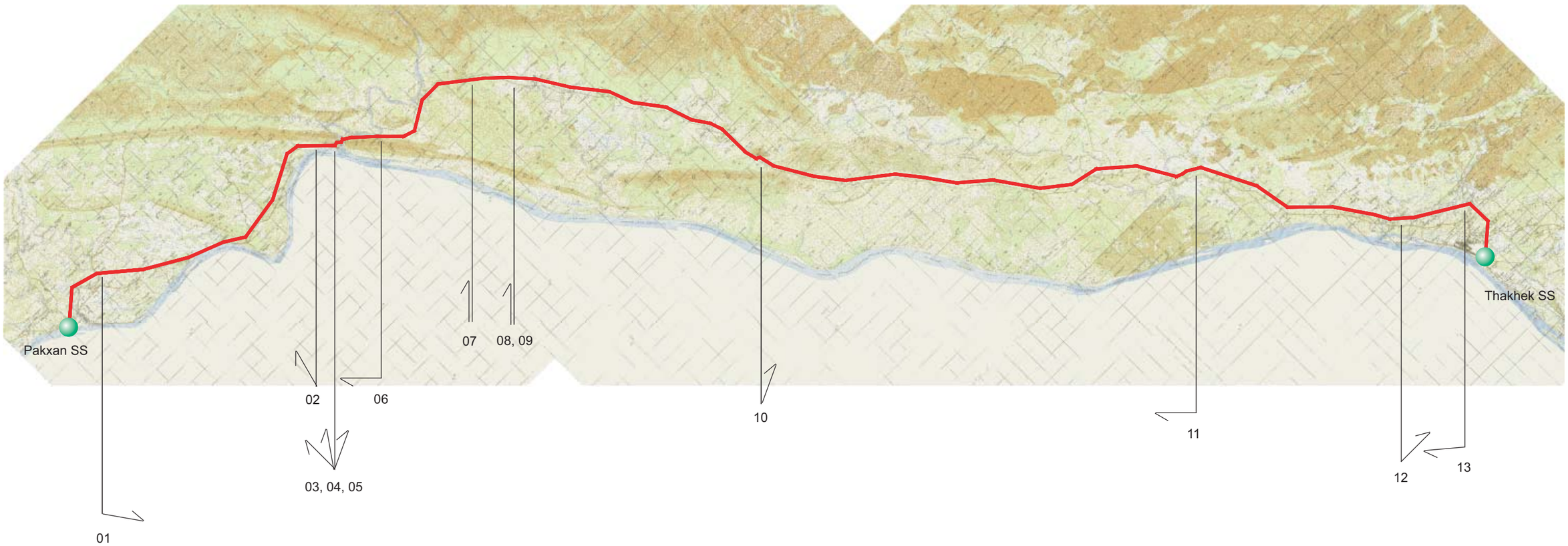
Estimate cost of spare parts, tools and measuring instruments for the Project is assumed to be around 5 % of total costs of line materials.



Outline of Facilities

	Section		Total
	Pakxan SS - Thakhek SS	Thakhek SS - Pakbo SS	
Voltage	115 kV		
Number of Circuit	2 cct		
Length	194.6 km	105.2 km	299.8 km
Number of Tower	562 units	300 units	862 units
Type of Conductor	ACSR 240 mm^2 (Hawk)		
Type of Ground Wire	GSW 50 mm^2 (GSW 3/8)		

Electricite du Laos	Japan International Cooperation Agency (JICA) Joint Venture Nippon Koei Co., Ltd. & Tokyo Electric Power Company	The Study on Master Plan of Transmission Line and Substation System	**Figure No.** 2.1-1 **Title** Selected Transmission Line Route from Pakxan SS to Pakbo SS



Electricite du Laos	Japan International Cooperation Agency (JICA) Joint Venture Nippon Koei Co., Ltd. & Tokyo Electric Power Company	The Study on Master Plan of Transmission Line and Substation System	**Figure No.** 2.1-2 **Title** Selected Transmission Line Route from Pakxan SS to Thakhek SS

Photographs along the Planned Line Route: Pakxan SS - Thakhek SS Section (1/2)

Photo-01: B. Thasikhai

Photo-02: B. Paknamkading

Photo-03: Nam Kading (1)

Photo-04: Nam Kading (2)

Photo-05: Nam Kading (3)

Photo-06: B. Hatxaykham

Photo-07: B. Namdua

Photo-08: B. Nakhua (1)

Photographs along the Planned Line Route: Pakxan SS - Thakhek SS Section (2/2)

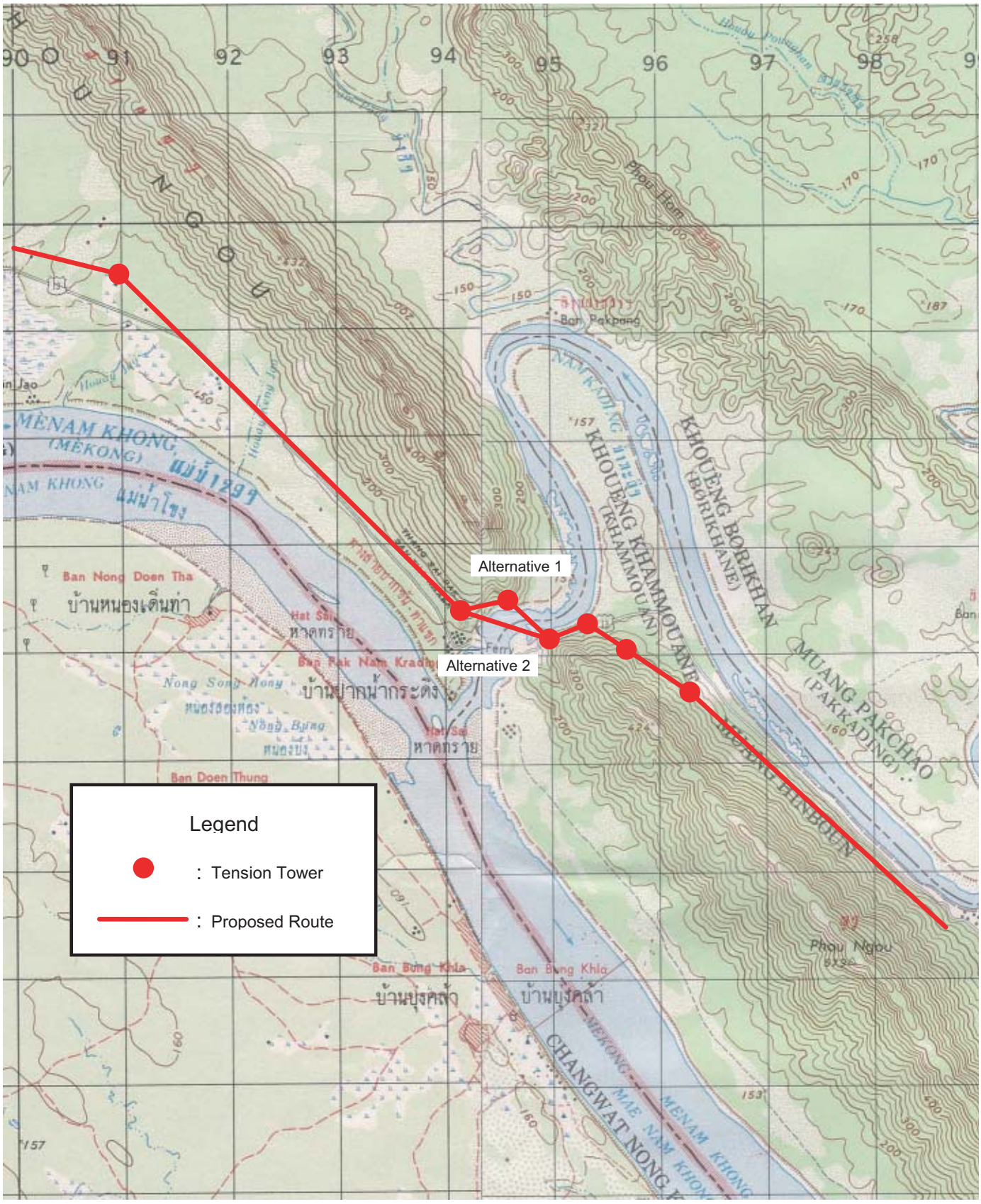
Photo-09: B. Nakhua (2)

Photo-10: B. Naliang

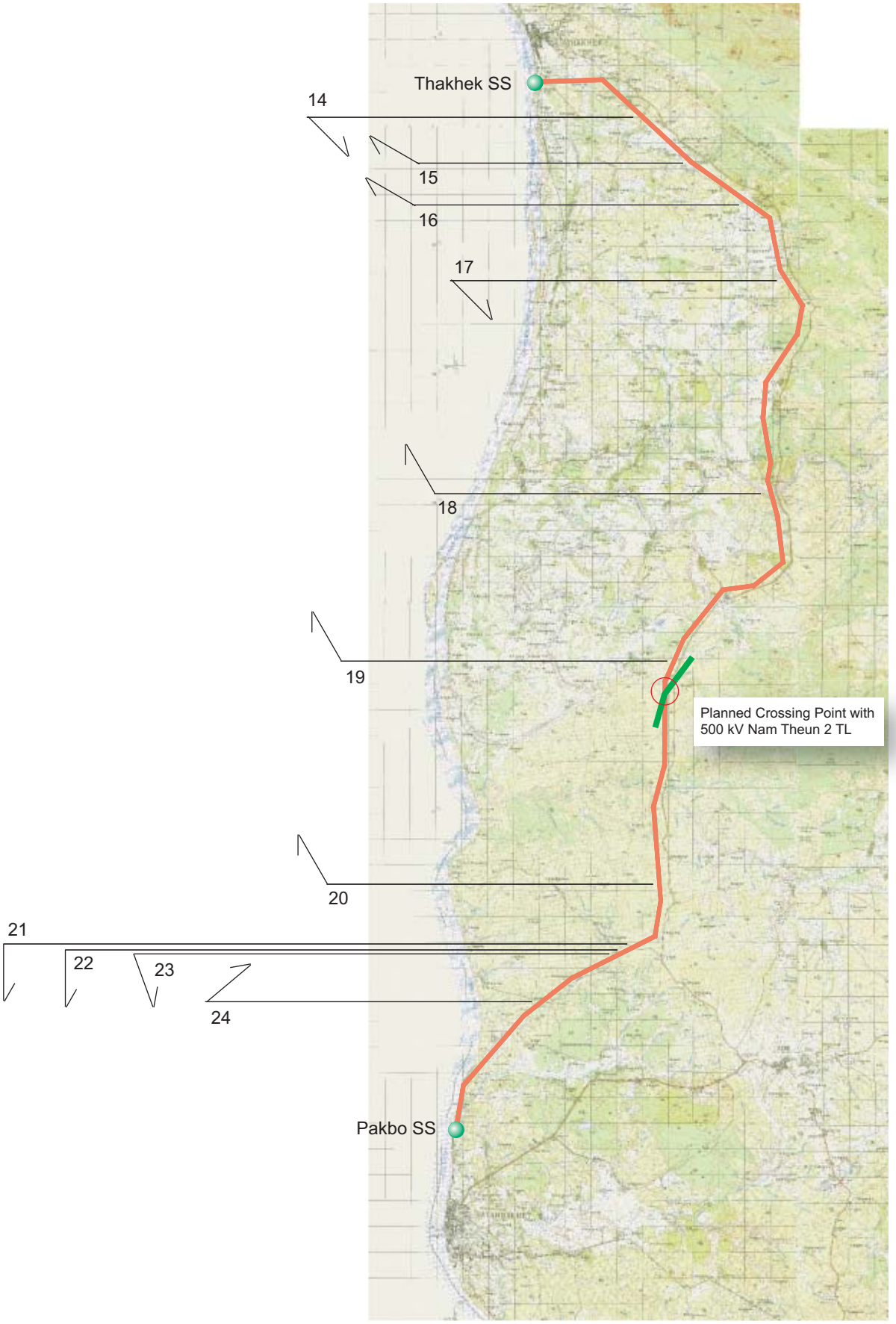
Photo-11: Theun Hinboun Crossing Section

Photo-12: Behind the School

Photo-13: Route 2 Crossing Section



Electricite du Laos	Japan International Cooperation Agency (JICA) Joint Venture Nippon Koei Co., Ltd. & Tokyo Electric Power Company	The Study on Master Plan of Transmission Line and Substation System	**Figure No.** 2.1-3 **Title** Proposed Route of Nam Kading River Crossing (Scale 1:50,000)



Electricite du Laos	Japan International Cooperation Agency (JICA) Joint Venture Nippon Koei Co., Ltd. & Tokyo Electric Power Company	The Study on Master Plan of Transmission Line and Substation System	**Figure No.** 2.1-4 **Title** Selected Transmission Line Route from Thakhek SS to Pakbo SS

Photographs along the Planned Line Route: Thakhek SS - Pakbo SS Section (1/2)

Photo-14: Road to B. Gnangkok

Photo-15: B. Gnangbung

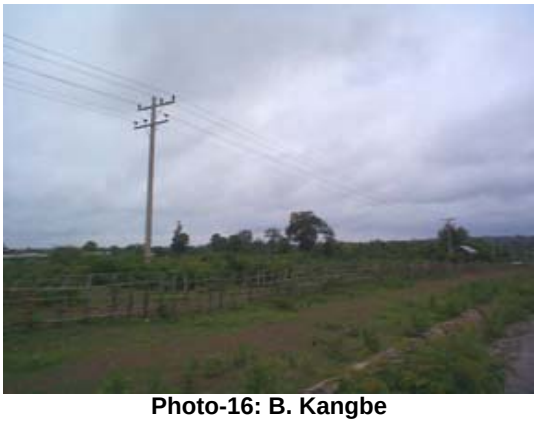


Photo-16: B. Kangbe

Photo-17: B. Phonsavang

Photo-18: Xe Bangfai

Photo-19: B. Laofay

Photo-20: B. Dongmakngeo

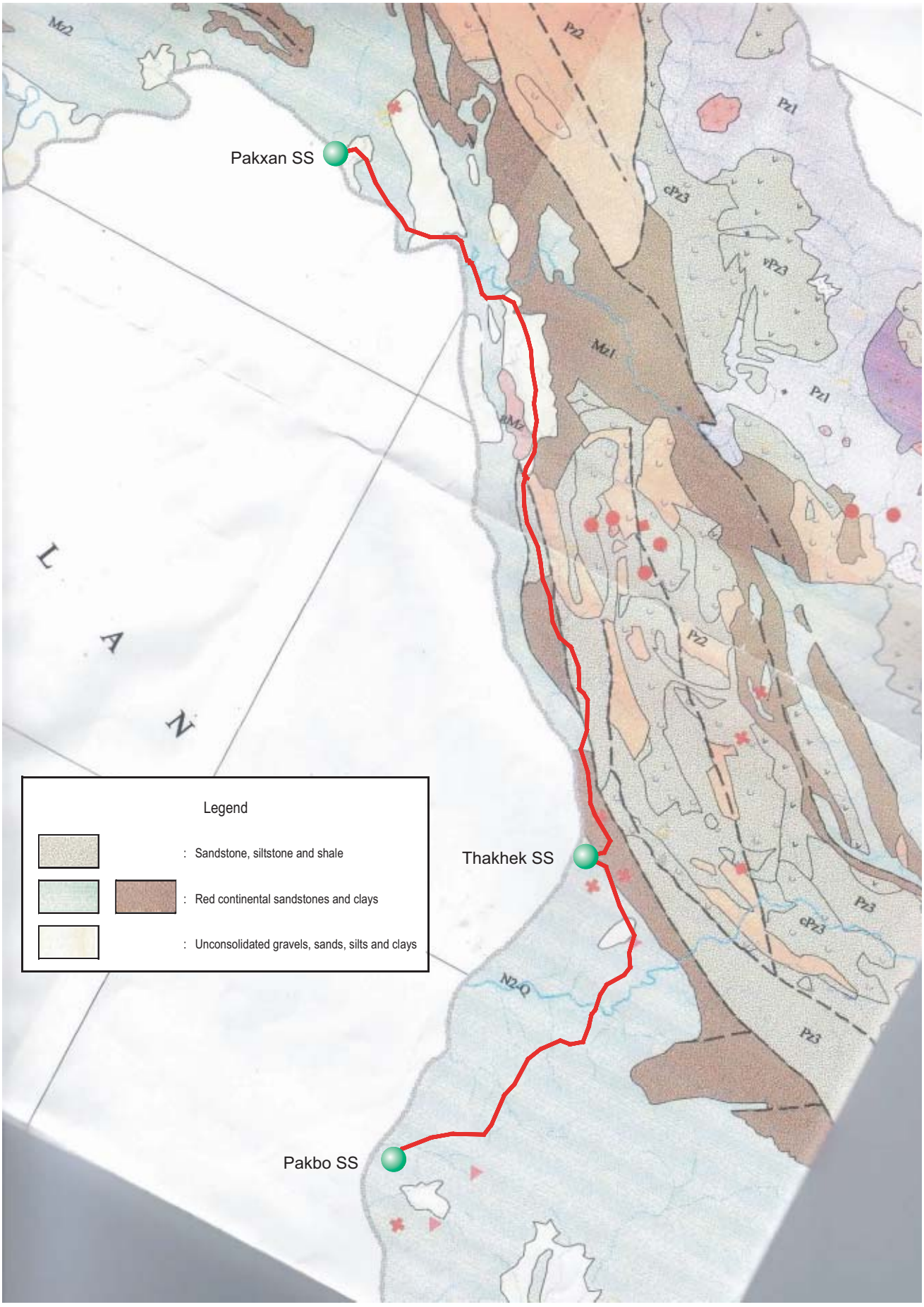
Photo-21: B. Nongsaphan (1)

Photographs along the Planned Line Route: Thakhek SS - Pakbo SS Section (2/2)

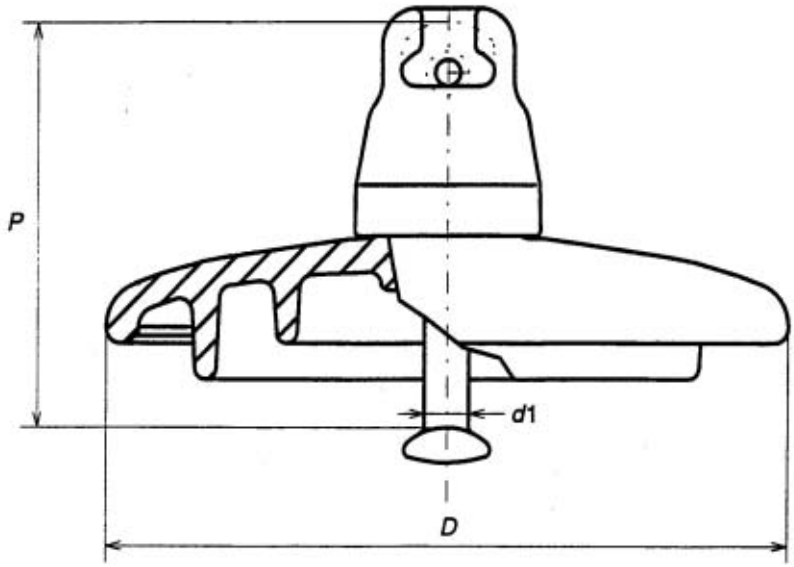
Photo-22: B. Nongsaphan (2)

Photo-23: B. Phakkhagna-Nua

Photo-24: B. Phakkhagna-Tai

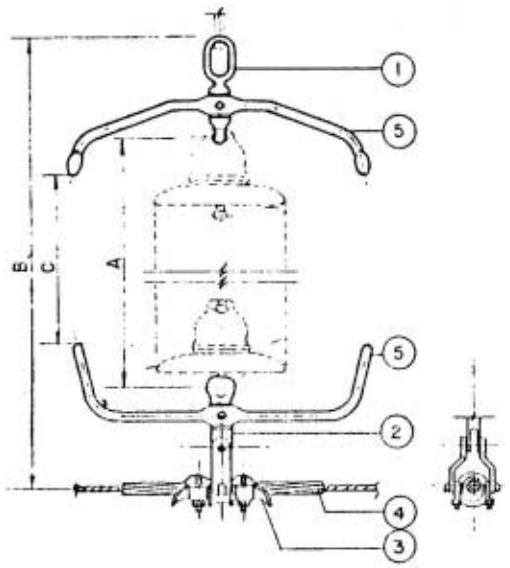


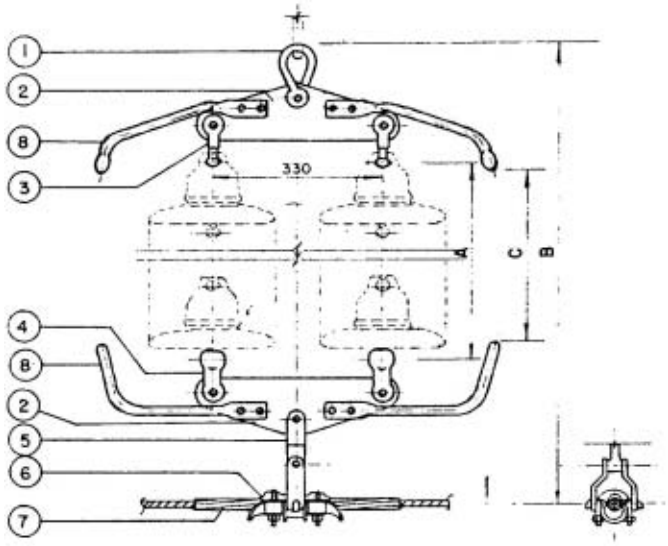
Electricite du Laos	Japan International Cooperation Agency (JICA) Joint Venture Nippon Koei Co., Ltd. & Tokyo Electric Power Company	The Study on Master Plan of Transmission Line and Substation System	Figure No. 2.1-5 Title Geological Features Map



Designation	Electromechanical or mechanical failing load kN	Maximum nominal diameter of the insulating part D mm	Nominal spacing P mm	Minimum nominal creepage distance mm	Standard coupling according to IEC 120 d1
U 120 B	120	255	146	295	16

Electricite du Laos	Japan International Cooperation Agency (JICA) Joint Venture Nippon Koei Co., Ltd. & Tokyo Electric Power Company	The Study on Master Plan of Transmission Line and Substation System	**Figure No.** 2.2-2 **Title** String Insulator Unit with Ball and Socket Coupling





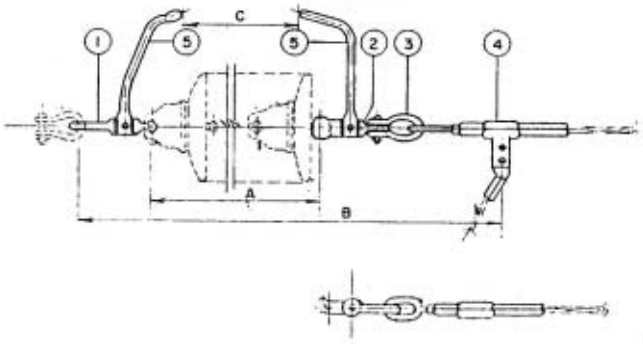
Legend	Qty per set	Description
1	1	Horn holder oval ball-eye
2	1	Horn holder socket-eye
3	1	Suspension clamp
4	1 set	Preformed armor rod
5	1 set	Arcing horn

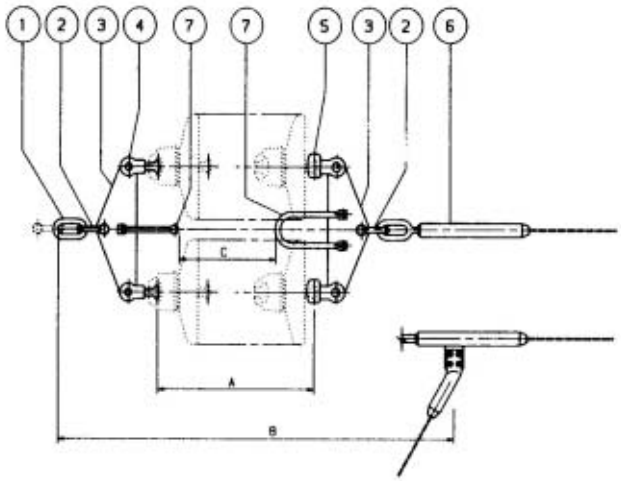
Line Voltage kV	Insulator per set	Approx. dimension (mm)		
		A	B	C
115	10	1,460	1,960	1,240

Legend	Qty per set	Description
1	1	Twisted shackle or shackle
2	2	Yoke plate
3	2	Ball clevis
4	2	Socket clevis
5	1	Straight clevis eye
6	1	Suspension clamp
7	1 set	Preformed armor rod
8	1 set	Arcing horn

Line Voltage kV	Insulator per set	Approx. dimension (mm)		
		A	B	C
115	2×10	1,460	2,110	1,240

Electricite du Laos	Japan International Cooperation Agency (JICA) Joint Venture Nippon Koei Co., Ltd. & Tokyo Electric Power Company	The Study on Master Plan of Transmission Line and Substation System	**Figure No.** 2.2-3 **Title** Suspension Set





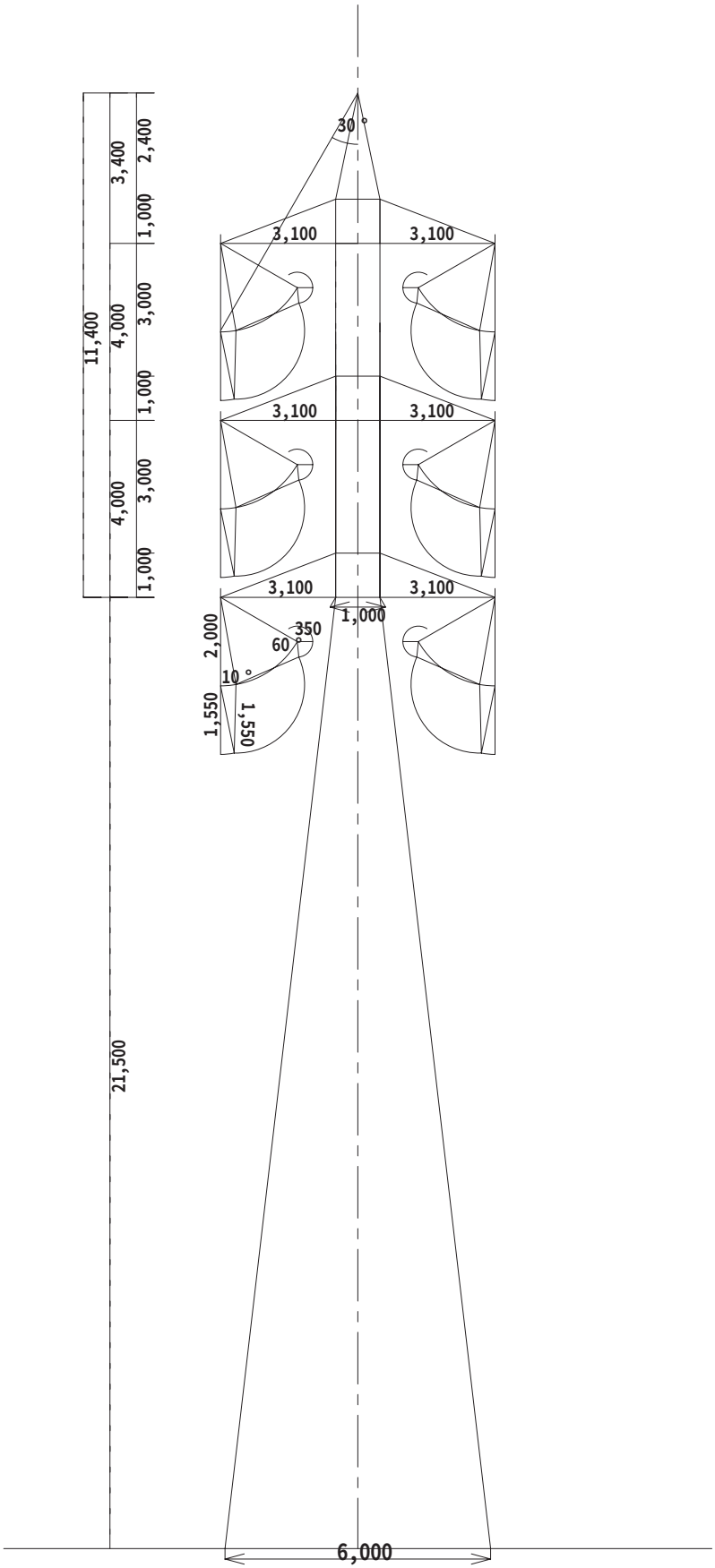
	Qty per set	Description
1	1	Horn holder oval ball-eye
2	1	Horn holder socket-eye
3	1	Shackle
4	1	Compression deadend clamp
5	1 set	Arcing horn

Line Voltage kV	Insulator per set	Approx. dimension (mm)		
		A	B	C
115	10	1,460	2,150	1,240

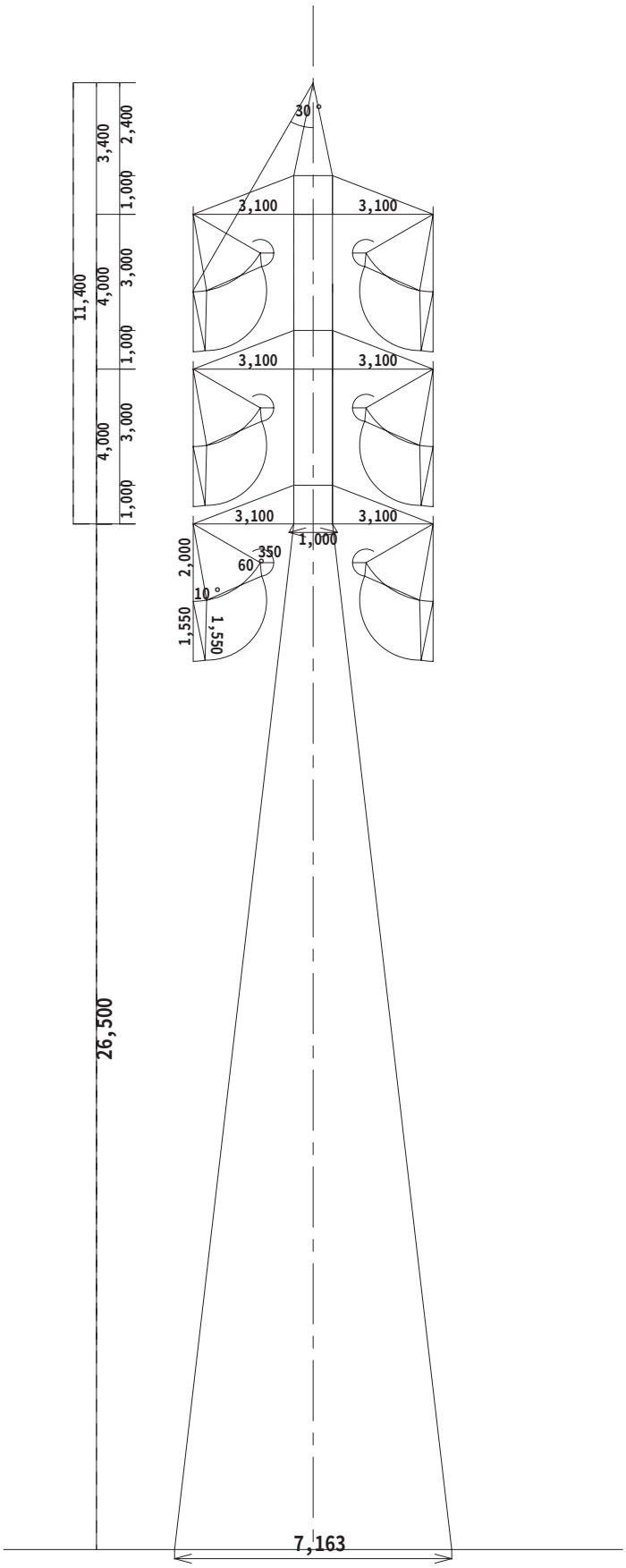
Legend	Qty per set	Description
1	1	Oval link
2	2	Shackle
3	2	Yoke plate
4	2	Ball clevis
5	2	Socket clevis
6	1	Compression deadend clamp
7	1 set	Arcing horn

Line Voltage kV	Insulator per set	Approx. dimension (mm)		
		A	B	C
115	10	1,460	2,500	1,240

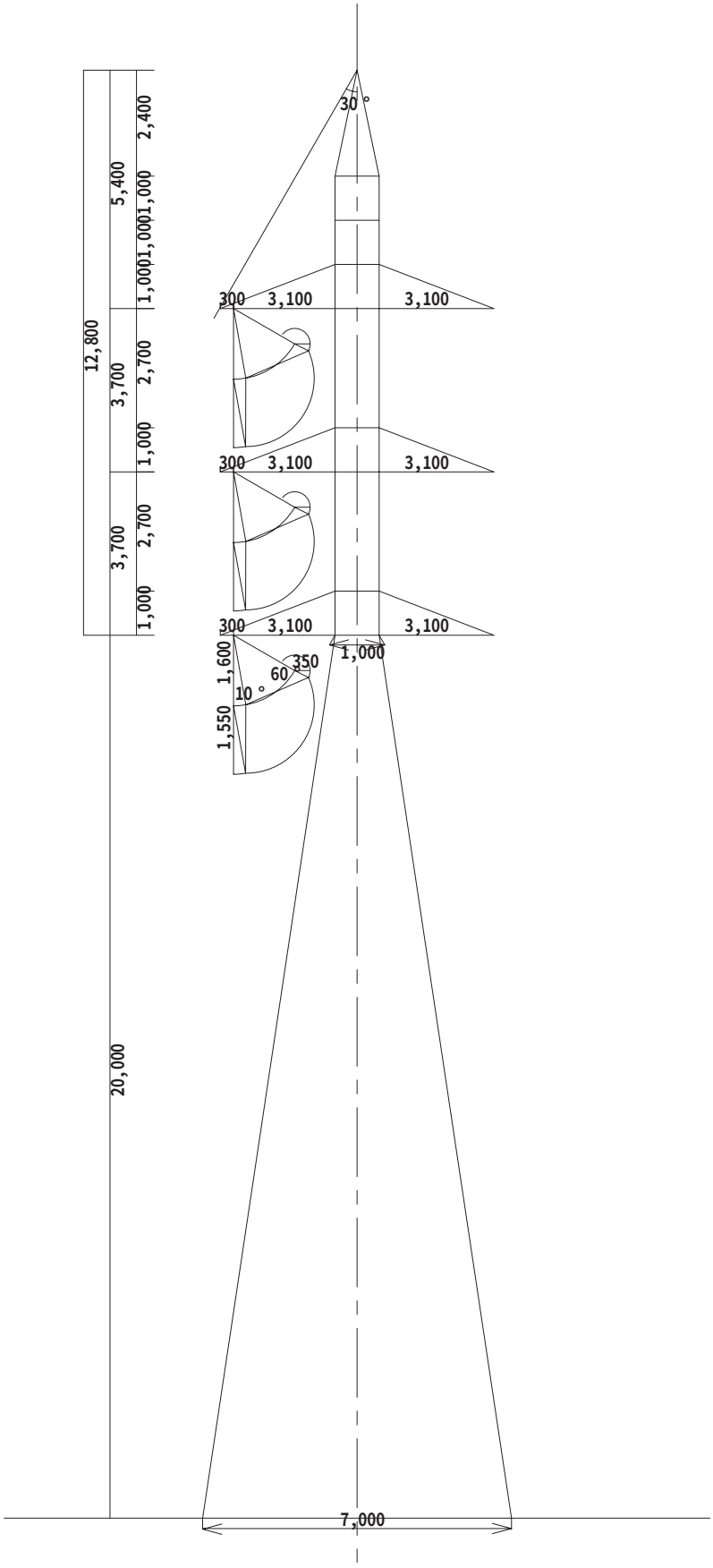
Electricite du Laos	Japan International Cooperation Agency (JICA) Joint Venture Nippon Koei Co., Ltd. & Tokyo Electric Power Company	The Study on Master Plan of Transmission Line and Substation System	Figure No. 2.2-4 Title Tension Set



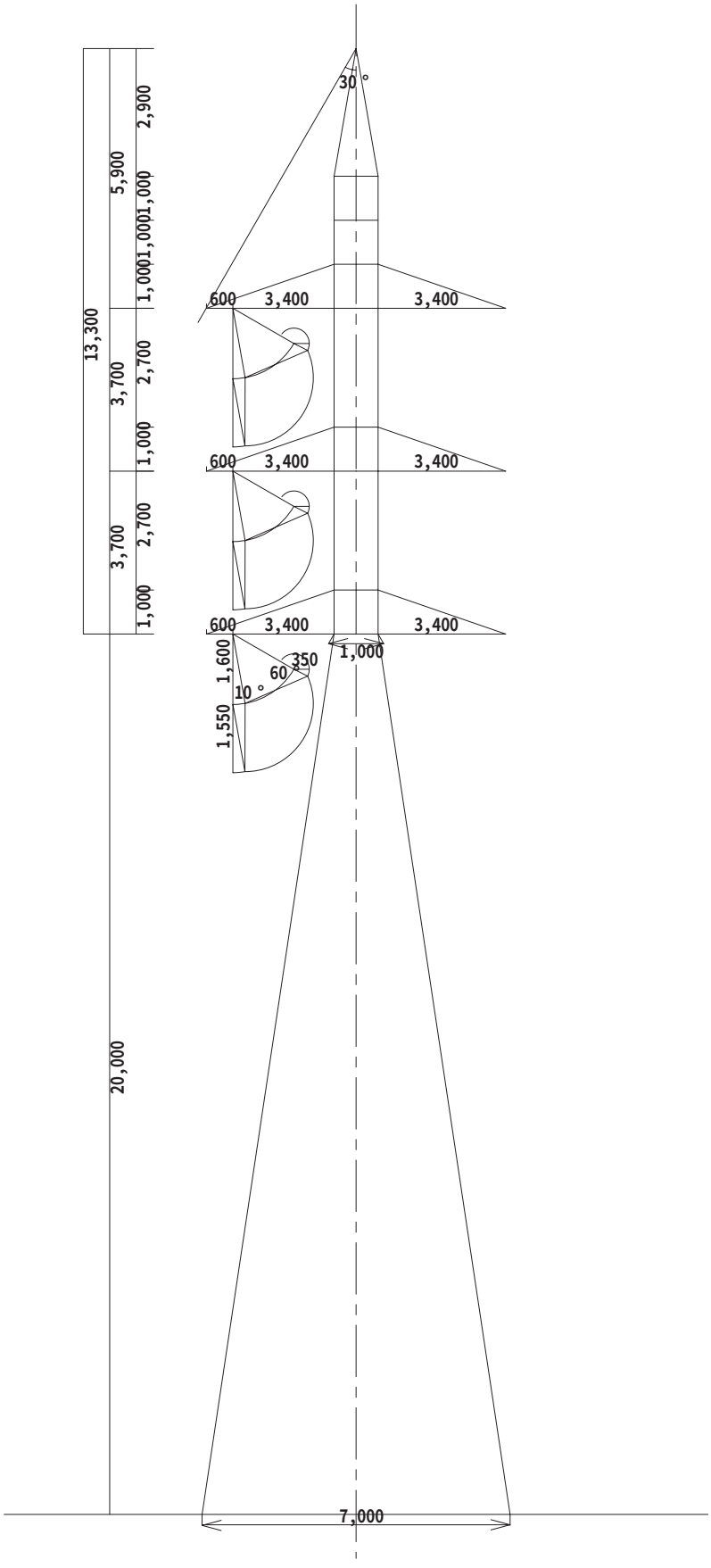
Electricite du Laos	Japan International Cooperation Agency (JICA) Joint Venture Nippon Koei Co., Ltd. & Tokyo Electric Power Company	The Study on Master Plan of Transmission Line and Substation System	**Figure No.** 2.2-5 **Title** Suspension Tower : A1 Type (Line Horizontal Angle : 0 - 3 deg.)



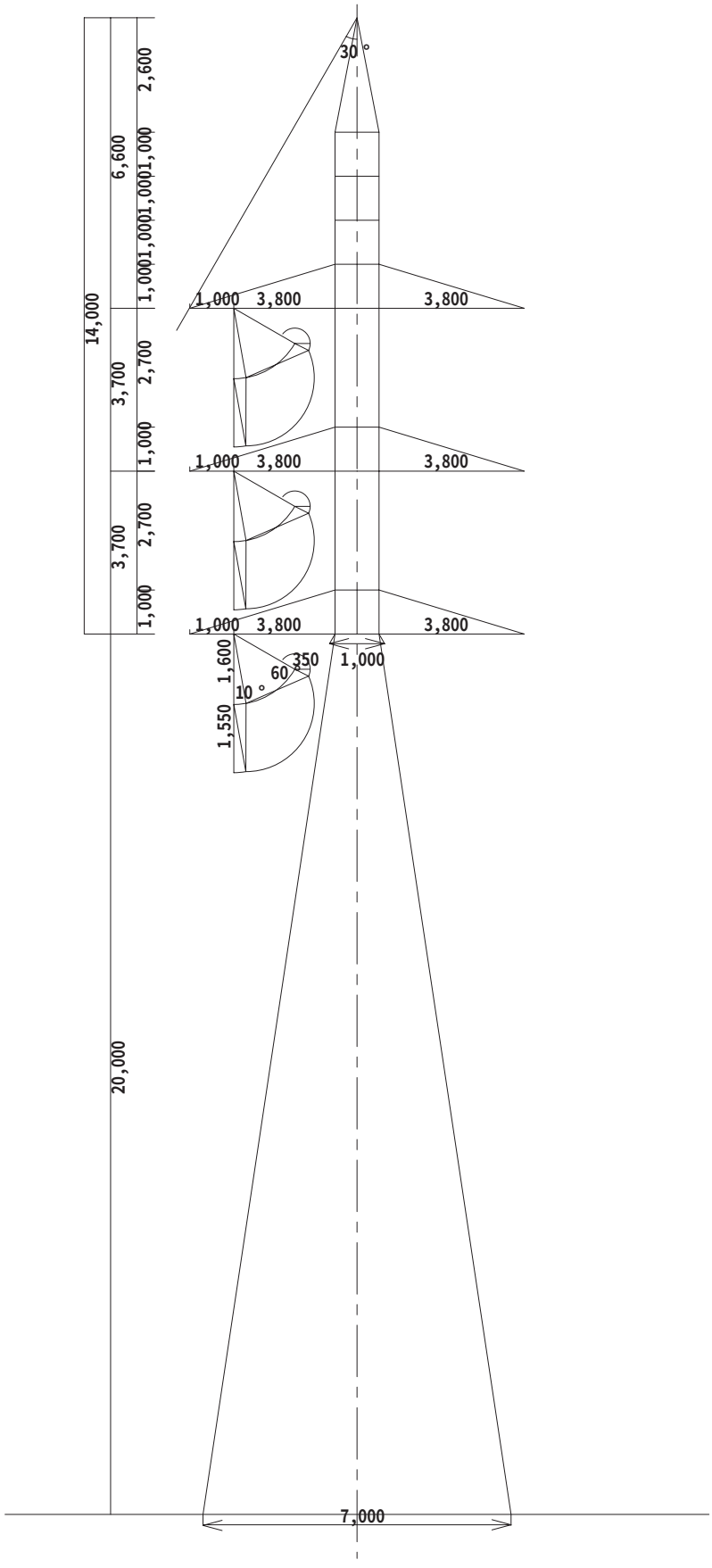
Electricite du Laos	Japan International Cooperation Agency (JICA) Joint Venture Nippon Koei Co., Ltd. & Tokyo Electric Power Company	The Study on Master Plan of Transmission Line and Substation System	**Figure No.** 2.2-6 **Title** Suspension Tower : A2 Type (Line Horizontal Angle : 0 - 3 deg.)



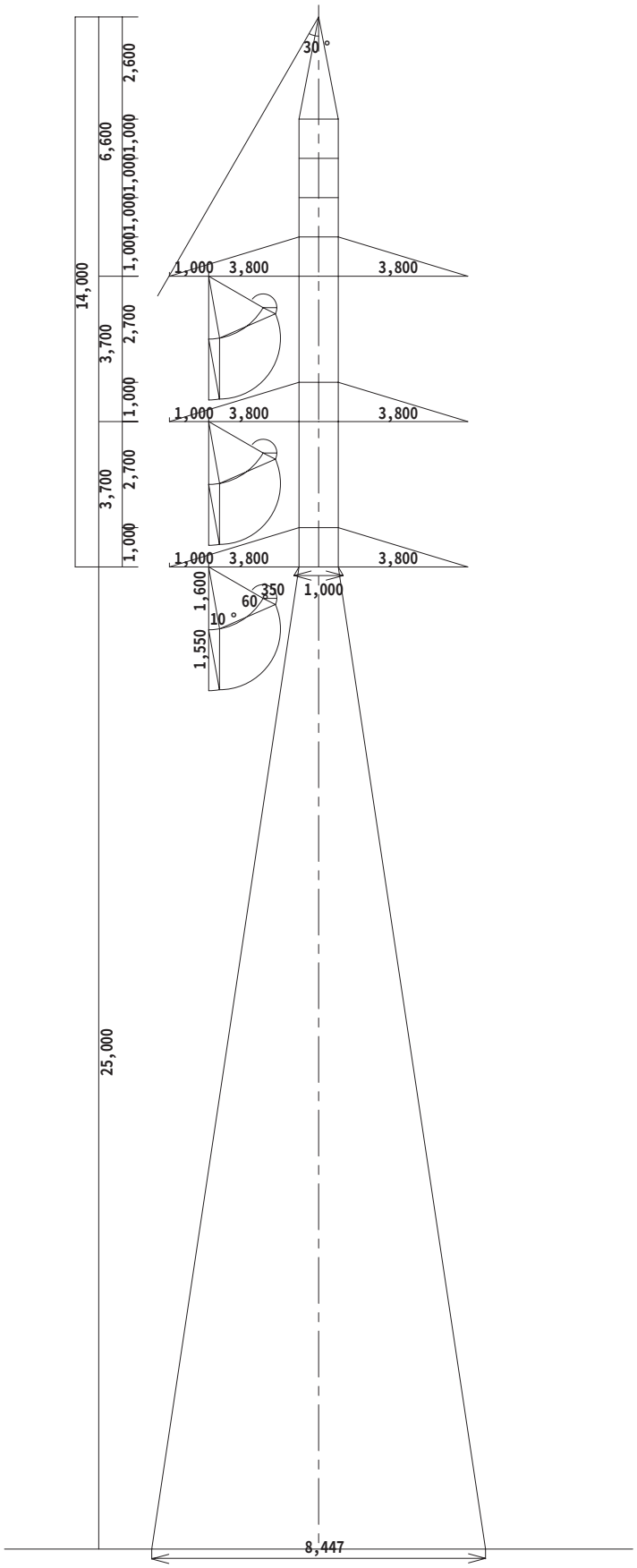
Electricite du Laos	Japan International Cooperation Agency (JICA) Joint Venture Nippon Koei Co., Ltd. & Tokyo Electric Power Company	The Study on Master Plan of Transmission Line and Substation System	**Figure No.** 2.2-7 **Title** Tension Tower : B1 Type (Line Horizontal Angle : 0 - 15 deg.)



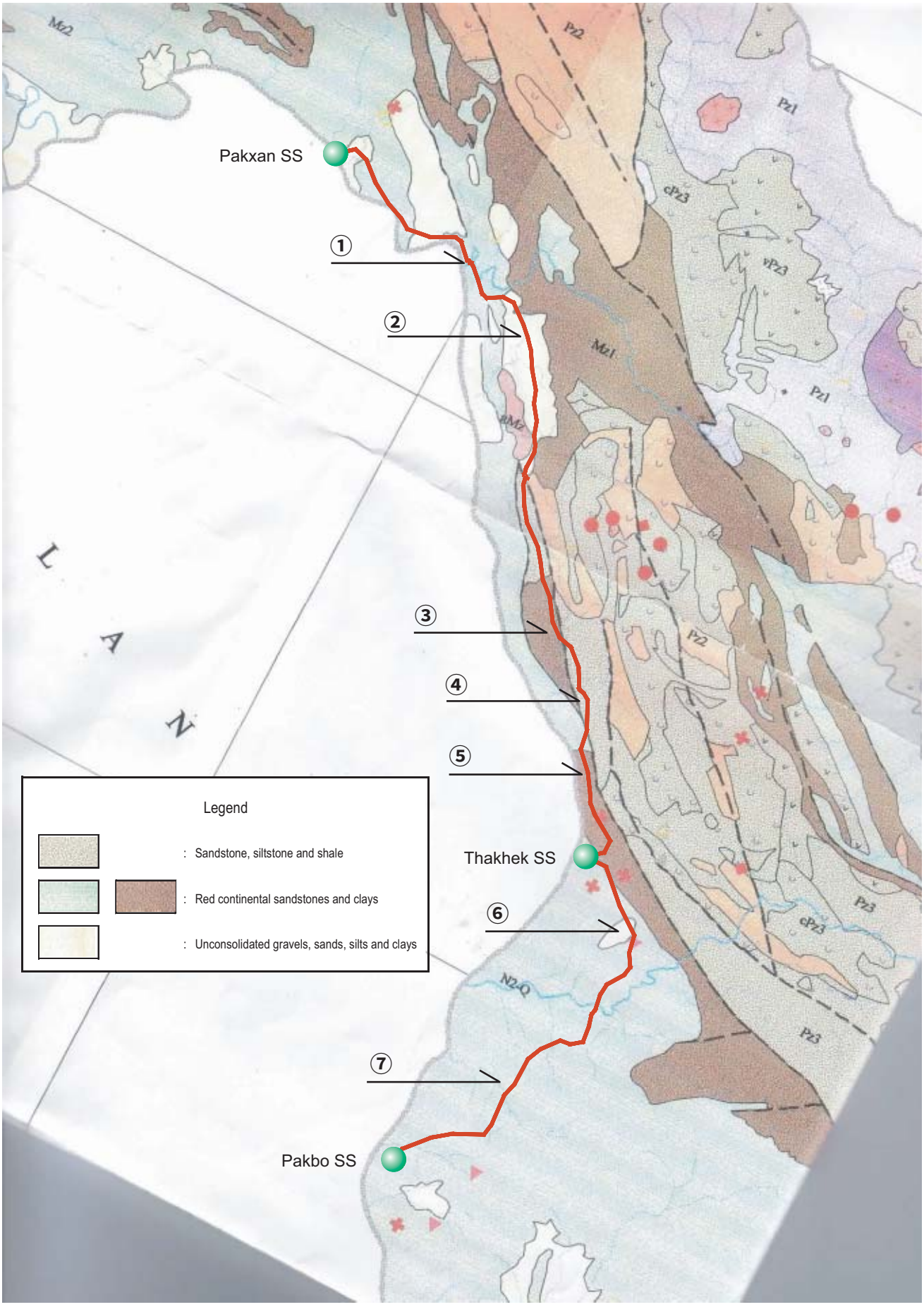
Electricite du Laos	Japan International Cooperation Agency (JICA) Joint Venture Nippon Koei Co., Ltd. & Tokyo Electric Power Company	The Study on Master Plan of Transmission Line and Substation System	**Figure No.** 2.2-8 **Title** Tension Tower : C1 Type (Line Horizontal Angle : 0 - 30 deg.)



Electricite du Laos	Japan International Cooperation Agency (JICA) Joint Venture Nippon Koei Co., Ltd. & Tokyo Electric Power Company	The Study on Master Plan of Transmission Line and Substation System	**Figure No.** 2.2-9 **Title** Tension Tower : D1, DE Type (Line Horizontal Angle : 0 - 90 deg.)



Electricite du Laos	Japan International Cooperation Agency (JICA) Joint Venture Nippon Koei Co., Ltd. & Tokyo Electric Power Company	The Study on Master Plan of Transmission Line and Substation System	**Figure No.** 2.2-10 **Title** Tension Tower : D2 Type (Line Horizontal Angle : 0 - 90 deg.)



Electricite du Laos	Japan International Cooperation Agency (JICA) Joint Venture Nippon Koei Co., Ltd. & Tokyo Electric Power Company	The Study on Master Plan of Transmission Line and Substation System	Figure No. 2.2-11(1) Title Geological Features Map

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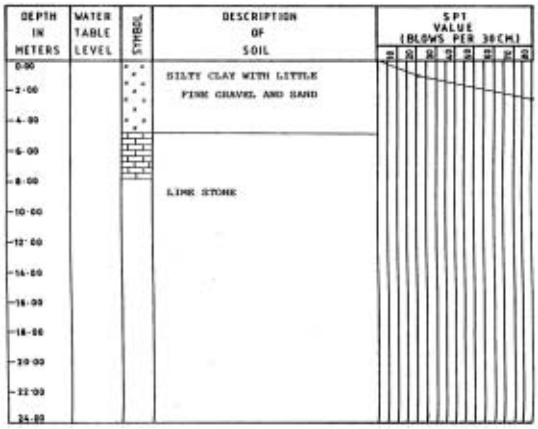
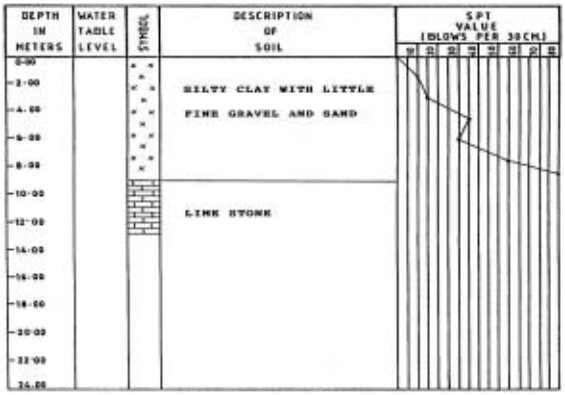
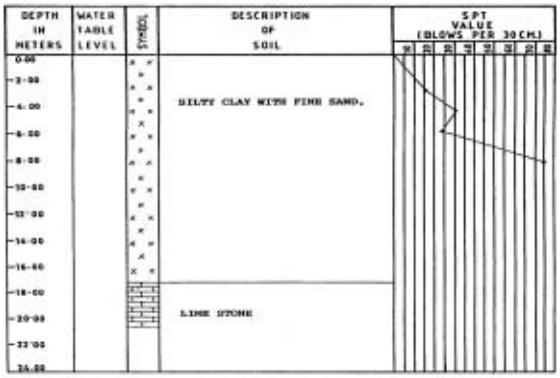
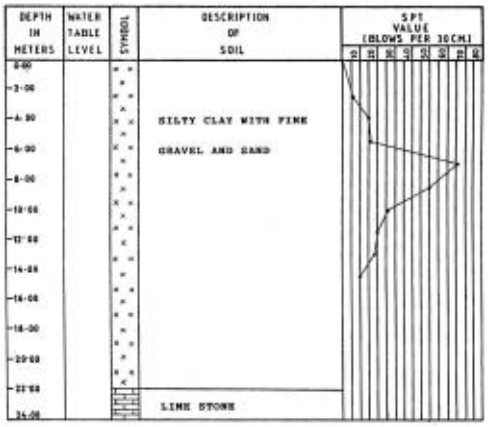
1	
2	
3	
4	

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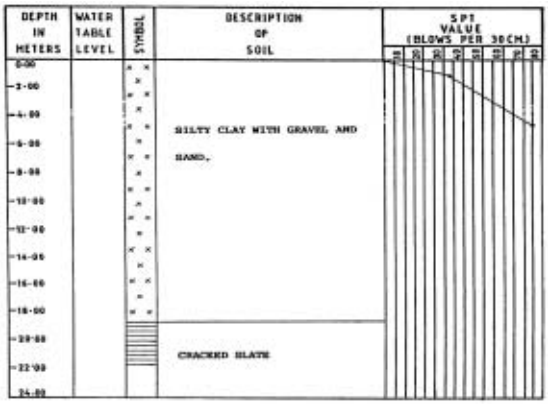
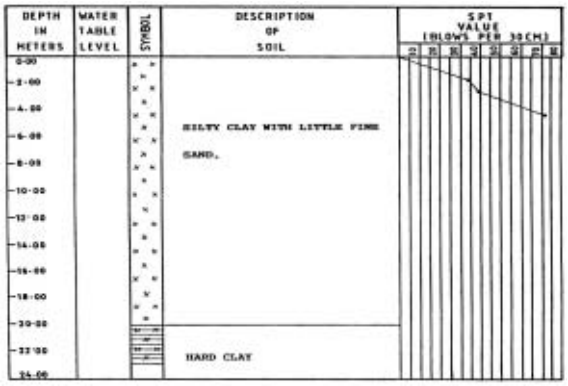
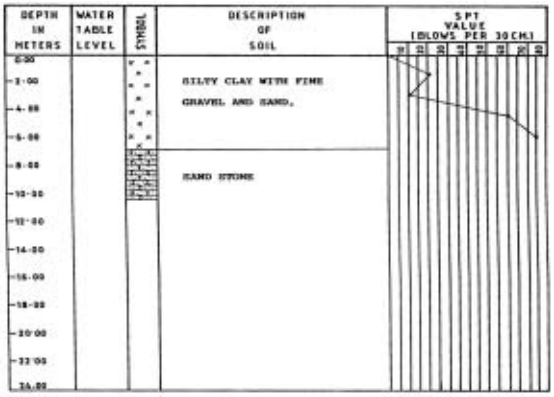
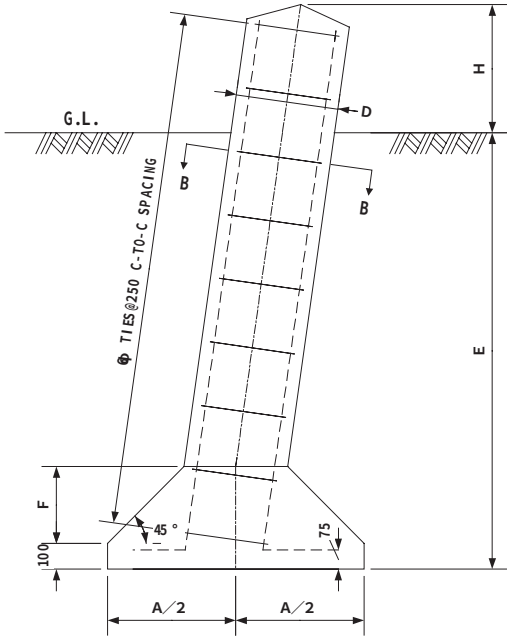
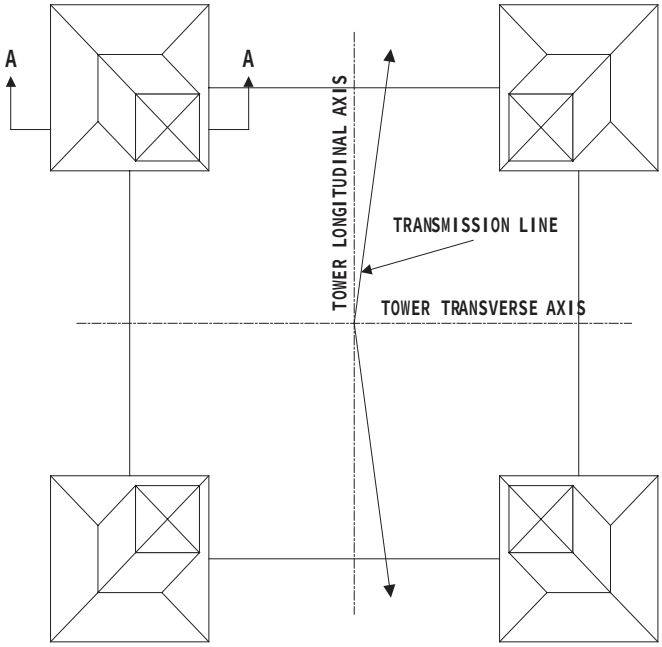
5	
6	
7	

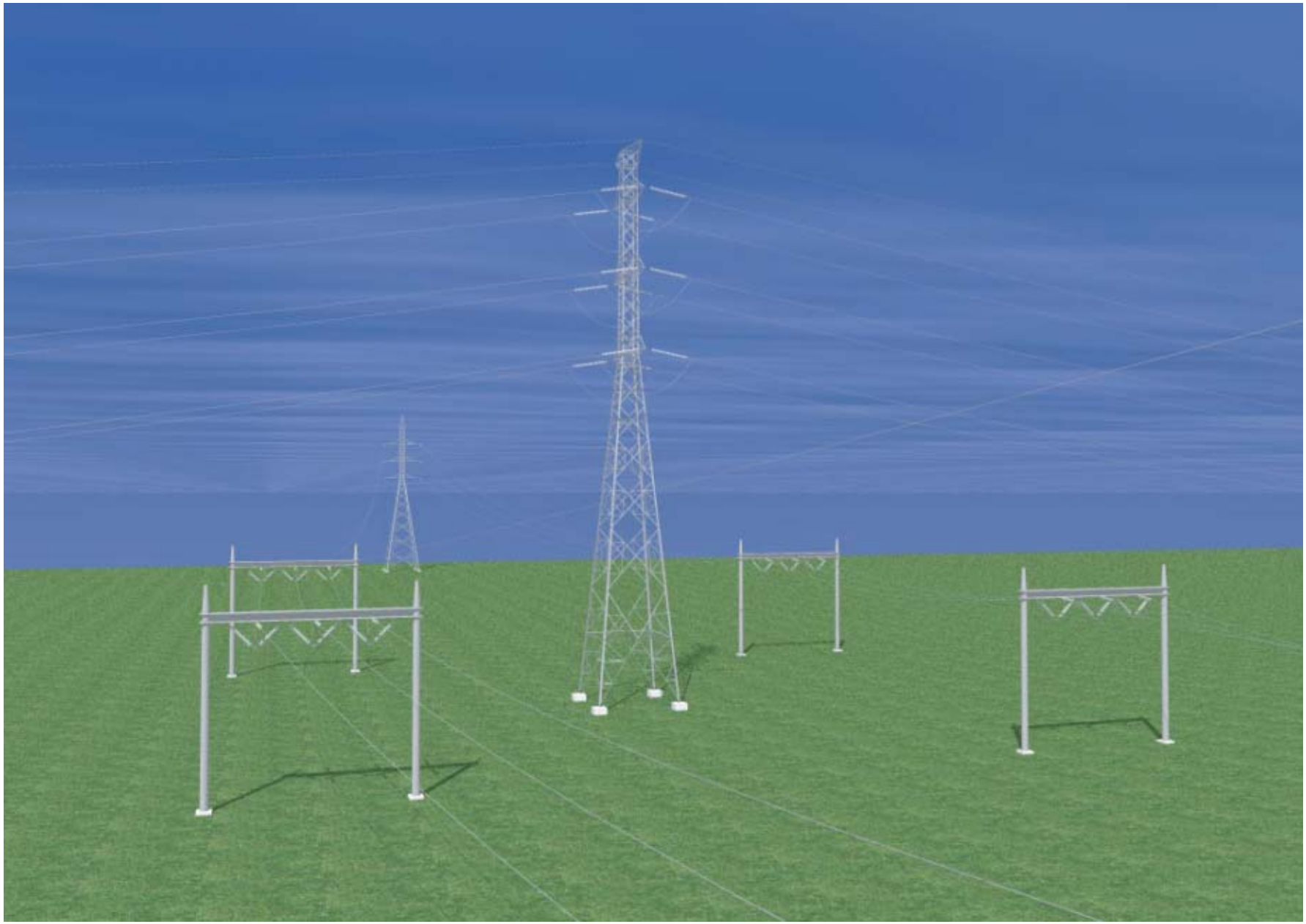
Electricite du Laos	Japan International Cooperation Agency (JICA) Joint Venture Nippon Koei Co., Ltd. & Tokyo Electric Power Company	The Study on Master Plan of Transmission Line and Substation System	**Figure No.** 2.2-11(2) **Title** Boring Data



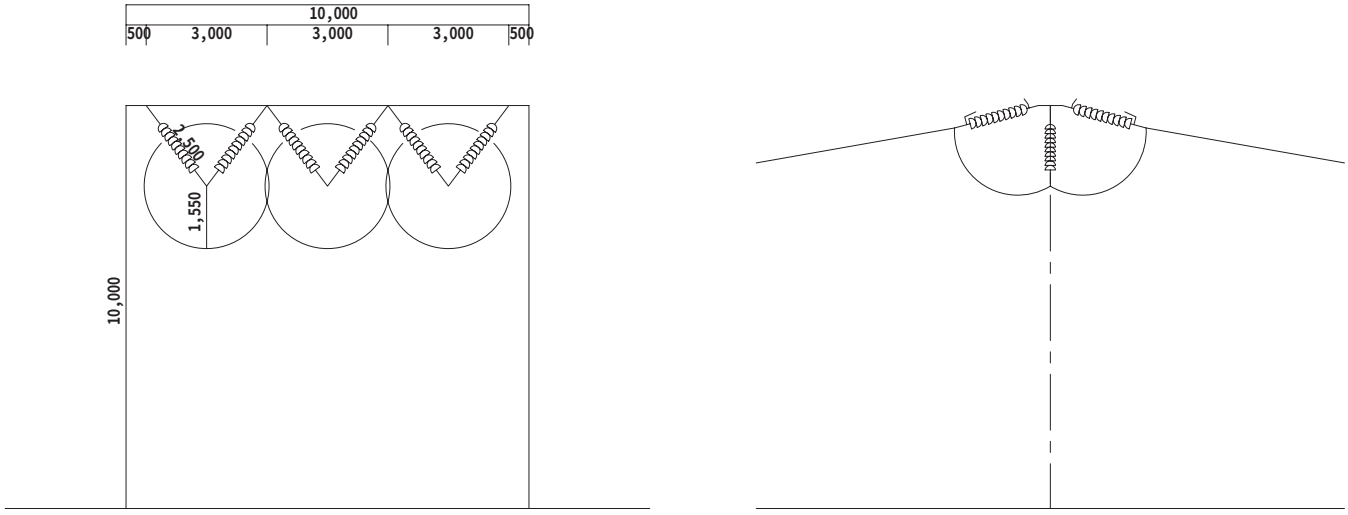


	TOWER TYPE	COMPRESSION LOAD [kN] from TOWER	UPLIFT LOAD [kN] from TOWER	APPLIED FOUNDATION TYPE	LOAD(kN) COMPRESSION and UPLIFT	E [mm]	A [m]	F [mm]	D [mm]	H [mm]
Soil - I	A1	182	148	Pad -1	~200	2500	800	200	400	500
	A2	192	152							
	B1	252	211	Pad -2	200~400	2600	1800	700	500	500
	C1	344	299							
	D1	543	486	Pad -3	400~600	2800	2800	1200	500	500
	D2	552	486							
	DE	596	532							
Soil - II	A1	182	148	Pad -4	~200	2600	1200	400	400	500
	A2	192	152							
	B1	252	211	Pad -5	200~400	2600	2400	1000	500	500
	C1	344	299							
	D1	543	486	Pad -6	400~600	2800	3500	1500	500	500
	D2	552	486							
	DE	596	532							
Soil - III	A1	182	148	Pad -7	~200	3500	1600	600	400	500
	A2	192	152							
	B1	252	211	Pad -8	200~400	3500	3000	1300	500	500
	C1	344	299							
	D1	543	486	Pad -9	400~600	3500	4300	1900	500	500
	D2	552	486							
	DE	596	532							

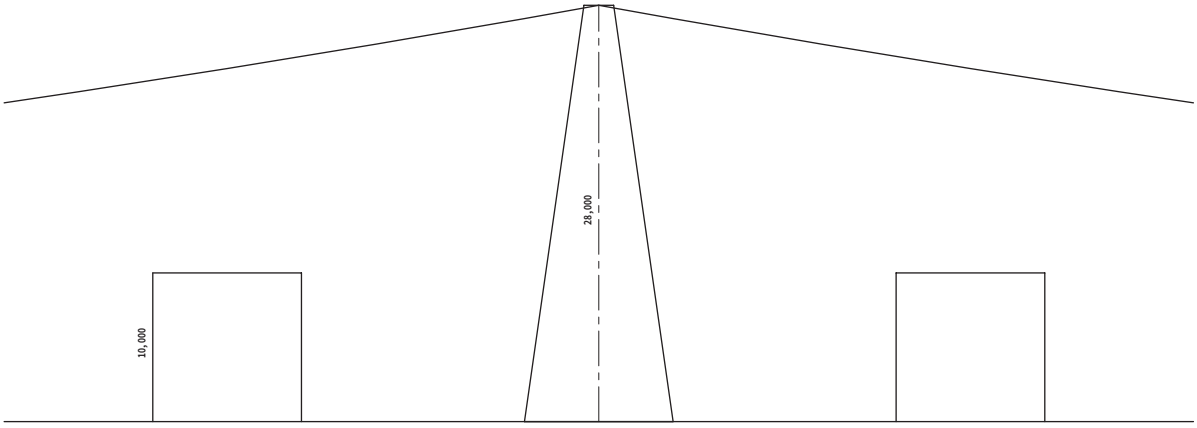
Electricite du Laos	Japan International Cooperation Agency (JICA) Joint Venture Nippon Koei Co., Ltd. & Tokyo Electric Power Company	The Study on Master Plan of Transmission Line and Substation System	Figure No. 2.2-12 Title Foundations



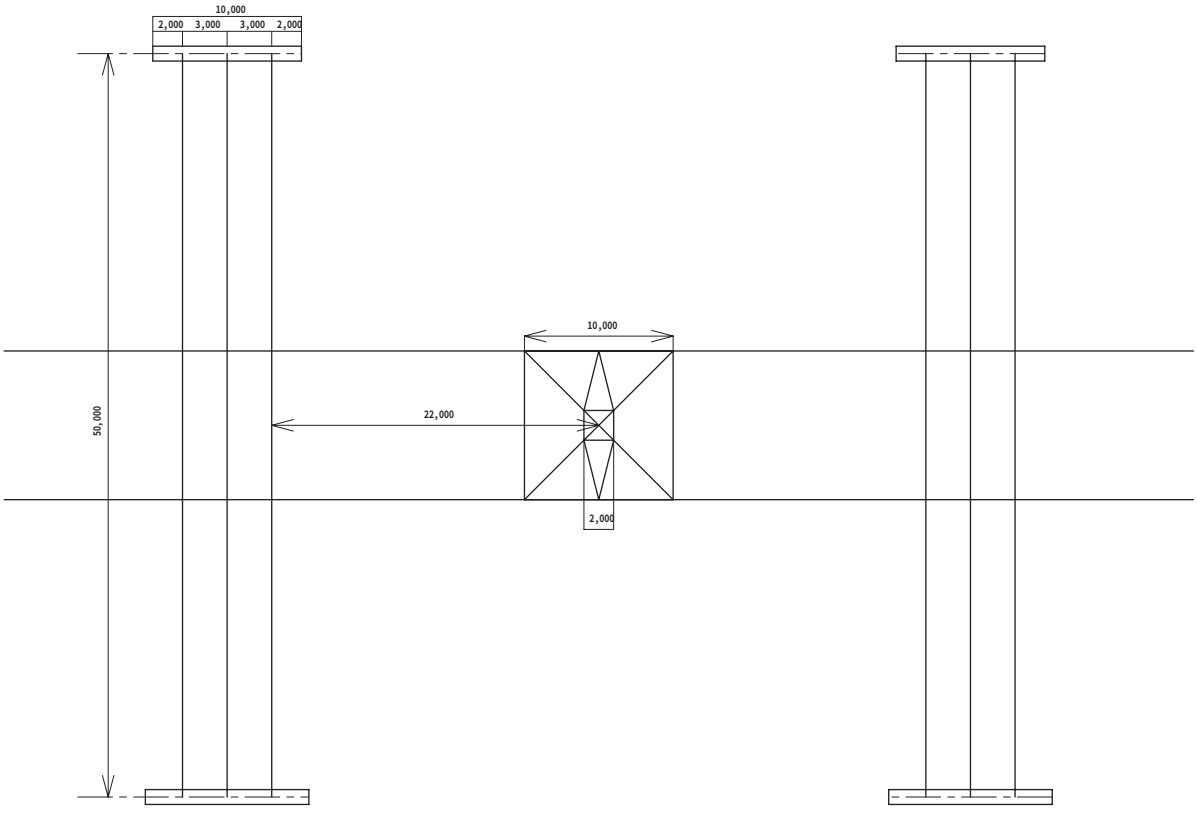
Electricite du Laos	Japan International Cooperation Agency (JICA) Joint Venture Nippon Koei Co., Ltd. & Tokyo Electric Power Company	The Study on Master Plan of Transmission Line and Substation System	Figure No. 2.2-13 Title Image Illustration of the Cross Point with 230 kV Transmission Line



Electricite du Laos	Japan International Cooperation Agency (JICA) Joint Venture Nippon Koei Co., Ltd. & Tokyo Electric Power Company	The Study on Master Plan of Transmission Line and Substation System	**Figure No.** 2.2-14 **Title** Gantry Structure : Ga Type



Gantry of 115 kV Transmission line | Tower of 230kV Transmission line | Gantry of 115 kV Transmission line



Electricite du Laos	Japan International Cooperation Agency (JICA) Joint Venture Nippon Koei Co., Ltd. & Tokyo Electric Power Company	The Study on Master Plan of Transmission Line and Substation System	**Figure No.** 2.2-15 **Title** Design of the Cross Point with 230 kV Transmission Line

CHAPTER III

SUBSTATIONS

Chapter 3 Substations

3.1 Design Concept

In addition to the general concept of the preliminary design described in Section 7.3 of Part I, the design concept focusing on the Project is stated in this section.

(1) Utilization of the existing substations

Pakxan、Thakhek and Savannakhet Cities are connected under the Project. The existing 115 kV substations are in service in the 2 cities except Thakhek. If the transmission line bays are installed in the existing Pakxan SS and Pakbo SS, the transmission lines constructed under the Project can be connected to the substations. A new 115 kV substation is planned to be constructed in Thakhek City by the year 2004 under the IDA fund. In the new Thakhek Substation, the land space for the transmission line bays for the Project has already been secured.

In other words, the new construction of the substation is not necessary for the Project and the effective utilization of the existing substations is possible.

(2) Coordination to the existing substation facilities

The specifications and the layout of the existing substation facilities in the country are not standardized but different among substations depending on the time of construction or the facility designers. Accordingly, the specifications and layout of the facilities for the Project should be determined in considering of the coordination with the existing facilities in each substation.

(3) Busbar system

Pakxan SS and the planned Thakhek SS are equipped with the double busbar (main and transfer) system, but Pakbo SS is equipped with the single busbar system.

The existing Pakbo SS has only 3 bays, i.e. 2 bays for 2×10 MVA transformer and 1 bay for transmission line connecting with the EGAT's Mukudahan SS to import electricity. In such a simple substation, it seems that the single busbar system dose not cause a serious obstruction to the system operation. However, a new transmission line bay to Kengkok SS is now constructed now in the Pakbo SS under the IDA fund (SPRE project), and two more transmission line bays will be constructed under the Project. Such expansion in the existing substation equipped with a single

busbar system may have high possibility to cause operational obstruction. Because the transmission lines constructed under the Project are the very important lines as the backbone of the power system of Lao PDR, the substations connected with those trunk lines should have sufficient reliability. Accordingly, the single busbar system in Pakbo SS should be upgraded to the double busbar system.

(4) Main transformer and 22 kV facilities

In Pakbo SS, the SPRE project including replacement of transformers from 2×10 MVA to 2×20 MVA and reinforcement of 22 kV system is in progress under IDA fund. In Pakxan SS, there is a project to replace the existing 1×5 MVA transformer to new 2×16 MVA transformers and to reinforce the 22 kV facilities. The status of the project is under tender evaluation stage as of July 2002. In the planned Thakhek SS, 2×30 MVA transformers are planned to be installed, and the status of the project is also under tender evaluation stage.

These transformer capacities in each substation can meet the electricity demand at least 10 years hence, which has been forecasted by the Study Team. The necessity of reinforcement for 22 kV facilities in each substation under the Project is not also recognized. Accordingly, the replacement and/or reinforcement of transformers and 22 kV facilities are not considered in the Project.

3.2 Substation Site

3.2.1 Pakxan Substation

Figure 3.2-1 Pakxan SS Location

In 1999, the existing Pakxan SS was commenced its operation to distribute electrical energy from Nam Ngum 1 and Nam Leuk PS to Pakxan City, and to export the surplus energy to Thailand. As shown in Figure 3.2-1, Pakxan SS is located in 2 km east of Pakxan City in Bolikhamxai Province along Route 13.

Two bays for the Pakxan - Thakhek 2 cct transmission line are to be installed at Pakxan SS under the Project. There are four 115 kV switchgear bays in Pakxan SS, i.e. two TL bays for Nam Leuk PS and Bungkhan SS (EGAT), one TR bay and one bus-tie bay. The land space for installation of two additional line bays under the Project is available in the existing 115 kV switchyard.

Since no habitation exists surrounding Pakxan SS, there is no anxiety for social environment influence such as the noise/vibration from the construction works.

3.2.2 Thakhek Substation

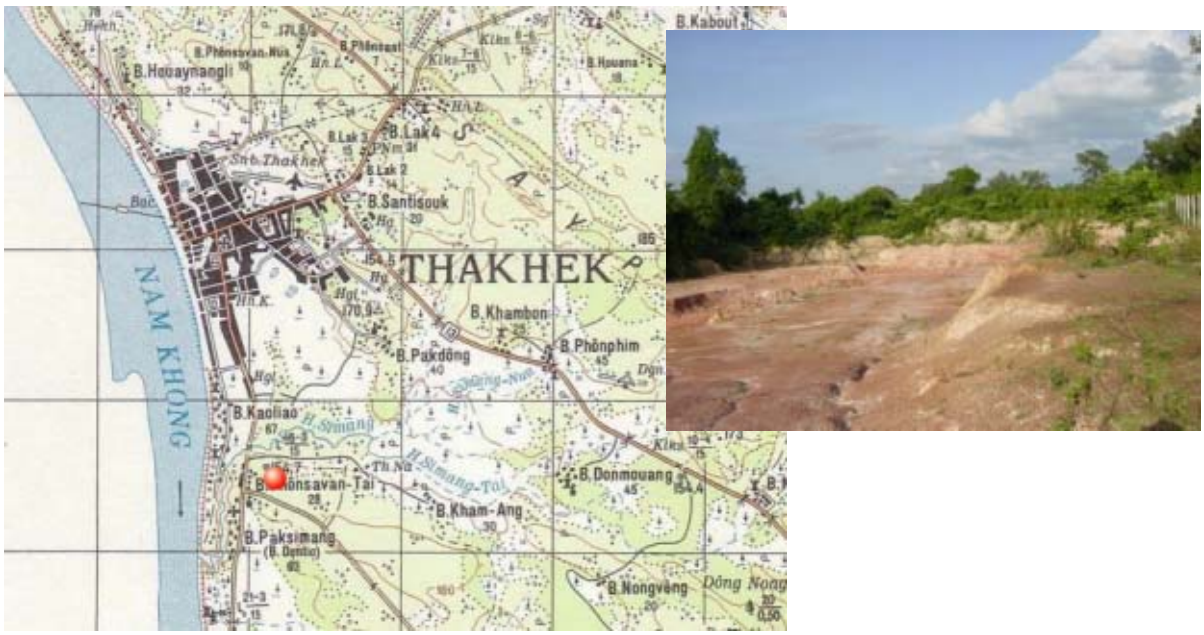


Figure 3.2-2 Planned Thakhek SS Location

There is no 115 kV substation available in Thakhek town to which the new transmission line under the Project can be connected. A 22 kV substation is currently in operation to distribute the import energy from Thailand to the city. However, a new 115 kV Thakhek substation is planned to be constructed as part of the SPRE project funded by IDA. The new Thakhek SS project is under tender evaluation of offers as of July 2002, and its commissioning is scheduled to be within 2004. A 115 kV line from this substation to Nam Theun 2 IPP project will be constructed from this substation to the Nam Theun 2 project to deliver electricity for its construction use.

EDL has secured a sufficient land space in the new 115 kV substation premises for 4 bays of 115 kV TL to connect the transmission lines to Pakxan SS and Pakbo SS under the Project. Accordingly, the 115 kV switchgear for the Project will be installed in the new 115 kV Thakhek SS.

As shown in Figure 3.2-2, the planned site for new 115 kV Thakhek SS is located in 3 km south of Thakhek City in Khammouan Province. Since the planned site is on the slightly elevated hill and no habitation exists surrounding there, there is no anxiety for social environment influence by the construction works.

3.2.3 Pakbo Substation

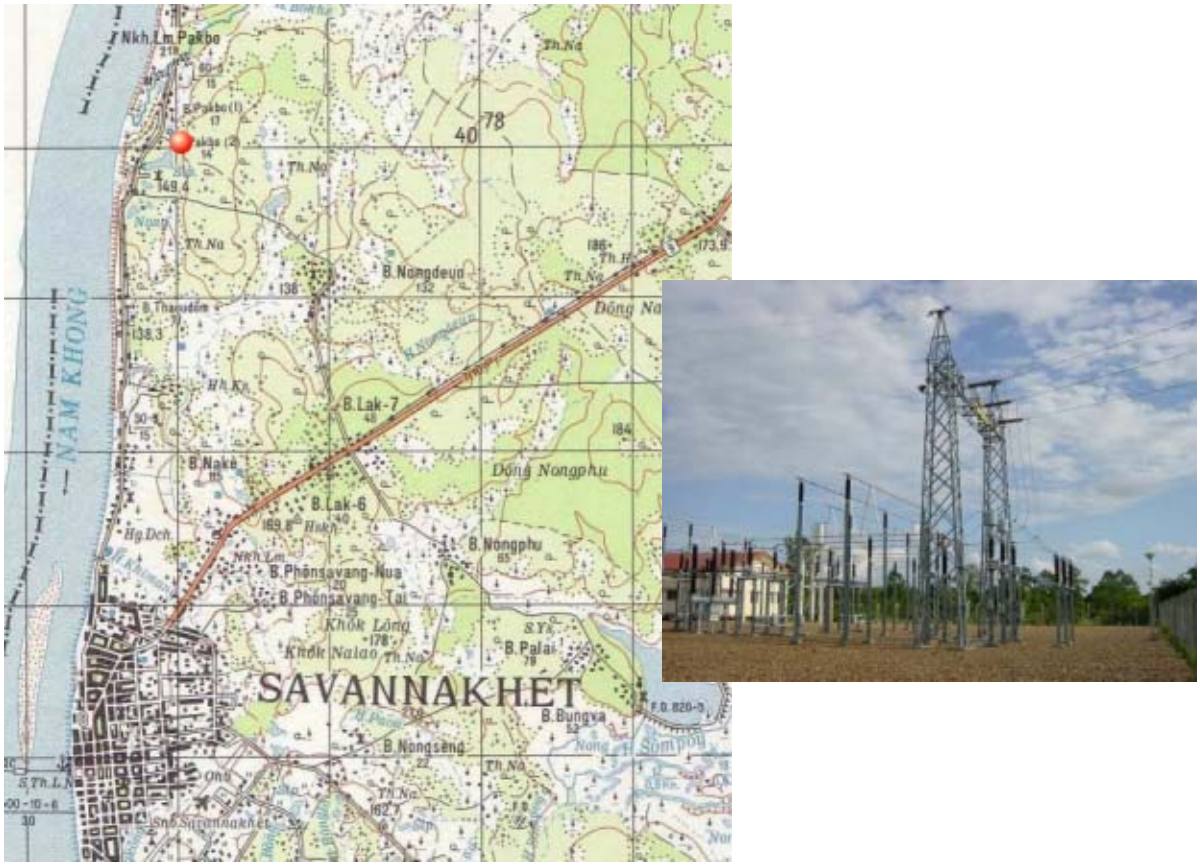


Figure 3.2-3 Pakbo SS Location

The existing Pakbo SS was commenced the operation in 1996 to import electrical energy from Thailand and to distribute it to Savannakhet City. As shown in Figure 3.2-3, Pakbo SS is located in approximately 7 km north of Savannakhet City in Savannakhet Province. The SPRE project is on-going under the IDA fund in Pakbo SS for replacement of transformers, installation of a new TL bay for Kengkok SS, and reinforcement of 22 kV facilities.

The Project plans to install two TL bays to the Thakhek SS and to upgrade the existing single busbar

system to double busbar in Pakbo SS. However, the present land space of the substation is insufficient for those plans. Expansion of the land of the Pakbo SS is necessary. The adjacent land to be expanded is available and owned by EDL, and there is no inhabitation around Pakbo SS.

3.3 Design for Pakxan Substation

3.3.1 General

Figures 3.3-1 and 3.3-2 show respectively the single line diagram and layout drawing of the existing Pakxan SS. The general profile of the existing Pakxan SS as of July 2002 is as follows.

(i)	Location	Pakxan City, Bolikhamxai Province
(ii)	Year of commissioning	1999
(iii)	Bus system	Double busbar system (Main and Transfer)
(iv)	Main transformer	115/22 kV, 5 MVA Transformer 1 unit (The transformer will be replaced to 2×16 MVA by 2004.)
(v)	115 kV switchgear	transformer bay: 1 bay bus-tie bay: 1bay transmission line bay: 2bays (Nam Leuk PS, Bungkan SS)
(vi)	22 kV feeder	3 feeders (Additional 3 feeders will be installed with the replacement of transformers.)

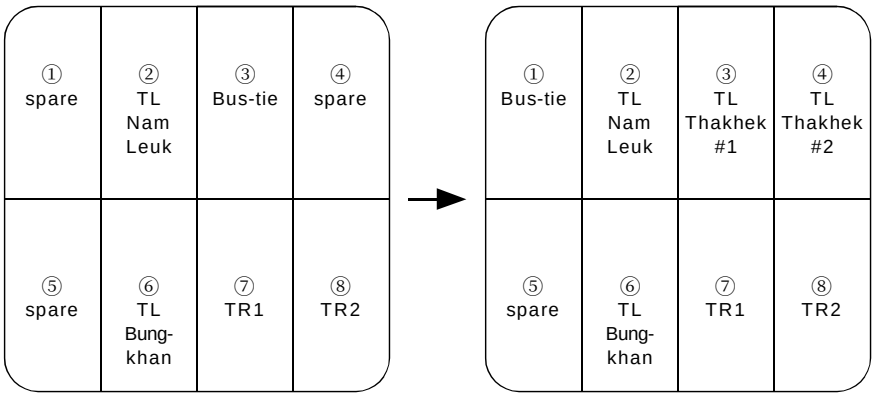
The replacement of transformers and reinforcement of 22 kV facilities are planned as part of the SPRE project in Pakxan SS. The status of the project is under tender evaluation stage and the project is expected to be completed within the year 2004. Therefore, the design for Pakxan SS under the Project should be focused on the substation facilities and layout after completion of the SPRE project.

3.3.2 Design and Scope of Works

Figure 3.3-3 and Figures 3.3-4 (1) & (2) show respectively the single line diagram and the layout plans of Pakxan SS for the Project.

Installation of two transmission line bays connecting Thakhek SS is necessary in Pakxan SS. Although there are three rooms for the TL bays on the 115 kV switchyard after the above mentioned SPRE project, those rooms locate separately each other as shown in Figure 3.3-5 (a). If two circuits of transmission line are connected to the substation simultaneously, it is desirable to arrange the TL bays considering the location of a dead-end tower and easiness for the maintenance works. Result of the discussion with EDL was that the bus-tie bay would be moved from the room ③ to room ① in Figure 3.3-5, and 115 kV switchgear for two circuits of transmission line would be installed at the

rooms ③ and ④ in a line under the Project.



(a) after the SPRE project (b) layout plan for the Project

Figure 3.3-5 Pakxan SS, 115 kV switchyard layout plan

The Scope of Works for Pakxan SS under the Project is as follows;

(a) Shift of bus-tie bay from the rooms ③ to ① in Figure 3.3-5

(b) Installation of TL bays for 2 circuits of transmission line at the rooms ③ and ④
- A TL bay consists of 1 Circuit Breaker, 2 disconnecting switches, 1 disconnecting switch with earthing switch, 3 Current Transformers, 3 Voltage Transformers, 2 Line Traps (Phase R & T), and 3 Lightning Arresters
- Installation of PLC equipment and its coordination with other stations
- Installation of protection relay panels and control panels in the substation control room (*Extension of the control room space will not be necessary.)
- Adjustment of AC and DC panels

(c) Extension of gantries
- Extension of gantries at the rooms ① and ⑤ in the above figure
- Bus work between the gantries

(d) Civil and erection works
- Foundation work
- Erection work
- Wiring work
- Grounding work
- Extension of cable trench, etc.

(e) Procurement of accessories including conductors, cables, insulators, etc., and special tools and measuring instruments for operation and maintenance

(f) Procurement of spare parts

3.4 Design of Thakhek Substation

3.4.1 General

The new 115 kV Thakhek substation is also planned to be constructed as a part of the SPRE project, and to be commissioned within the year 2004.

The planed outline of the new Thakhek SS is as follows;

(i)	Location	Thakhek City in Khammouan Province
(ii)	Year of commissioning	2004
(iii)	Bus system	Double busbar system (Main and Transfer bus)
(iv)	Main transformer	115/22 kV, 30 MVA transformer 2 units
(v)	115 kV switchgear	transformer bay: 2 bays bus-tie bay: 1 bay transmission line bay: 2 bays (Nakhon Phanom SS (EGAT)) * Two circuits of transmission line bays to Nam Theun 2 PS will be installed under the Nam Theun 2 IPP project.
(vi)	22 kV facilities	11 feeders station service transformer: 100 kVA×2 units static capacitor: 5 MVar×4 units

The plan for the new Thakhek SS has already secured the land space for installation of 4 transmission line bays to connect the transmission lines with Pakxan SS and Pakbo SS under the Project. Accordingly, substantial modification of the switchyard in the new Thakhek SS will not be necessary for the Project.

3.4.2 Design and Scope of Works

Four transmission line bays connecting to Pakxan SS and Pakbo SS are to be installed in the Thakhek SS under the Project. Figure 3.4-1 and Figures 3.4-2 (1) & (2) show respectively the single line diagram and the layout plans of Thakhek SS for the Project. But, the specifications and layout of the planned 115 kV facilities of Thakhek SS might be altered, depending on the SPRE project for the construction of Thakhek SS under the tender evaluation stage as of July 2002.

The Scope of Works for Thakhek SS under the Project is as follows;

(a) Installation of TL bays for 4 circuits of transmission line
- A TL bay consists of 1 Circuit Breaker, 2 disconnecting switches, 1 disconnecting switch with earthing switch, 3 Current Transformers, 3 Voltage Transformers, 2 Line Traps (Phase R & T), and 3 Lightning Arresters

- Installation of PLC equipment and its coordination with other stations
- Installation of protection relay panels and control panels in the substation control room
- Adjustment of AC and DC panels

(b) Civil and erection works
- Foundation work
- Erection work
- Wiring work
- Grounding work, etc.

(c) Procurement of accessories including conductors, cables, insulators, etc., and special tools and measuring instruments for operation and maintenance

(d) Procurement of spare parts

3.5 Design of Pakbo Substation

3.5.1 General

The replacement of transformers, installation of TL bay, and reinforcement of 22 kV facilities are on-going at Pakbo SS as a part of the SPRE project, and the works will be completed within the year 2003. Therefore, the design for Pakbo SS under the Project should be focused on the substation facilities after the SPRE project.

Figures 3.5-1 and 3.5-2 show respectively the single line diagram and layout drawing of Pakbo SS after the SPRE project.

The general profile of the existing Pakbo SS as of July 2002 is as follows.

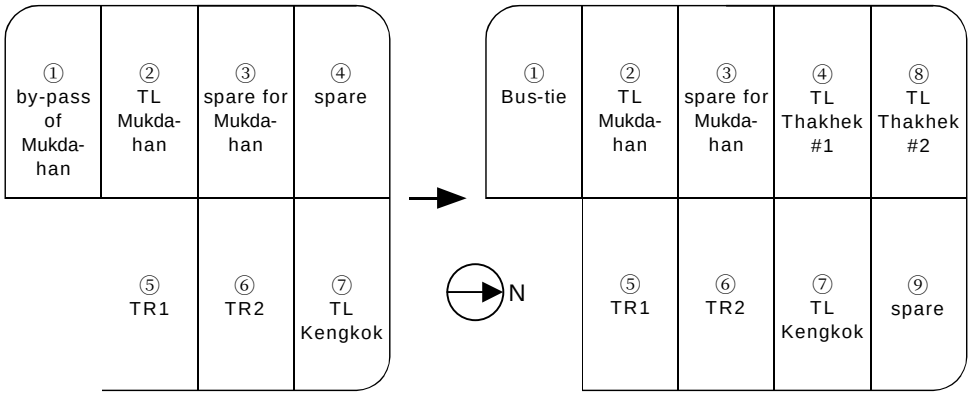
(i)	Location	Savannakhet City in Savannakhet Province
(ii)	Year of commissioning	1996
(iii)	Bus system	Single busbar system
(iv)	Main transformer	115/22 kV, 10 MVA transformer 2 units (The transformers will be replaced to 2×20 MVA by 2003.)
(v)	115 kV switchgear	transformer bay: 2 bays transmission line bay: 1 bay (Mukdahan SS (EGAT)) (Additional 1 bay to Kengkok SS will be installed by 2003.)
(vi)	22 kV feeder	5 feeders (Additional 2 feeders will be installed with the replacement of transformers.)

3.5.2 Design and Scope of Works

Figure 3.5-3 and Figures 3.5-4 (1) & (2) show respectively the single line diagram and the layout plans of Pakbo SS for the Project.

Installation of two transmission line bays connecting Thakhek SS is necessary at Pakbo SS under the Project. There is, however, only one room for the TL bay on the 115 kV switchyard after the above mentioned SPRE project. There are two spare rooms for the TL bay, the rooms ③ and ④ in Figure 3.5-5 (a). EDL emphasized that the room ③ should be kept for the connection of 2nd circuit to Mukudahan SS (EGAT) in the near future. Steel towers of this transmission line for the Mekong River crossing are structured for double circuit and one circuit only is now strung.

Therefore, as shown in Figure 3.5-5 (b), extension of the northern side of 115 kV switchyard is necessary for the Project (the rooms ⑧ and ⑨ in the figure). The land for the extension is owned by EDL. The discussion with EDL concluded that 115 kV switchgear for two circuits of transmission line to Thakhek SS would be installed at the rooms ④ and ⑧ in a line under the Project.



(a) after the SPRE Project (b) layout plan for the Project

Figure 3.5-5 Pakbo SS, 115 kV switchyard layout plan

The single busbar system of Pakbo SS is planned to be upgraded to the double busbar under the Project to improve the system reliability. The existing single busbar should be used as the main bus of double busbar systems. There is a by-pass bay of transmission line to Mukudahan SS at the room ① in Figure 3.5-5 (a). This by-pass bay can be modified to the bus-tie bay with installing a circuit breaker and a disconnecting switch. The by-pass will be apart from the Mukudahan line and will be modified to the transfer bus by extending the end of the by-pass (see Figure 3.5-4 (1)).

Following the upgrade to the double busbar system, overhead bus-work between the existing gantries and installation of disconnecting switch on the gantries are necessary. The existing transformer bays

and transmission line bays will be connected to the new transfer busbar through them (see Figure 3.5-4 (2)).

Because there is no space for installation of control and relay panels of the transmission lines of the Project, extension of the existing substation control room is also planned (see Figure 3.5-4 (1)).

The Scope of Works for Pakbo SS under the Project is as follows;

(a) Upgrading the single busbar to double busbar
- Modification of the by-pass bay to the bus-tie bay (installation of 1 circuit breaker and 1 disconnecting switch)
- Overhead bus-work between the existing gantries
- Installation of disconnecting switches on the existing gantries for transformer bays and transmission line bay
- Extension of tubular busbars on both of main and transfer bus

(b) Installation of TL bays for 2 circuits of transmission line at the rooms ④ and ⑧ in Figure 3.5-5 (b)
- A TL bay consists of 1 Circuit Breaker, 2 disconnecting switches, 1 disconnecting switch with earthing switch, 3 Current Transformers, 3 Voltage Transformers, 2 Line Traps (Phase R & T), and 3 Lightning Arresters
- Installation of PLC equipment and its coordination with other stations
- Installation of protection relay panels and control panels to the substation control room
- Adjustment of AC and DC panels

(c) Extension of gantries
- Extension of gantries at the rooms ③, ④, ⑧ and ⑨ in Figure 3.5-5 (b)
- Bus work between the gantries

(d) Installation of a voltage transformer to the main bus

(e) Extension of the substation control room

(f) Civil and erection works
- Foundation work
- Erection work
- Extension of the 115 kV switchyard (filling, compaction)
- Extension of the service road in the substation
- Extension of the external guard fence
- Wiring work
- Grounding work including extension of the existing grounding mesh
- Extension of cable trench, etc.

(g) Procurement of accessories including conductors, cables, insulators, etc., and special tools and measuring instruments for operation and maintenance

(h) Procurement of spare parts

3.6 Main facilities

3.6.1 General Electrical Requirements

The following are general electrical requirements for 115 kV switchgear of the Projects.

(i)	Nominal system voltage	115 kV
(ii)	Rated voltage (r.m.s. value) (Highest voltage for equipment)	123 kV
(iii)	Rated frequency	50 Hz
(iv)	Insulation level	
	Rated short-duration power-frequency withstand voltage (r.m.s. value)	230 kV
	Rated lightning impulse withstand voltage (peak value)	550 kV
	System neutral grounding	direct
	Minimum clearance of phase-to-earth	1,100 mm
	Standard clearance of phase-to-earth	1,400 mm
	Minimum clearance of phase-to-phase	1,400 mm
	Standard clearance of phase-to-phase	2,300 mm
(v)	Rated current	1,250 A
(vi)	Rated short-duration withstand current (3 sec)	40 kA
(vii)	Creepage Distance (minimum value)	16 mm/kV

3.6.2 Specification and Quantity of the Main Facilities

(1) Specification of the Main Facilities

All main facilities installed under the Project should be of outdoor type. Major specifications of the facilities are as follows.

(a)	Circuit Breaker (3 -phase)	SF6 gas type Rated voltage: 123 kV Rated normal current: 1,250 A

		Rated short-circuit breaking current: 40 kA Rated operation sequence: O - 0.3s - CO - 3min - CO Rated insulation level (IEC 60694) Rated short-duration power-frequency withstand voltage (rms); - common value: 230 kV - across the isolating distance: 265 kV Rated lightning impulse withstand voltage (peak); - common value: 550 kV - across the isolating distance: 630 kV
(b)	Disconnecting Switch (3 phase)	Two-column or three-column rotary type with horizontal operation Rated voltage: 123 kV Rated continuous current: 1,250 A Rated short-duration withstand current: 40 kA (3sec) Rated insulation level (IEC 60694) Rated short-duration power-frequency withstand voltage (rms); - common value: 230 kV - across the isolating distance: 265 kV Rated lightning impulse withstand voltage (peak); - common value: 550 kV - across the isolating distance: 630 kV 110V DC motorized and manual operation
(c)	Disconnecting Switch with Earthing Switch (3 phase)	same as item (b)
(d)	Disconnecting Switch (single phase)	Pantograph Type (only for Thakhek SS) The electrical specification is same as item (b).
(e)	Current Transformer	Rated voltage: 123 kV Core 1: 400/1 A, 5P20, 25VA Core 2: 400/1 A, 5P20, 25VA Core 3: 400/1 A, cl.0.5, 25VA
(f)	Voltage Transformer	Capacitive Type Voltage ratio: 115 / √ 3 kV, 110 / √ 3 V, 110 / √ 3 V Accuracy and burden; secondary (measurement): 0.5, 100 VA tertiary (protection): 3P, 100 VA Coupling capacitance: 8,800 pF

(g) Lightning Arrester — ZnO type
with surge counter
Rated voltage: 123 kV
Rated voltage (rms): 96 kV
Rated discharge current: 10 kA

(h) Line Trap — Rated continuous current: 800A
Coil inductance: 0.5 mH

Because the status of construction project of the new Thakhek SS is under the tender evaluation stage as of July 2002, specifications of the 115 kV facilities of Thakhek SS might be altered, and they should be confirmed in the detail design stage, accordingly.

(2) Quantity of the Main Facilities

With reference to the single-line diagrams and layout drawings of each substation, quantity of the main facilities of each substation required for the Project is shown in the following table.

Table 3.6-1 Quantity of the Main Facilities

	Main facilities	Pakxan SS	Thakhek SS	Pakbo SS
(a)	Circuit Breaker (3 phase)	2 units	4 units	3 units
(b)	Disconnection Switch (3 phase)	4 units	-	9 units
(c)	Disconnection Switch with Earthing Switch (3 phase)	2 units	4 units	2 units
(d)	Disconnection Switch (single phase – pantograph type)	-	8 sets	-
(e)	Current Transformer	6 units	12 units	6 units
(f)	Voltage Transformer	6 units	12 units	9 units
(g)	Lightning Arrester	6 units	12 units	6 units
(h)	Line Trap	4 units	8 units	4 units

3.6.3 Protection Relay System

The following protection relay system will be applied to the Project.

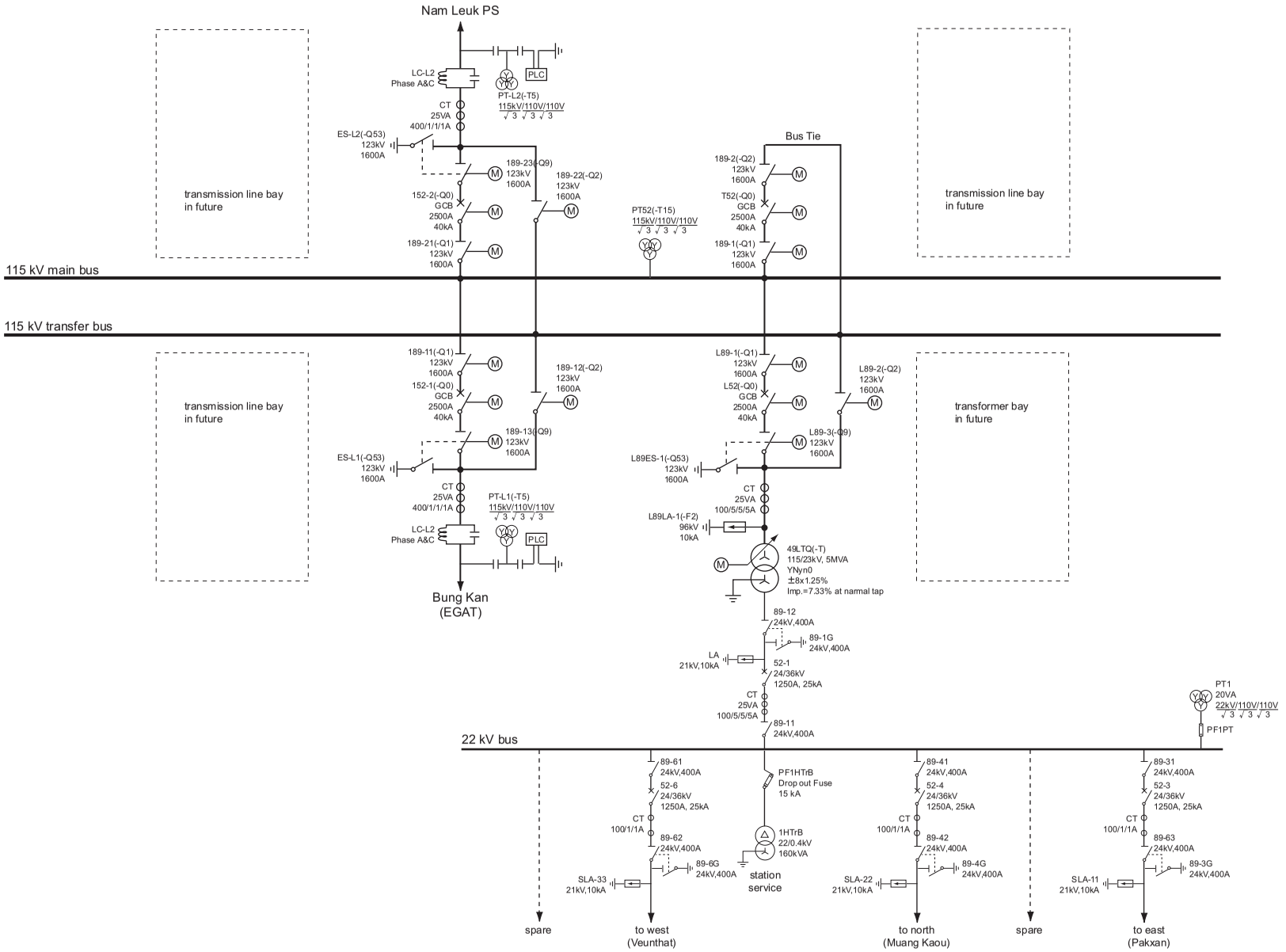
(a) 115 kV transmission lien protection
- Distance protection
- Directional earth fault protection
- Over-current and earth fault protection
- Automatic re-closing

(b) 115 kV busbar protection
- Differential protection
- Under voltage protection

3.6.4 Spare Parts and Tools

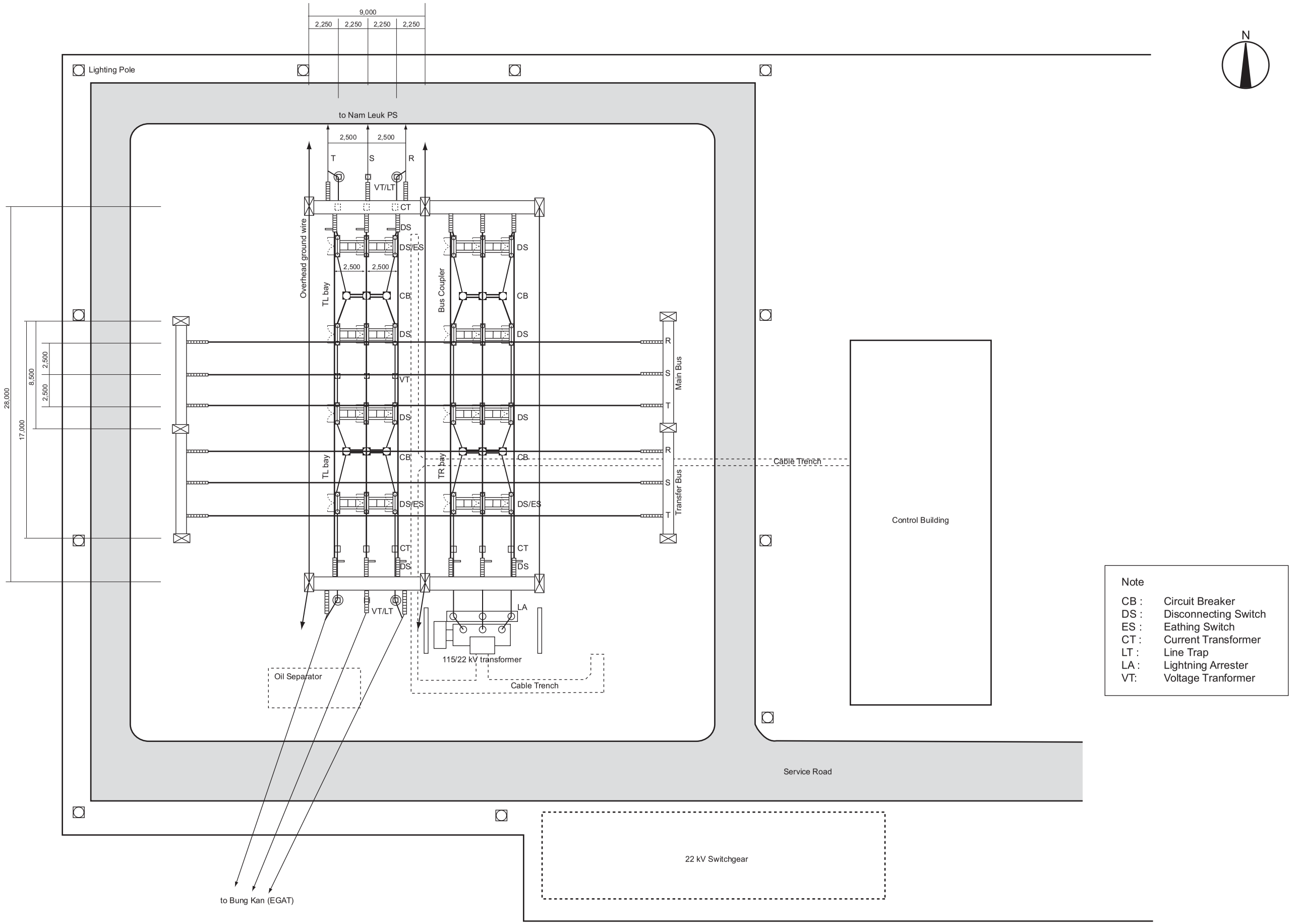
Spare parts, tools and measuring devices for O&M of each substation should be procured and stored by each substation and the EDL's branch office in each Province, which controls the substation. Accordingly, items and quantities to be procured will be decided in the detail design stage.

Costs for procurement of spare parts, tools and measuring devices will be estimated 5 % of the total cost of substation facilities of each substation.



as of July, 2002

Electricite du Laos	Japan International Cooperation Agency (JICA) Joint Venture Nippon Koei Co., Ltd. & Tokyo Electric Power Company	The Study on Master Plan of Transmission Line and Substation System	**Figure No.** 3.3-1 **Title** Pakxan Substation Single Line Diagram (as of July 2002)

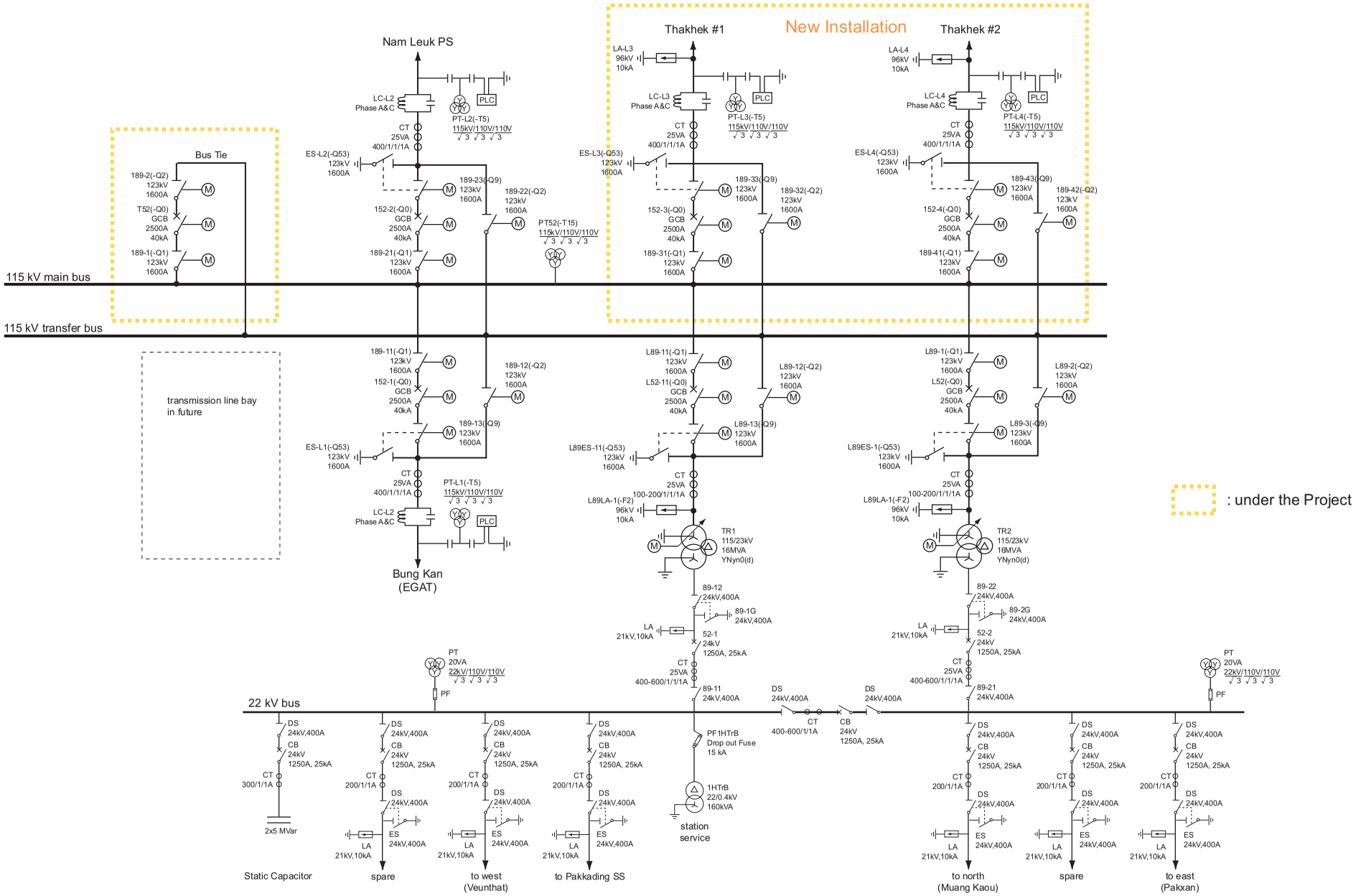


Note

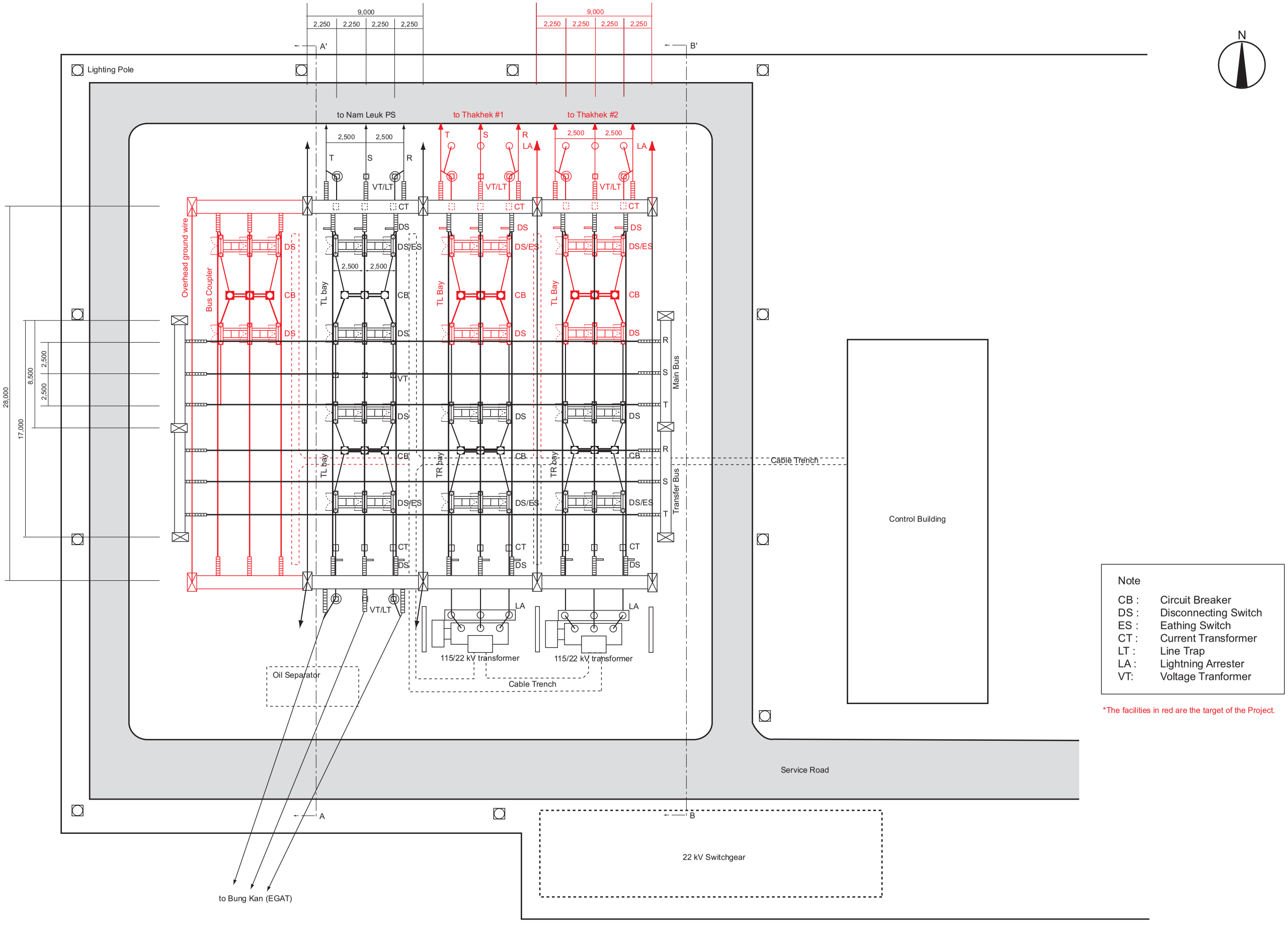
CB :	Circuit Breaker
DS :	Disconnecting Switch
ES :	Eathing Switch
CT :	Current Transformer
LT :	Line Trap
LA :	Lightning Arrester
VT:	Voltage Tranformer

* not to scale

Electricite du Laos	Japan International Cooperation Agency (JICA) Joint Venture Nippon Koei Co., Ltd. & Tokyo Electric Power Company	The Study on Master Plan of Transmission Line and Substation System	**Figure No.** 3.3-2 **Title** Pakxan Substation Existing 115 kV Switchyard Layout (as of July 2002)



Electricite du Laos	Japan International Cooperation Agency (JICA) Joint Venture Nippon Koei Co., Ltd. & Tokyo Electric Power Company	The Study on Master Plan of Transmission Line and Substation System	Figure No. 3.3-3 Title: Pakxan Substation Single Line Diagram (after the Project)



Note

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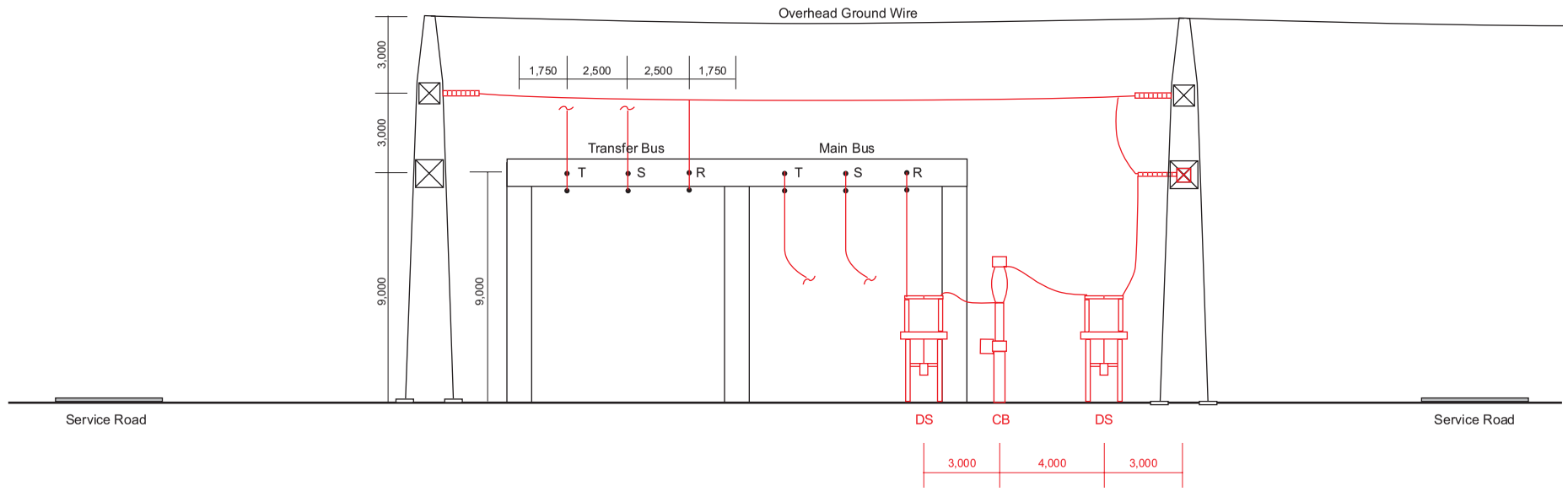
LA :	Lightning Arrester
VT:	Voltage Tranformer

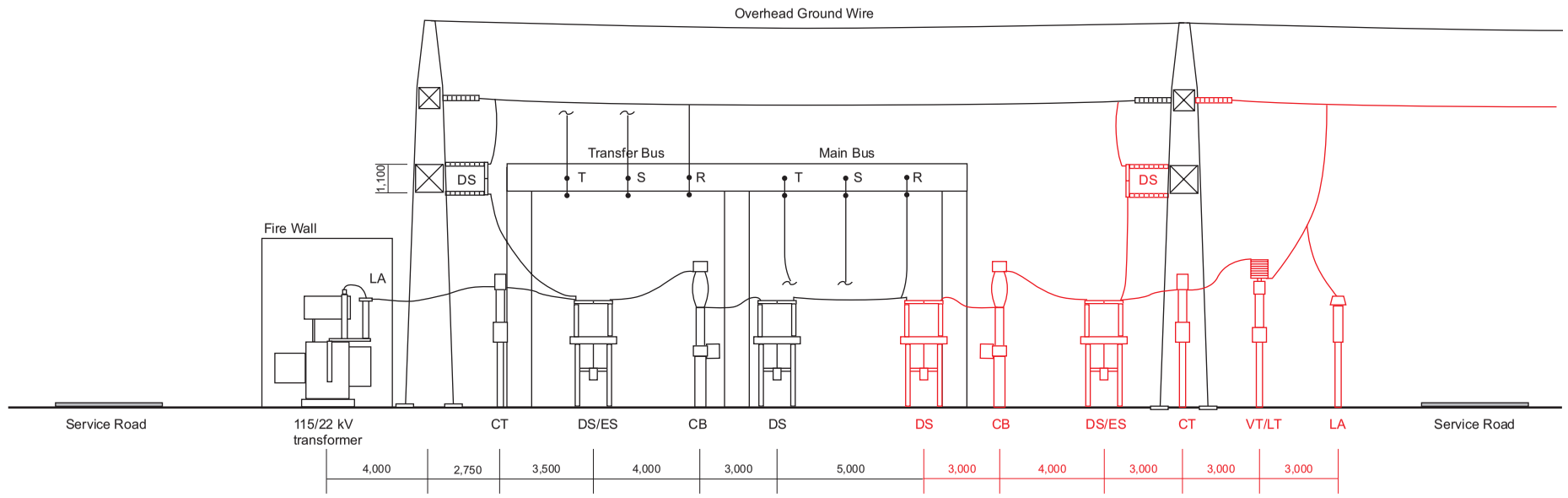
*The facilities in red are the target of the Project.

* not to scale

Electricite du Laos	Japan International Cooperation Agency (JICA) Joint Venture Nippon Koei Co., Ltd. & Tokyo Electric Power Company	The Study on Master Plan of Transmission Line and Substation System	**Figure No.** 3.3-4 (1) **Title** Pakxan Substation 115 kV Switchyard Layout Plan



Section A - A'



Section B - B'

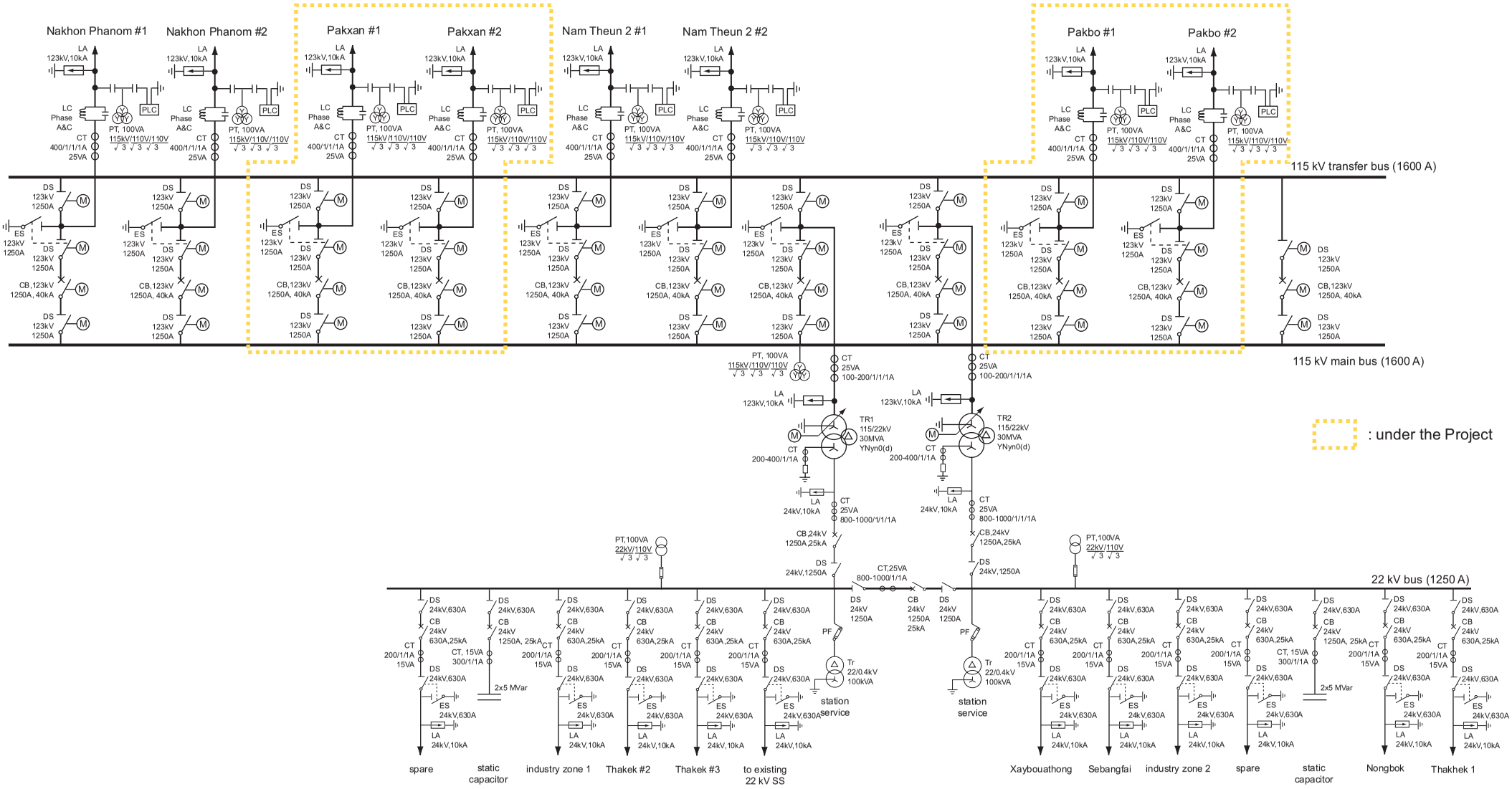
Note

CB :	Circuit Breaker
DS :	Disconnecting Switch
ES :	Eathing Switch
CT :	Current Transformer
LT :	Line Trap
LA :	Lightning Arrester
VT:	Voltage Tranformer

*The facilities in red are the target of the Project.

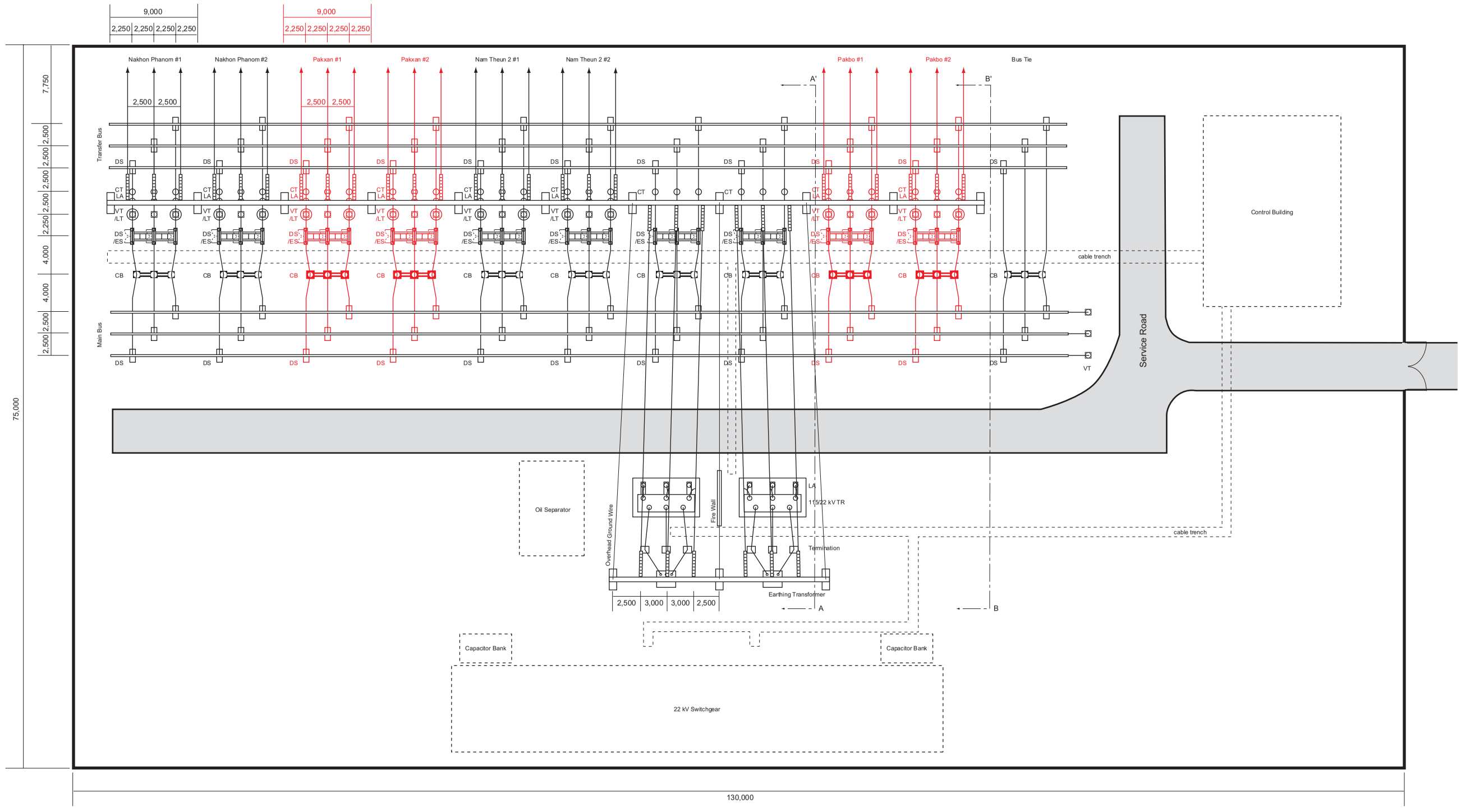
* not to scale

Electricite du Laos	Japan International Cooperation Agency (JICA) Joint Venture Nippon Koei Co., Ltd. & Tokyo Electric Power Company	The Study on Master Plan of Transmission Line and Substation System	**Figure No.** 3.3-4 (2) **Title** Pakxan Substation 115 kV Switchyard Layout Plan (Side View)



as of June 22, 2001

Electricite du Laos	Japan International Cooperation Agency (JICA) Joint Venture Nippon Koei Co., Ltd. & Tokyo Electric Power Company	The Study on Master Plan of Transmission Line and Substation System	Figure No. 3.4-1 Title Thakhek Substation Single Line Diagram



Note

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LT :	Line Trap
LA :	Lightning Arrester
VT:	Voltage Tranformer

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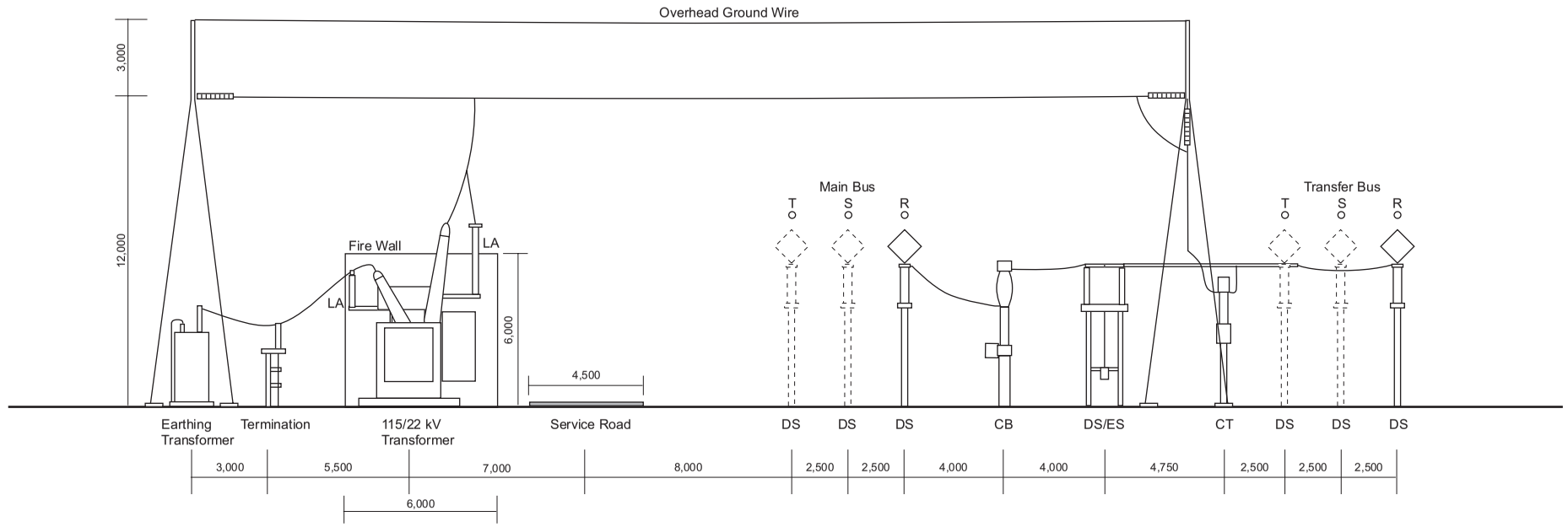
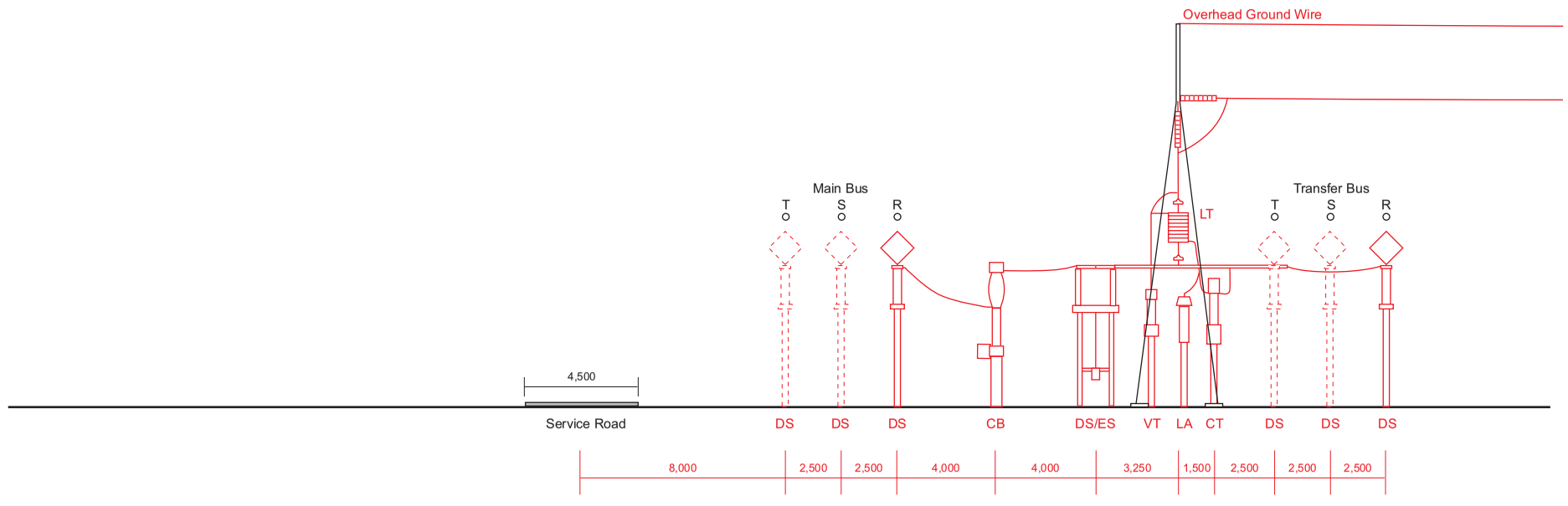
* not to scale

Electricite du Laos	Japan International Cooperation Agency (JICA) Joint Venture Nippon Koei Co., Ltd. & Tokyo Electric Power Company	The Study on Master Plan of Transmission Line and Substation System	Figure No. 3.4-2 (1) Title Thakhek Substation 115 kV Switchyard Layout Plan



Section A - A'



Section B - B'

Note

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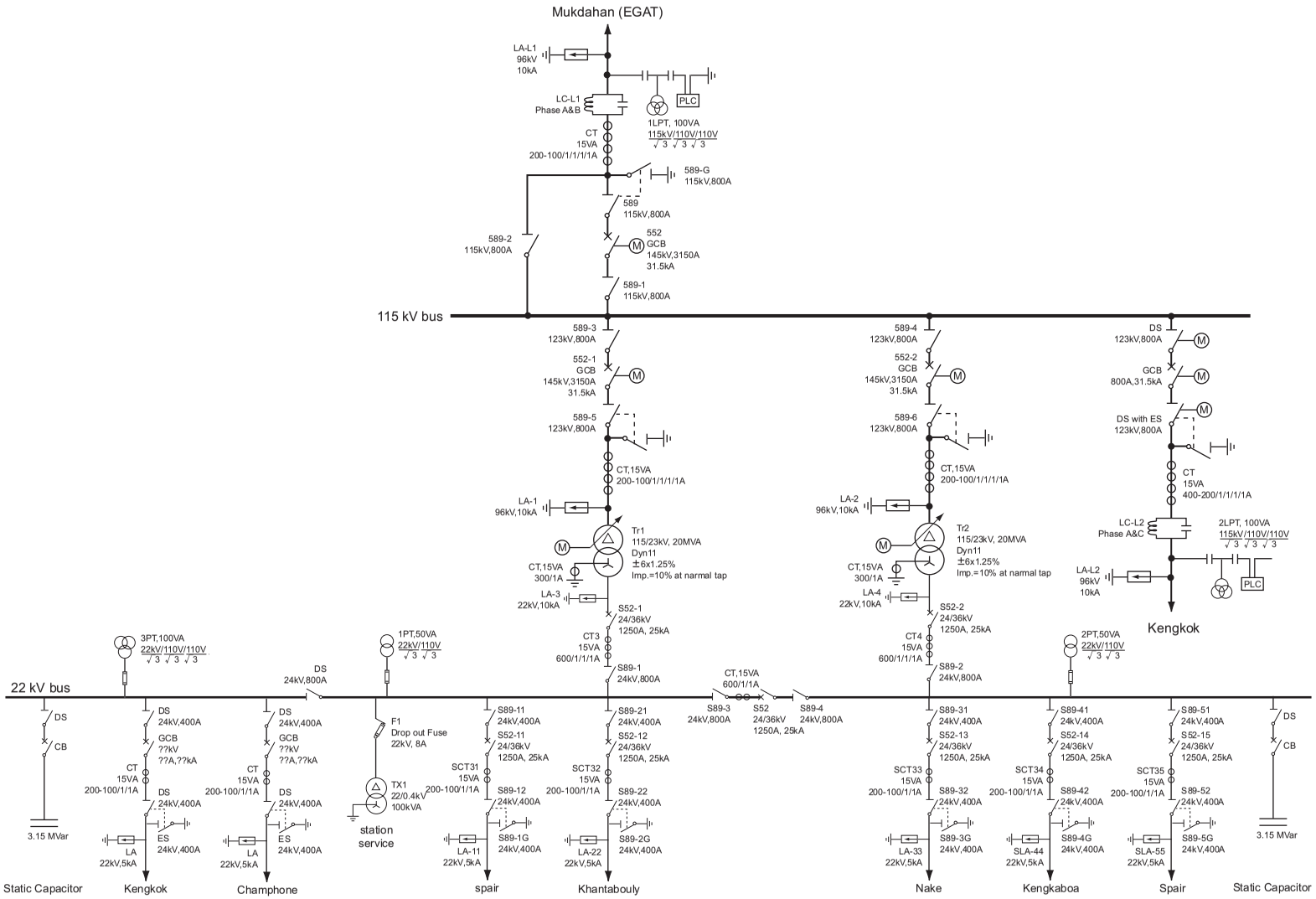
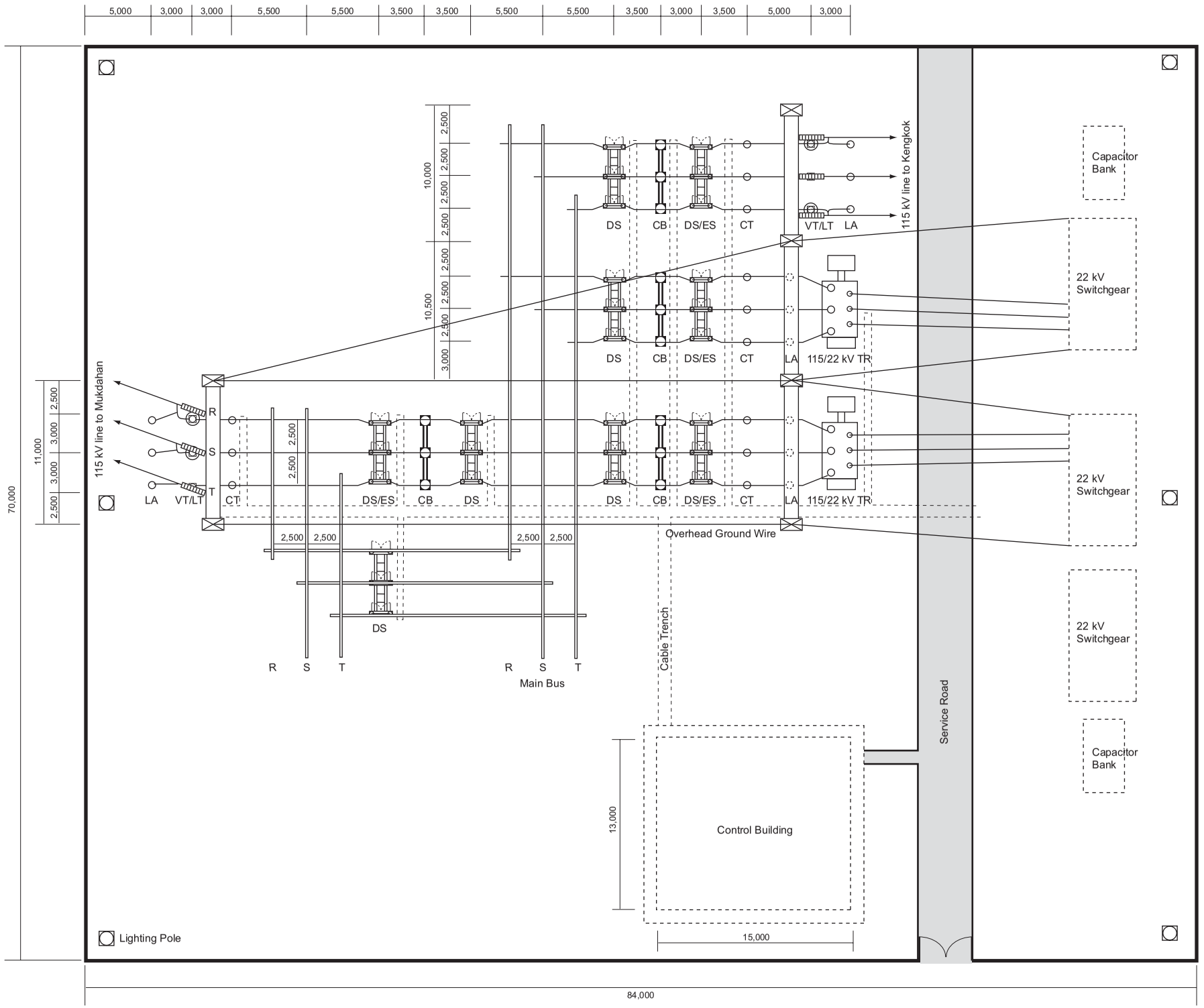
*The facilities in red are the target of the Project.

* not to scale

Electricite du Laos	Japan International Cooperation Agency (JICA) Joint Venture Nippon Koei Co., Ltd. & Tokyo Electric Power Company	The Study on Master Plan of Transmission Line and Substation System	**Figure No.** 3.4-2 (2) **Title** Thakhek Substation 115 kV Switchyard Layout Plan (Side View)



Electricite du Laos	Japan International Cooperation Agency (JICA) Joint Venture Nippon Koei Co., Ltd. & Tokyo Electric Power Company	The Study on Master Plan of Transmission Line and Substation System	Figure No. 3.5-1 Title: Pakbo Substation Single Line Diagram (after the SPRE project)



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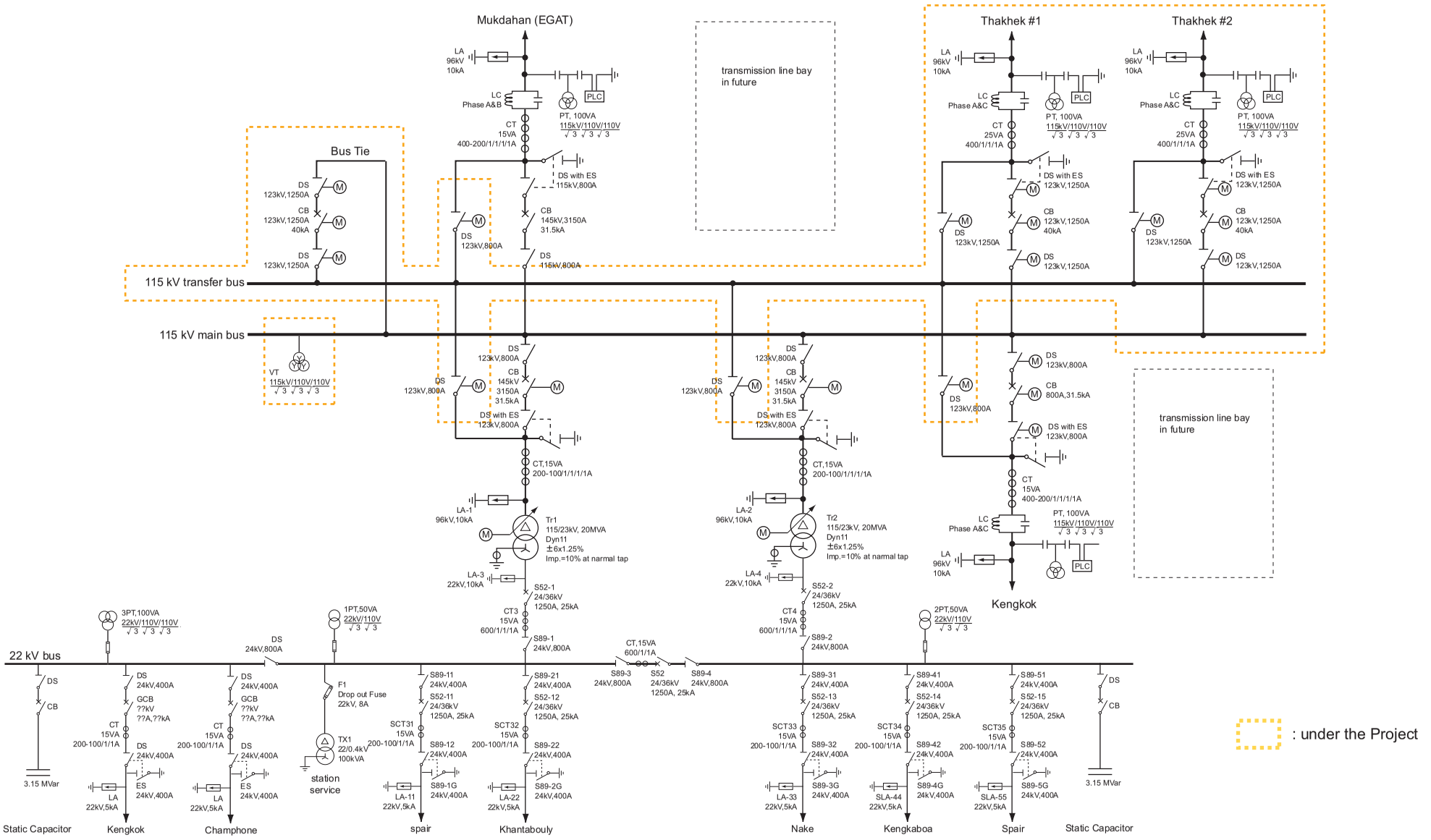
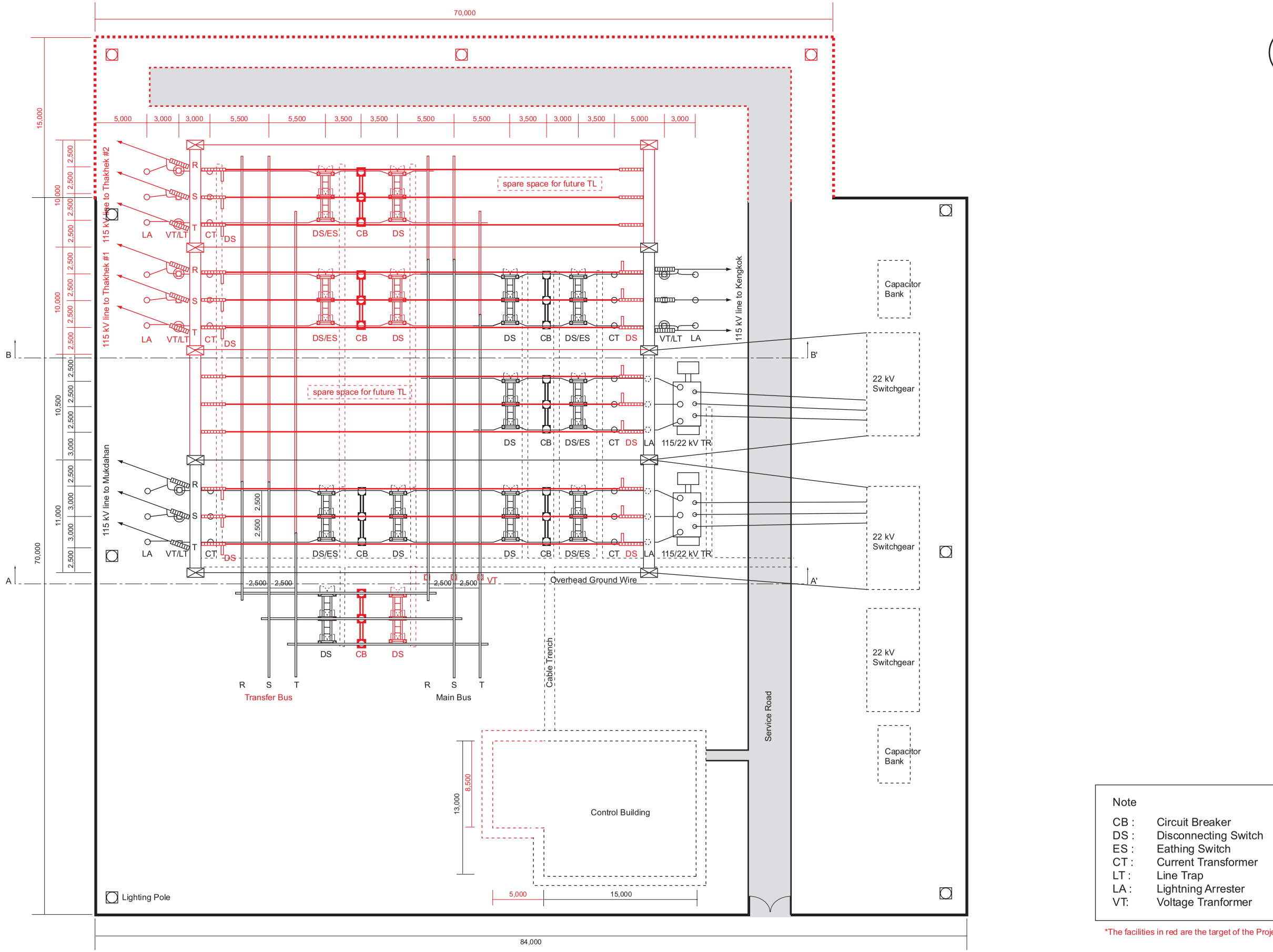
VT:	Voltage Tranformer

* not to scale

Electricite du Laos	Japan International Cooperation Agency (JICA) Joint Venture Nippon Koei Co., Ltd. & Tokyo Electric Power Company	The Study on Master Plan of Transmission Line and Substation System	**Figure No.** 3.5-2 **Title** Pakbo Substation 115 kV Switchyard Layout (after the SPRE project)



Electricite du Laos	Japan International Cooperation Agency (JICA) Joint Venture Nippon Koei Co., Ltd. & Tokyo Electric Power Company	The Study on Master Plan of Transmission Line and Substation System	Figure No. 3.5-3 Title: Pakbo Substation Single Line Diagram (after the Project)



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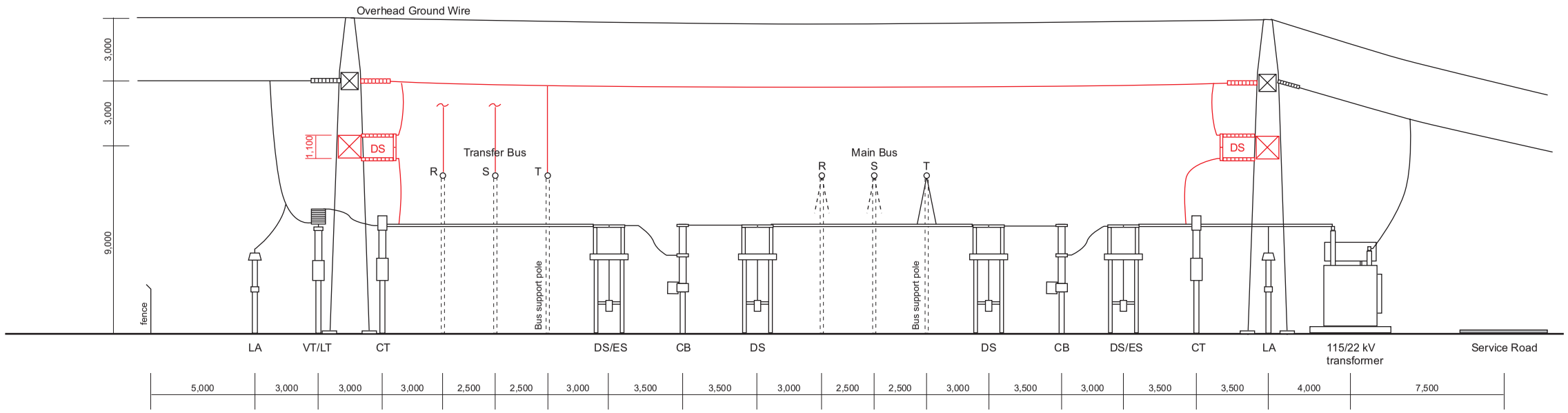
Note

CB :	Circuit Breaker
DS :	Disconnecting Switch
ES :	Eathing Switch
CT :	Current Transformer
LT :	Line Trap
LA :	Lightning Arrester
VT:	Voltage Tranformer

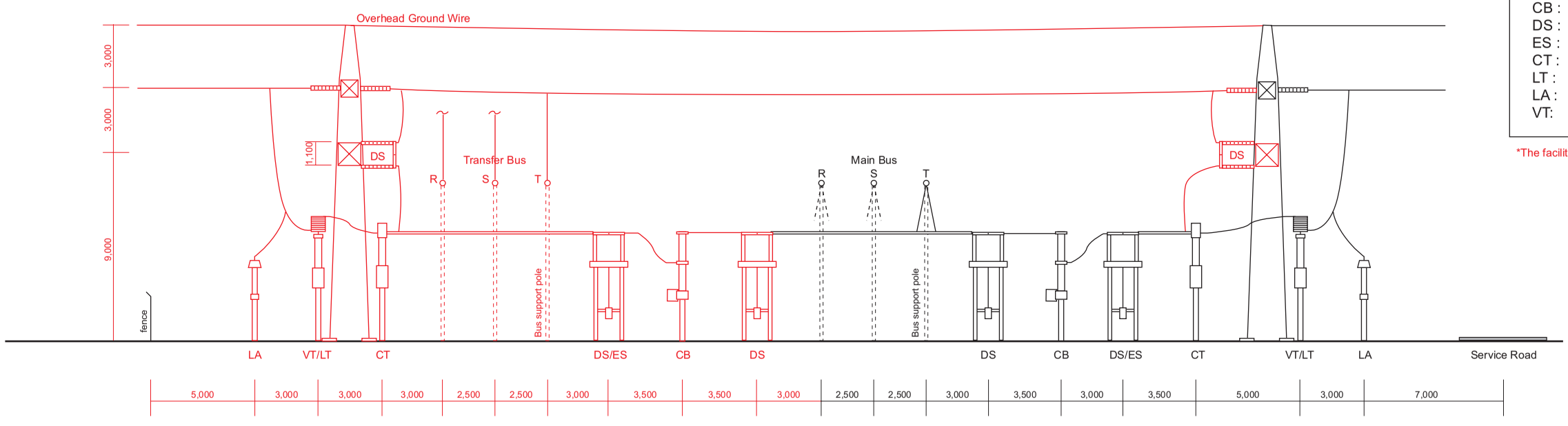
*The facilities in red are the target of the Project.

* not to scale

Electricite du Laos	Japan International Cooperation Agency (JICA) Joint Venture Nippon Koei Co., Ltd. & Tokyo Electric Power Company	The Study on Master Plan of Transmission Line and Substation System	Figure No. 3.5-4 (1) Title Pakbo Substation 115 kV Switchyard Layout Plan



Section A - A'



Section B - B'

Note

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* not to scale

Electricite du Laos	Japan International Cooperation Agency (JICA) Joint Venture Nippon Koei Co., Ltd. & Tokyo Electric Power Company	The Study on Master Plan of Transmission Line and Substation System	**Figure No.** 3.5-4 (2) **Title** Pakbo Substation 115 kV Switchyard Layout Plan (Side View)

CHAPTER IV

IMPLEMENTATION PLAN

Chapter 4 Implementation Plan

As outlined in Clause 1.3 of Part II, the detailed design including field survey for the Project will be required for realizing the Project. This Chapter discusses the specific implementation plan for the Project.

4.1 Implementation Policy

4.1.1 Overall Policy

Subsection 1.3 "Basic Plan" of Part II states preparatory works to accelerate the Project; acquisition of the environment certificate for the Project from STEA, arrangement of fund for the Project, employment of a project consultants, etc. A draft organization for implementation of the Project is as below:

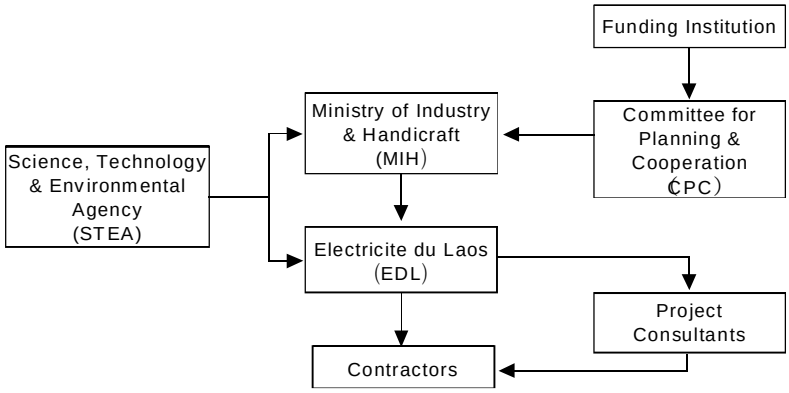


Figure 4.1-1 Organization for the Project Implementation

Following are the envisioned undertakings allotted to the implementation agency (EDL) and consultants, after implementation of the Project is assured to start.

(1) Implementation Agency of Lao PDR

The agency for the Project of Lao PDR will be EDL under supervision of the MIH. In particular, the project office organized under Development Division of EDL will be responsible for the Project implementation. The project office manages now implementation of PTD project funded by ADB and SPRE project funded by IDA. The office will organize a new team for the Project in assuring its implementation. The office has well experience in managing the similar projects.

EDL will be responsible for the following in implementation of the Project.

(a) Organizing a new Project Implementation Unit for the Project,
(b) Coordination among the related ministries and provincial authorities for smooth implementation of the Project,
(c) Acquisition of right to enter into the Project areas and acquisition of land/compensation of houses in right-of-way of the transmission line,
(d) Prior securing of the environmental certificate for the Project from STEA,
(e) Appointment of the Project consultants, and cooperation with /assistance to them,
(f) Close communication with institution(s) of the Project fund on bidding, contracts, procurement, project progress, and other various information,
(g) Proper actions for necessary procedures on facility import for the Project,
(h) Issue of payment certificates for the consultants and contractors,
(i) Claim management of contractors, local people, and others,
(j) Prosecution of the commissioning test of the Project,
(k) Education and training of employees for operation and maintenance for transmission line and substations,
(l) Proper and operation and maintenance of the facilities after commissioned, and
(m) Removal of UXO if required.

EDL should secure budget and staffs to execute the above duties.

(2) Project Consultants

The consultants will be responsible for the following particulars.

(a) Detailed design of the Project including field survey and investigation of transmission line route,
(b) Preparation and submission to EDL of the Design report of the Project,
(c) Preparation and submission to EDL of bid documents for the Project,
(d) Evaluation of proposals forwarded by bidders and assistance to EDL evaluation committee in selection of the prospective bidders for the contracts,
(e) Assistance to EDL in the contract negotiation with the prospective bidders and in conclusion of the contracts,
(f) Examination on manufacturing/working drawings and various communications from the contractors for approval,
(g) Inspections and tests for equipment and materials to be carried out in the contractors' factories prior to shipment,
(h) Project management and supervision of the contractors' field works,
(i) Preparation of O & M manuals of the completed facilities and the completion report,

(j) Inspections on the facilities immediately before expiration of the guarantee period for the facilities,

(k) Transfer of knowledge to EDL staffs in charge of the Project.

(3) Contractors

The Project will be executed in the full-turn-key contracts. The contractors should be fully responsible for the following works strictly complying with all terms in the contract documents.

(a) Manufacturing design of equipment and materials required for completion of the Project,

(b) Manufacturing and tests of the equipment and materials,

(c) Packaging and transportation to the site of the equipment and materials,

(d) Survey for UXO remanence before excavation work for steel tower foundation,

(e) All civil/building works and installation of the equipment and materials,

(f) Verification of proper functions of all the facilities completed,

(g) Commissioning of the facilities to EDL,

(h) Transfer of knowledge to EDL through their working period for construction, maintenance and operation of the project facilities.

4.1.2 Procurement of Facilities

(1) Mode of Procurement

The Project comprises of two components: transmission line and substation. Although it depends on the source of the project fund, the Project will be in principle executed under separate contracts of transmission line and substation, and the contractors will be selected through ICB (International Competitive Bidding) mode for full-turn-key basis.

(2) Origin for Procurement

Origin of the facilities for the Project will not be limited in principle, because of ICB-base procurement. However, the contractors for each contract lot should be carefully selected taking into account their qualifications for quality control of goods, production capacities, experience in similar projects, remedial claims of their previous contracts, financial status of the contractor and their major subcontractors, and others. Bid documents prepared by the consultants will specify bidder's qualification and its evaluation criteria.

There is no manufacturer of materials and equipment available required for the Project at present in the country. Some consulting firms have just started their business for the study on local situations. Joint ventures with foreign firms for the construction sector are also established, but no remarkable

business except for investigation of UXO has been developed so far. Accordingly, participation of Lao enterprises to the Project deems to be limited to supply of labors, building expansion, normal civil works, and supply of concrete materials. All major equipment and materials should be imported.

(3) Guarantee Period of Facilities

It will be specified in the contract documents that the contractors should guarantee all functions of the facilities provided under the Project for the certain period after commissioning. Besides, it is recommended that the contractors will train on the job site EDL's operators and maintenance staffs during the construction period and a certain period after commencement of operation of the substations. A special term will be included in the contract documents as one of the contractor's duty.

4.2 Particular Conditions

(1) Management System of EDL for the Project

The Project will be executed in parallel with construction of other similar projects of IDA, ADB and others. As number of staffs of the EDL's project office is limited, less experienced staffs might be assigned for management and supervision of the Project. The project consultants should advise the dispatched staffs on their jobs by giving technical and managerial details of the works taking every opportunity.

(2) Safety of Construction Works

Substation works under the Project are planned for extension of the existing substations. As most of field works will be carried out under live condition or tentative de-energized condition of the existing facilities in the substations, the contractors for the Project should carefully and always work taking into account full attention to workers' accidents, damages to the existing facilities, unscheduled system supply interruptions, etc. Transmission line works over 300 km areas will have such various kinds of operation as on high towers, in deep foundation excavated pits, with special stringing tools, or frequent travelling on highways/small village roads, etc. There are many opportunities of fatal accidents and damages to public facilities. It is observed that local workers use to take less care for such construction works without any safety tools for protecting themselves. For preventing unexpected accidents, a term for the safe works should be specified in the contract documents.

(3) UXO

It is reported that there will be less remanence of UXO along the transmission line route selected for the Project. However, a careful investigation for the UXO is needed at the areas where its remanence is mentioned in the UXO map prior to the field works. In case that remanence is confirmed by the investigation, it should be immediately notified to related authorities, people and project workers, and entrance into the area should be prohibited until completion of clearance and confirmation of safety. Also in case that UXO would be found during works, the same step should be taken.

(4) Procurement and Transportation of Equipment and Materials

Most of equipment and materials as well as measuring instrument, heavy machinery and tools for construction use for the Project will be imported though Thailand. EDL should do prior arrangement for the import of those goods for smooth work progress of the Project, and also arrange for re-export of the instrument, machinery, and tools after completion of the works.

(5) Prevention of Disturbance to Environment during Construction

About 20 % of the selected transmission line route is to pass through paddy field and cultivated land. Those lands may be subject to trampling disturbance by transportation of materials and workers during the construction period. The contractors will be ordered to limit their access routes to the working sites, to restore disturbed lands, and to compensate crops, which should be specified in the contract documents. Some towers will be erected on the slopes of hill. Land cutting for tower foundations may cause collapse of surrounding lands. Such places should be firmly protected by provision of stone or concrete walls. It is planned that the transmission line will cross over the national route 13 at 7 points along the whole line section and over many provincial and village roads and paths. Such preventive measures to accidents as provision of scaffoldings or arrangement of watchmen during conductor stringing operation should be taken for protecting passengers, cattle, or vehicle from accidents. All those measures to prevent disturbances to environment and society should be specified in the contract documents to be responsibility of the contractors.

4.3 Scope of Works

Equipment/materials for the Project and construction works at site will be procured in the ICB full turn-key base. EDL will be responsible for special particulars required for the project execution. Following table shows major works allotted for the contractors and EDL. EDL should arrange its staffs and budget to execute the allotted works.

Table 4.3-1 Scope of Works

	Contractors	EDL
Procurement of Goods	- Design and manufacture of goods - Factory tests of goods - Packing for export & transportation - Storage of goods at site	- Examination on drawings & documents from contractors - Pre-arrangement for customs clearance of imported goods - Issue of payment certificates
Construction	- Civil & building works for the Project - UXO survey - Overall construction of line facilities - Overall construction of substations - Commissioning test	- Securing of land for the Project - Acquisition of right for tree clearing - UXO clearance, if any - De-energizing schedule - Dispatch of inspectors - Issue of payment certificate - Acceptance of completion

4.4 Plan of Supervision

Procurement, management and supervision of the Project after the contracts between EDL and the contractors would have been concluded will be performed by the following staffs from EDL and the project consultants.

(1) EDL Staffs

(a) Project manager in the EDL's project office is to be assigned throughout whole project period. (He will be also a counterpart of the project consultants.)

(b) Staffs of the EDL's environment office for monitoring the environmental measures taken by the contractors, are to be timely dispatched to the sites. Persons from the related province and/or district may also monitor the situation.

(c) Transmission line inspectors including persons from EDL branch offices: at least 1 civil work inspectors throughout the contractors' civil works, at least 2 inspectors for tower erection and stringing operation, for each working section of the contractors. Those inspectors should be responsible not only for supervision of the contractors' work but also for communication and negotiation with local authorities on the matters for which EDL has responsibility. Depending on number of the contractors' working groups, EDL will need many inspectors for the Project. As the number of working groups will be defined in the contract negotiation, EDL may arrange inspectors at the time.

(d) The contractor may simultaneously execute works of 3 substations. EDL's inspectors will be lined up with 1 person for civil/building works and 1 person for electrical works per each substation. Participants of OJT people for O & M of each substation under the Project are separate from the inspectors.

(e) In addition to the above-mentioned inspection team and trainees, procurement committee, project implementation unit, management committee, and bid evaluation working group will be organized as a standard rule of EDL for the project implementation and perform each duty for the Project. As demanded, EDL sections concerned the customs of imported goods, payment procedures, communications with other authorities will execute their duties for the Project

(2) Consultants

(a) Detailed Design and Preparation of Bidding Documents

The consultants will execute the detailed design, cost estimate and detailed implementation plan for the Project through discussions with EDL and in accordance with results of the field survey and investigation. Design report prepared by the consultants will cover whole results of the design. After approval of the report by the funding institutions or in parallel with the report preparation, the consultants will produce bidding documents for the Project. A team leader, transmission line engineer, substation engineer, and survey engineer from the consultants will work in this stage. In a short-term, experts for environment, PLC system and cost estimate experts will also join the works.

(b) Public Bid and Contract

The consultants will carry out assistance to EDL in public announcement of the bid, bid opening, bid evaluation, contract negotiation and preparation of the contract documents. A team leader, transmission lines engineer and substation engineer will be in charge of the works.

(c) Procurement Management

The consultants will manage all works for examinations on the contractors' drawings and designs, and inspection/tests of equipment/materials at the contractors' factory. A team leader, transmission lines engineer and substation engineer will be in charge of the works.

(d) Supervision of Contractors' Field Works

Through the whole period of the Contractors' field works, the consultants will supervise all the field works. The consultants will have responsibility for education of EDL's operators and maintenance people for the facilities after completion of the Project. A team leader, 2 transmission line engineers, and 1 substation engineer (one more engineer to be added, in case) will be resident at site through the contractors' field works. A communication engineer may be assigned for a short term.

(e) Commissioning Test and Inspection for Defect Liability Period

After completion of construction of all facilities, the consultants will supervise the

contractors' commissioning tests of individual facilities for transmission line and substations, and also the system operation test combining both transmission line and substation. Further, the consultants will prepare the project completion report and O & M manuals of the completed facilities, and assist EDL in procedure for issuing the taking-over certificates to the contractors. Immediately before the expiration of the defect liability period of the Project facilities, the consultants with EDL will inspect all the facilities under the Project for issuing the final certificates to the contractors.

4.5 Quality Control Plan

(1) Quality Control of Equipment and Materials to be supplied

(a) Design and Manufacturing Drawings

The consultants will examine design, manufacturing drawings, and quality control manuals to be submitted for approval by the contractors in accordance with the contract documents, for confirming quality of the proposed equipment and materials. If needed, the consultants will not approve the proposals of the contractors and order to re-design to fully comply with the contract specifications.

(b) Inspection and Tests of Equipment and Materials

Major equipment and materials manufactured for the Project will be inspected and tested at the contractors' factories prior to shipment to the Project site for assuring their qualities. EDL staffs will witness to those factory inspections and tests.

(2) Quality Control during Field Construction

(a) Construction Drawings

The consultants will order the contractors to submit the construction drawings, construction schedules, and plan for quality control of the works for the consultants' approval, and manage quality control of the works done by the contractors.

(b) Tests of Materials

The consultants will order the contractors to test samples of concrete and re-bars to be used for foundations and buildings at a reputed local laboratory. The contract documents will specify duty of the contractors to carry out compression tests on concrete pieces sampled by the consultants from mixing batches.

(c) Control of Field Works

During the construction period of transmission line works (foundations, tower erection and

stringing operation) and substation works (land expansion, foundations, expansion works of substation building and installation of equipment), the consultants and EDL inspectors will care damages on equipment and materials, and order to repair or replacement of the damaged equipment and materials if found. Prior to issue of payment certificates to the contractors, the consultants and EDL inspectors will inspect not only progress but also quality of all facilities claimed by the contractors in their application for the payment.

(d) Commissioning Tests

The consultants and EDL will finally confirm the quality of the facilities by the comprehensive commissioning inspection and tests to be carried out before the taking-over of the facilities.

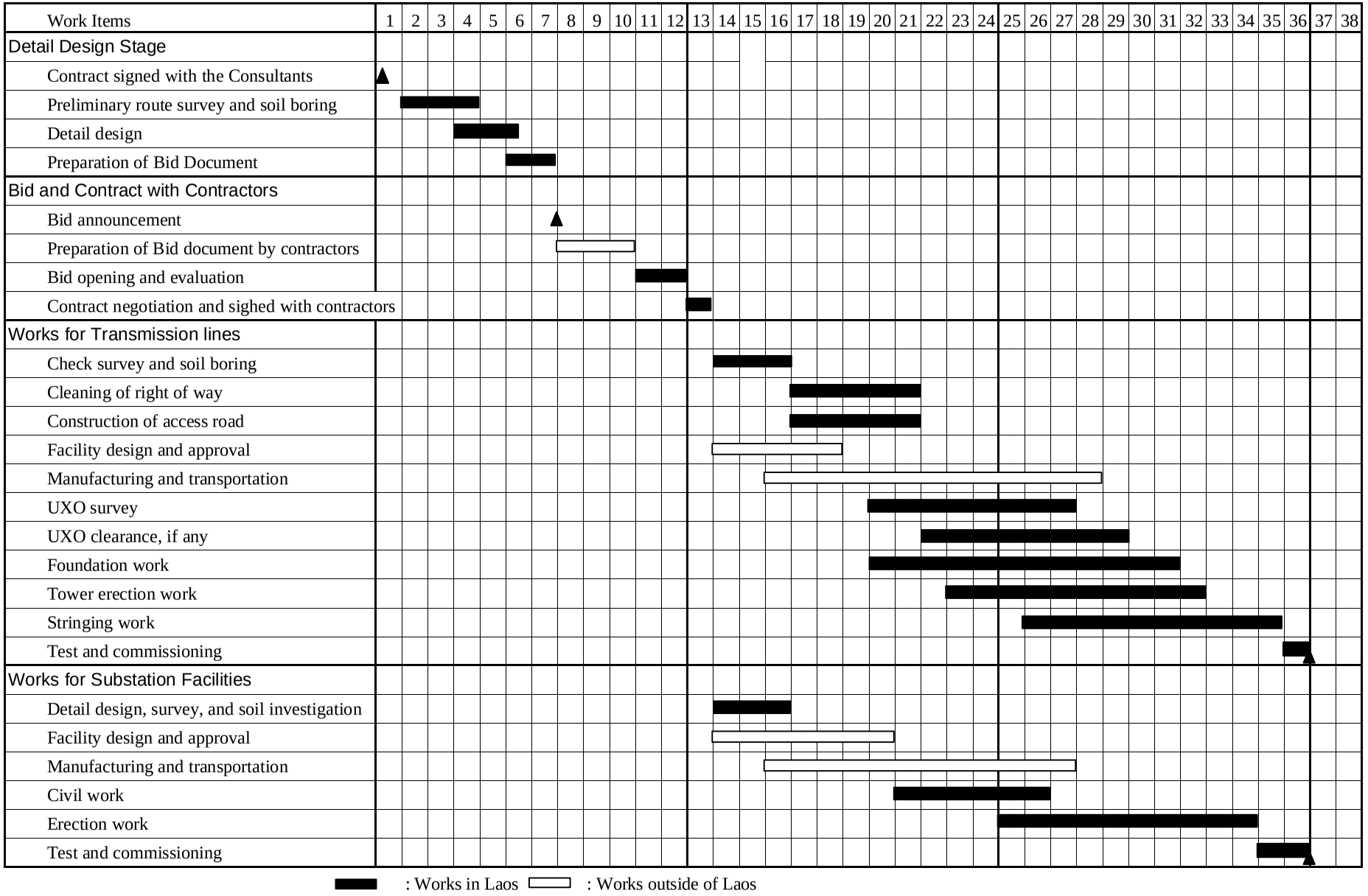
4.6 Implementation Schedule

Figure 4.6-1 shows the overall implementation time schedule of the Project.

The period from appointment of the project consultants to the conclusion of the turn-key contracts for both transmission line and substations is assumed to be 13 months. The period from the conclusion of the contracts to the taking-over of the facilities is assumed to be 23 months making total implementation period to be 36 months after appointment of the project consultants.

Prior to commencement of excavation work for tower foundations, investigation of UXO remanence and clearance of UXO if found should be performed for the safety. The investigation for UXO will be conducted for the sections only for possible remanence as noted in clause 6.1.2 hereinafter but not for the whole line route. If found in the section, all the works in the area will be postponed until complete clearance of the UXO. The remanence of UXO should affect the overall implementation schedule of the Project.

Figure 4.6-1 Implementation Schedule



CHAPTER V

PROJECT OPERATION PLAN

Chapter 5 Project Operation Plan

Chapter 4 states the implementation plan of this Project. This chapter discusses and recommends the operation plan after the Project completion.

5.1 Organization

5.1.1 Present Organization

At present, EDL's 115 kV transmission lines and substations are operated in the following 3 areas only;

(a) Nam Ngum 1/Nam Leuk system in provinces of Vientiane, Bolikhamxai, and Luang Prabang and Vientiane municipality,
(b) Pakbo import system in Savannakhet province, and
(c) Xeset 1 system in Champasak province.

Section 3.2 of Part I stated the present (as of June 2002) EDL organization and general functions assigned for each division. The distribution division of head office manages and controls the operation and maintenance of 115 kV substations as well as MV and LV distribution networks in the country but excluding 115 kV transmission line facilities. Technical Service Department (TSD) in the Distribution Division of EDL Head Office manages and controls all the works for operation and maintenance works of all branch offices except 115 kV transmission lines. EDL Branch Offices carry out actual operation and maintenance works of all 115 kV facilities together with MV and LV networks in their territory.

The TSD consisting of 43 persons as of July 2002 receives all daily information for operation and maintenance of facilities from all branch offices and gives necessary instructions to the offices. Power Line Carrier (PLC) and public telephone facilities are used for daily and emergent communication among TSD and branch offices. Besides, official reports from branch offices and instructions from TSD made through telephone facilities are confirmed in writing. TSD is to dispatch 2～3 persons of its staffs to a branch office for supervising major repairing works of substation and distribution facilities when judged to be necessary.

In the Nam Ngum 1/Nam Leuk power system, for an example, 115 kV substations and switchyard listed in Table 5.1-1 are operated as of June 2002. EDL branch offices of 4 provinces and 1 municipality are responsible for the routine operation and maintenance of those facilities.

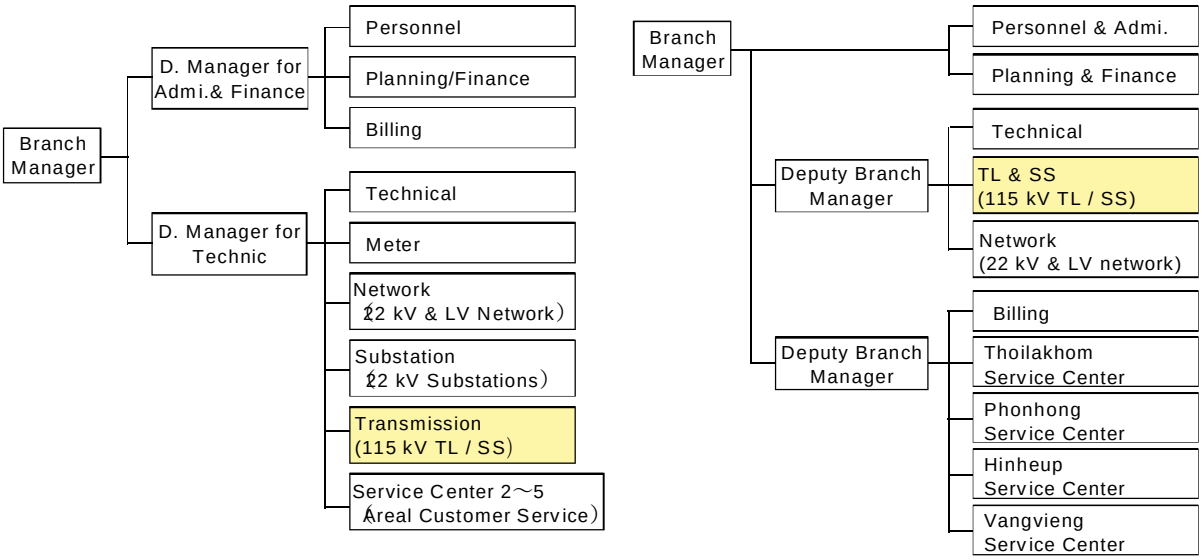
Table 5.1-1 115 kV Substation and Switching Station in Nam Ngum 1/Nam Leuk System

Stations	Location	Branch office in charge
Thalat SwS	Vientiane province	Vientiane province
Vangvieng SS	Vientiane province	Vientiane province
Luang Prabang SS	Luang Prabang province	Luang Prabang province
Phonesoung SS	Vientiane province	Vientiane province
Tha Ngon SS	Vientiane municipality	Vientiane municipality
Phonetong SS	Vientiane municipality	Vientiane municipality
Thanaleng SS	Vientiane municipality	Vientiane municipality
Pakxan SS	Bolikhamxai province	Bolikhamxai province

After commissioning of the new substations being constructed under the ADB rural electrification project and under Nam Mang 3 hydropower project in this area, Oudomxai and Xieng Khuang provinces will have new 115 kV system s However, EDL has currently no branch office in the latter province.

While, responsible territory for maintenance of the existing 115 kV transmission lines is extended to the boundary of the provinces where the line runs. Transmission line maintenance group of each branch office has its full responsibility for the facilities existing in its territory.

Figure 5.1-1 shows organizations of branch offices of Vientiane municipality and Vientiane province for examples. Both branch offices organize a particular section for maintenance work of transmission lines; Transmission Line section of Vientiane municipality and Transmission and Substation section of Vientiane province. Other branch offices have also a similar section in their organizations.



(a) Vientiane Municipality Branch Office (b) Vientiane Province Branch Office

Figure 5.1-1 Organizations of Branch Offices

The Phonetong substation, the largest substation in the country with 3 units of 30 MVA transformer (115/22 kV), organizes 3 shifts operation system (4 operation groups) consisting of 3 operators per shift. Other substations organize also 3 shifts operation system, but number of operators per shift differs from the Phonetong substation depending on its scale. Each substation reports its daily works for operation and maintenance to TSD. Comparatively important repairing works are carried out under supervision of TSD staffs. EDL's repair shop in Vientiane repairs MV distribution transformers only at the present. Repair of other equipment is executed by each branch office or substation under supervisors from TSD.

Total length of the existing 115 kV transmission line operated in Vientiane municipality is 225 cct-km which are maintained through patrol, inspection and repair by 15 persons of the branch office. The maintenance program of transmission lines is planned so that the same section and same facility should be inspected at a minimum rate of twice per year. In thick tree and grass areas, the inspection is in particular carried out before and after rainy season for prevention of grounding faults of the lines due to touch of tree, bamboo, or grass to energized parts of the lines. Clearing of those trees, bamboos, and grasses are carried out by local people sublet by the EDL branch office. All other branch offices have the similar maintenance program and practice.

Spare parts for substations and transmission lines are stored in substations or branch offices. Quantity of spare parts stocked for transmission lines, insulators in particular, is arranged for use for a period of 6 months from the past experience. While, items and quantities of spare parts for substations are based on those recommended by the consultant in charge of the substation and EDL's experience for consumption. Supplement of the parts are made in such a way that branch office proposes items and quantities to TSD, TSD forwards the list to GM, and the GM approves the procurement.

EDL does not find any serious issues to the present organization and procedures for operation and maintenance of transmission lines and substations in the current system and also the future system after the progressing ADB and IDA projects.

5.1.2 Reinforcement of Operation and Maintenance of 115 kV Systems

There seems no serious issues in the current EDL's operation and maintenance system of 115 kV transmission lines and substations except a heavy duty to TSD, as far as the works are carried out strictly following the EDL's operation and maintenance manuals and the present scale of power system.

Three (3) power regions out of 4 regions of the country are to be interconnected when the Project would have been completed. The interconnected system should be more systematically, stably, and

economically operated and maintained. The government has an idea for establishing the Lao National Grid Company (LNGC) as stated in Sub-section 3.11 of Part I. The LNGC is basically planned for operation of 500 kV and energy exporting systems, but the company might also cover domestic power systems. The plan has not been embodied, but operation of the domestic transmission systems might be drastically altered, if the LNGC would be established.

While, for stable and economical operation of the national power system including power stations, transmission lines, substations, and distribution networks, as well as power export and import, Load Dispatching Center (LDC) is indispensable in the near future regardless of establishment of the LNGC. Transmission and substation facilities in the country will be operated in accordance with instructions of the LDC. Study on the LDC for the country should be commenced at the earliest time.

Reinforcement of O & M plan for 115 kV systems was examined on the assumption that the LNGC and LDC will not be realized before the project would be commissioned.

Before this Project, the running rural electrification projects of ADB in the northern and Central 1 regions (PTD) and of IDA in the Central 1 and Central 2 regions (SPRE) will be commissioned. The 115 kV power systems and MV/LV networks in the country will be broadly extended. Before the year 2005, new seven (7) 115 kV substations (Oudomxai, Xieng Nguen, Phonsavan, Ban Don, Non Hai, Lakxaosi, and Thakhek) and 115 kV transmission line over 1,100 cct-km are scheduled to be commissioned. In addition, development of a huge number of MV and LV distribution networks are in progress. Total quantities of 115 kV substations and transmission lines after the commission of those projects will increase to about double the existing facilities of 10 substations and 1,100 cct-km lines which are currently operated in the country.

Before commissioning of the current rural electrification projects, following measures will be required for stable and sustainable operation of the facilities to be completed for the Project.

(a) Duty of EDL Head Office for 115 kV Transmission Lines

At present each branch office manages the operation and maintenance of 115 kV transmission line facilities in its territory, independently. No department or section in the head office is concerned in operation of the HV transmission lines. Under such a system, efficient, qualified, and stable operation of the expanding transmission network will be not expected. Before completion of LDC, a particular unit in the head office should have duty to manage and control the operation of HV transmission lines by branch offices. The unit will analyze all information from branch offices for comprehending situations of the interconnected transmission line, advise the preventive measures to line faults, plan an efficient use and procurement of spare parts, and program overall maintenance works and re-education of maintenance crew. TSD in charge of

HV substations will be competent for the unit.

(b) Reinforcement of Distribution Division

TSD, one of the busiest departments of EDL, shall have more works in proportion to commission of new facilities now in progress, unless EDL will reorganize the current operating rules. Reinforcement of TSD is necessary. It is recommended that EDL shall train recruits to this department from now onwards for managing the increasing facilities.

(c) Education to Persons for O & M of 115 kV Transmission Lines and Substations

Additional manpower in almost same number as the current manpower for O & M works of HV transmission lines and substations will be required by the year 2005. Basic education of technology to those recruits will be given in the EDL training center in Vientiane at first. Then, they will be further trained for actual operation and maintenance works of transmission lines and substations in the existing HV facilities. EDL shall initiate such education and training to those recruits from now onwards.

(d) OJT of EDL's Staffs during Project Implementation

In addition to the education stated above, the manpower completed the course in the training center will participate to construction works of transmission lines and substations if such opportunity is available. Through the OJT (On the Job Training), they will further understand functions, characteristics, and components of various equipment, inspection/test methods, and others. In the contracts for the Project, a special term shall be provided for the OJT of EDL persons by the contractors and for instructions of operation and maintenance of the facilities for a certain period at the initial operation stage of the new facilities by the consultants and contractors.

(e) Procurement of Measuring Instrument, Spare Parts and Tools

The measuring instruments and tools for use of operation and maintenance are common for equipment from different manufacturers. Procurement of those instrument and tools will be made taking into account common use of plural substations for saving the project cost. While, spare parts for the substation equipment are different among manufacturers even under the same technical specifications. Procurement of spare parts for the substation equipment shall be determined through discussions of EDL and the consultants concerned.

(f) Standardization of Recording Format of Operation Data

For simplification of EDL's work process and database preparation of operation and maintenance of substations by computers, the recording format for operation of substations shall be standardized. Computerized format of the Theun Hinboun power station may be referred to.

The database will be easily and quickly standardized and processed by EDL's computer office. Standard format is recommended also for efficient analysis of statistics of system operation.

(g) Enrichment of EDL's Repair Shop

The shop works mainly for repair of distribution transformers at the present. Its works should extend to repair various substation and distribution equipment utilizing its experience. For activating the shop, the medium-term procurement of machine tool and meters will be necessary. Preventive mend of equipment in coordination with substation maintenance groups will reduce faults of equipment and prolong the life of equipment.

(h) Development of Communications among Power Systems

PLC (Power Line Carrier) telephone facility is provided on all the existing 115 kV transmission lines and 22 kV lines in Vientiane City. The facility is necessary for the future transmission lines, too, for operation of SCADA (supervisory control data acquisition) and quick communication of reporting, instructions, fault treatment, and others among branch offices, substations, power stations and the head office. Development of the communication system will be utilized for operation of the future LDC. Facilities should be developed under a common design policy of equipment in various projects for easy interconnection among the different systems.

(i) Substation Maintenance Group

Staffs dispatched from TSD perform the present maintenance of substations. In line with development of HV power system, multiple 115 kV substations will be operated in territory of a branch office. The present system will not be adequate for the future substation maintenance. It should be examined such a system that a substation maintenance group will be organized in a power region (Northern, Central 1, Central 2 and Southern), who will be responsible for all substations in its region. TSD will give the group its advice and detailed instructions for preventive works for faults and specific measures for restoration of faults. Quicker restoration of faults is anticipated.

(j) Aggressive Utilization of EDL's Training Center

As stated in Sub-section 3.9 of Part-I, the center provides modern educational facilities and lecturers educated in France for all fields of the power system. Training of manpower for new 115 kV transmission lines and substations should be commenced as early as possible in this center. In addition to the standard curriculum of the center, it is recommended to provide a program for EDL's standard O & M manuals for HV transmission lines and substations lectured by staffs of TSD. Besides, re-education to the present O & M staffs of branch offices is also necessary for letting them recognize anew importance of O & M works and of strict compliance

to the instructions ruled in the manuals. It is also strongly recommended that the trainees may have a special course for studying the Laotian Electric Power Technical Standard established by JICA STEP team for understanding the bases of planning and design of the facilities.

5.2 O & M Manuals and Education

EDL provides the standard O & M manuals (Lao version) for 115 kV transmission lines and substations. The manuals have been revised as needed referring to experience in faults occurred and measures taken for restoration of the faults. The revised manuals are explained in detail to staffs of each substation, transmission line group, and branch office. The present O & M manuals are prepared on the bases of the manuals submitted by the related consultants and suppliers to the projects. Both contracts of the consultants and contractors for the Project should also include a term for duty of submission of the O & M manuals.

The present EDL's standard manuals seem adequate. However, in implementing the Project, review of the standard manuals is recommended taking into account the O & M organization and particular circumstances around the Project, referring to the following draft contents of the manuals.

Maintenance Manual for Transmission Lines

(a) Organization and duty/responsibility of maintenance group
(b) Job classification of maintenance (daily, emergent and particular patrols and inspections) and their objectives
(c) Detailed work items and objectives in the line patrol and frequency of the patrol
(d) Job classification of line inspections (initial, periodical, particular and special inspections) and their objectives
(e) Detailed work items of the line inspections and frequency of the inspections
(f) Measures for faults and restoration of faults
(g) Safety measures and special attentions for the works

Maintenance Manual for Substations

(a) Organization and duty/responsibility of maintenance group
(b) Details of routine operational works and records
(c) Special attentions for daily operation
(d) Job classification of maintenance (daily, periodical and special patrols) and their objectives
(e) Detailed work items and objectives in the patrol and frequency of the patrol
(f) Job classification of line inspections (initial, periodical, detailed and special inspections) and their objectives

(g) Detailed work items, methods and frequency of the inspections to each equipment

(h) Measures for faults and restoration of faults

(i) Safety measures and special attentions for the works

Samples for O & M manuals for transmission lines and substations are compiled in Annexes.

Generally, O & M manuals for a completed substation are to be prepared and submitted to EDL by the related consultants and contractor before commissioning of the substation. Manuals submitted by the contractor should cover technical specifications, characteristics, composition of components, dismantling and inspection procedures, adequate frequencies of parts replacement, etc. of all equipment installed in the substation in detail. The contract for the Project should also include contractor's duty for execution of OJT to EDL's operators during installation of equipment, tests of various facilities and initial operation of the substation under the supervision of the contractor. Manuals prepared by the consultants should be comprehensive by covering proper attentions to O & M works of the substation taking into account compliance between the EDL's standard manuals and the contractor's manuals.

Participation to the project construction sites of EDL' employees who are anticipated to be operators and maintenance crew of the facilities after commissioning of the Project is an effective training program. Another program for training of operation and maintenance of substations is that experts of the suppliers will jointly operate and maintain the substation for a certain period at the initial stage of operation.

Three days power interruption due to a fault on the 115 kV line in Vangvieng - Luang Prabang section as stated in Sub-section 9.2.2 of Part I was deemed to be an artificial fertilization. If the maintenance works to the line would have been executed as ruled in the manuals, the fault was not occurred. The most important duty for operation and maintenance of the facilities is strictly to follow all articles stipulated in the manuals. This depends on awareness of employees in charge and also on daily education to employees by responsible staffs of EDL. From the point, the EDL's management and the related consultants should pay a special attention to raise the employees' moral by emphasizing importance of operation and maintenance works. Further, effort of the management should be done to employees to habituate themselves to make quick and accurate report of their works.

CHAPTER VI

ESTIMATE OF THE PROJECT COSTS

Chapter 6 Estimate of the Project Costs

In this Chapter, the total costs for the Project were estimated on the basis of the ICB prices as of the year 2001.

6.1 Land and UXO

The bases of cost for lands and right of way (ROW) and for UXO survey and clearance of the transmission lines are discussed in this section to estimate the Project costs.

6.1.1 Compensation for Lands and Right of Way (ROW)

At present, EDL acts itself all negotiations for land procurement and resettlement required for the construction of transmission lines and substations in Laos PDR.

According to the information of EDL, there are no EDL's standards for compensation of land and ROW at present. EDL has taken the individual ways of land negotiation and compensation in each project. A standard procedure is, however, now under preparation. In case of the transmission line project of Nam Leuk PS - Pakxan SS, EDL compensated landowner of paddy field occupied by towers for the 5 years rice harvests from the occupied area. EDL also compensated growers and house-owners for cutting their valuable trees and resettlement from the ROW through individual negotiations with them. The compensation costs varied case-by-case, accordingly. The cost for paddy field compensation per tower paid under the above mentioned project was around US$ 20.

As the Project is considered to be extension of the Nam Leuk PS - Pakxan SS line, compensation costs for the Project were estimated in the similar way. Since 150 towers will be constructed in paddy fields over the whole sections of transmission lines under the Project, compensation costs for the harvest are roughly estimated at US$ 3,000. The total amount of compensation costs for the Project is thus assumed to be US$ 10,000 including compensation cost for trees and resettlement.

6.1.2 Costs for UXO Investigation and Clearance

Since a large quantity of UXO still remains in the country as shown in UXO map (refer to Figure 6.2-2 of Part I), investigation and clearance works of UXO will be necessary prior to the construction works. Under the ongoing PTD project (ADB), the locally organized consultant for UXO employed by the contractor carried out UXO investigation and clearing works at each tower site (16 m x 16

m=256 m^2 per tower). The cost for UXO investigation and clearance for the Project is estimated at the same manner, accordingly.

(1) Particular areas for UXO Investigation and Clearance

According to the UXO map, UXO scarcely remains on the some areas of the selected transmission line route for the Project. The areas where the map suggests the remanence of UXO are the following sections (see Figure 6.1-1).

(a) Pakxan SS～Thakhek SS section
Nam Kading River ～ Naliang Village: about 35 km (100 towers)

(b) Thakhek SS～Pakbo SS section
Thakhek SS ～ Xe Bang Fai River: about 44 km (126 towers)

It was assumed that UXO investigation and clearing works would be carried out at those tower sites (256 m^2／tower) constructed in the above areas prior to their excavation work for tower foundations.

(2) Costs for UXO Investigation and Clearance

The unit price of "US$ 500/ha in Light remnant UXO area" is applied with reference to the PTD project and information given by a firm in Vientiane for UXO investigation and clearance.

The cost of UXO investigation and clearance for the Project (226 towers in the UXO areas noted above) was roughly estimated at US$ 3,000 as below:

(Investigated range: 256 m^2 / tower)×(Numbers of investigated tower: 226)×(US$ 500/ha)
US$3,000

6.2. Construction Cost of Transmission Lines

The construction cost of transmission lines for the Project was estimated under the following assumptions.

(a) The construction cost of transmission lines for the Project would be estimated in such a way as the standard unit prices of equipment and civil & erection works multiplied by those quantities calculated in Section 2.2 of Part II. The standard unit prices have been prepared referring to the recent contract prices of such international competitive bidding projects as "PTD Project (ADB & NDF)" and "SPRE Project (IDA)". Various ICB price data owned by the Team has also been referred.

(b) The costs were estimated in foreign currency (US$) portion (FC) and local currency (US$ conversion) portion (LC)[1] based on Table 6.2-1 below.

Table 6.2-1 Share of FC and LC for each Work Item

	Work item	FC share	LC share
Equipment	Tower, Conductor, GW, Insulator sets, Accessories, Spare Parts, Tools, etc.	100%	0%
Civil & Erection Works	Route survey, design, clearing of ROW, access road construction	30%	70%
	Foundation work	50%	50%
	Tower erection and stringing work	40%	60%
	Earthing work	30%	70%
	Inland transportation	0%	100%

Table 6.2-2 shows the construction cost of transmission lines for the Project. Tables 6.2-3～6.2-4 show the details of the estimate.

Table 6.2-2 Construction Cost of Transmission Lines

Sections	Items	FC (US$)	LC (US$)	Total (US$)
Pakxan SS～Thakhek SS (194.6 km)	Plant & Equipment	8,233,500	0	8,233,500
	Civil & Erection	1,594,900	2,617,200	4,212,100
	Sub-total	9,828,400	2,617,200	12,445,600 ($63,955/km)
Thakhek SS ～ Pakbo SS (105.2 km)	Plant & Equipment	4,359,200	0	4,359,200
	Civil & Erection	817,600	1,370,300	2,187,900
	Sub-total	5,176,800	1,370,300	6,547,100 ($62,235/km)
Total (299.8 km)	Plant & Equipment	12,592,700	0	12,592,700
	Civil & Erection	2,412,500	3,987,500	6,400,000
	Total	15,005,200	3,987,500	18,992,700 ($62,351/km)

Construction cost in the above table was estimated on the bases of results of Team's site investigation for the Pakxan-Thakhek-Pakbo section during June 2002 and the design of towers and their foundations discussed in Chapter 2 of Part II.

The site investigation revealed the detailed information and facts for actual conditions for solid soil, flat terrain, less tree clearing in the right-of-way, easy transportation of materials to working sites,

[1] Term "FC" used in this report means expenditures spent abroad for procurement, ocean freight and insurance of the imported equipment and materials of the facilities and other general works for the local installation of the facilities including a part of survey and clearance of UXO. Term "LC" means all expenditures spent in the Lao PDR including costs for expatriate persons, procurement of local products, labours, inland transportation, insurance, hiring of heavy equipment, installation of facilities, a part of survey and clearance of UXO, compensation of lands, houses and vegetation and others. "LC" does not always mean the amount contributed by the Government of Lao PDR.

easy provision of access roads, almost non-UXO remnant, etc. along the selected transmission line route. The facility design resulted in economical towers and working volumes of their foundations. Further, breakdown of the recent ICB contracts for 115 kV transmission lines in Lao PDR was obtained.

Thus, the unit rate of construction cost for the highest priority project along Route 13 resulted in approximately 35 % lower than the average construction cost in Table 7.5-1 of Part I for the transmission lines planned in various terrains over the country for the optimum system.

6.3 Construction Cost of Substation Facilities

Construction costs of substation facilities for the Project are estimated based on the design for substations described in Chapter 3 of Part II.

(1) Standard Unit Prices

The standard unit prices have been decided referring to the recent contract prices of such international competitive bidding projects as for the PTD and SPRE project. Various ICB prices data owned by the Team have also been referred.

(2) Estimate Conditions

Estimate conditions for the substation facilities were as follows;

(a) All substation equipment will be procured from abroad, and the prices would be estimated in US dollars for CIF price.
(b) Costs for procurement of spare parts and tools would be estimated at 5 % of total equipment cost for each substation.
(c) The costs of civil and erection works would be estimated in foreign currency (US$) portion (FC), and local currency (US$ conversion) portion (LC).
(d) Land acquisition for the construction of substations for the Project would not be necessary except Pakbo SS. Since the land for expansion of Pakbo SS is owned by EDL, the cost for land acquisition would not be included in the construction costs for substation facilities.
(e) The costs for survey and clearance of UXO would not be included in the costs.
(f) Costs for such work items done by a contractor as facility design, documentation, training etc. would be estimated as miscellaneous costs. The costs would be estimated at 10 % of the total costs for equipment and civil & erection works for each substation.

(3) Construction Costs of Substation facilities

Table 6.3-1 summarizes the construction costs of substation facilities for the Project. Table 6.3-2 shows the details.

Table 6.3-1 Construction Cost of Substation Facilities

Substations	Items	FC (US$)	LC (US$)	Total (US$)
Pakxan SS	Plant & Equipment	619,400	0	619,400
	Civil & Erection	24,100	87,900	112,000
	Miscellaneous Costs	73,100	0	73,100
	Sub-total	716,600	87,900	804,500
Thakhek SS	Plant & Equipment	1,173,300	0	1,173,300
	Civil & Erection	48,200	170,500	218,700
	Miscellaneous Costs	139,200	0	139,200
	Sub-total	1,360,700	170,500	1,531,200
Pakbo SS	Plant & Equipment	1,093,300	0	1,093,300
	Civil & Erection	44,100	164,200	208,300
	Miscellaneous Costs	130,200	0	130,200
	Sub-total	1,267,600	164,200	1,431,800
	Total	3,344,900	422,600	3,767,500

6.4 Total Project Costs

The conditions for the estimate of the total Project costs were as follows;

(a) Compensation cost for lands and ROW and cost for UXO investigation and clearance were included in FC and LC portions of the total costs as described in Section 6.1 in this chapter.

(b) Consultant service fee was included in FC portion and estimated at 8 % of total construction cost of transmission lines and substations including the field topographical survey of the transmission lines and substations.

(c) Physical contingencies for both FC and LC portions were estimated at 10 % of each portion of total construction costs.

(d) Price contingencies for FC and LC portions were respectively estimated at 3%/year[2] of FC portion and 8%/year[3] of LC portion of total construction cost.

2 Inflation rate in foreign currency portion is estimated at 3% as same figure to have been applied by WB. (SPRE project Aide Memoire of the Midterm Review Mission, WB, dated April 25, 2002)

3 Estimated from the past record of inflation in Lao PDR (Bank of Lao PDR)

Table 6.4-1 shows the total costs for the Project.

Table 6.4-1 Total Project Costs

Items	FC (US$)	LC (US$)	Total (US$)
Transmission Lines	15,005,200	3,987,500	18,992,700
Substation Facilities	3,344,900	422,600	3,767,500
Sub-total	18,350,100	4,410,100	22,760,200
Lands & ROW Compensation	0	10,000	10,000
UXO Survey & Clearance	2,000	1,000	3,000
Consultant Fee	1,820,800	0	1,820,800
Physical Contingency	1,835,000	441,000	2,276,000
Price Contingency	550,500	352,800	903,300
Ground Total	22,558,400	5,214,900	27,773,300

6.5 Disbursement Schedule of the Costs

The Project will be carried out in 36 months as shown in Table 4.6-1 of Part II. Conditions for preparing the disbursement schedule of the investment for the Project were assumed as follows;

(a) The construction costs for transmission line and substation facilities for the Project would be disbursed in second and third years equally, after conclusion of the contracts with contractors.
(b) Compensation cost for lands and ROW would be disbursed in the first year.
(c) UXO investigation and clearance would be carried out before excavation work of foundations for steel towers, and its cost would be equally disbursed in the second and third years.
(d) The consultant fee would be disbursed equally over three years.
(e) Both physical and price contingencies would be disbursed equally in the second and third years.

Table 6.5-1 shows the disbursement schedule for the Project costs for three years.

Table 6.5-1 Disbursement Schedule

Months	Items	FC (US$)	LC (US$)	Total (US$)
1～12 Months	Transmission Lines	0	0	0
	Substation Facilities	0	0	0
(Design Stage)	Lands & ROW Compensation	0	10,000	10,000
	UXO Survey & Clearance	0	0	0
	Consultant Fee	607,000	0	607,000
	Physical Contingency	0	0	0
	Price Contingency	0	0	0
	Sub-total	607,000	10,000	617,000
13～24 Months	Transmission Lines	7,502,600	1,993,750	9,496,350
	Substation Facilities	1,672,450	211,300	1,883,750
(Construction	Lands & ROW Compensation	0	0	0
Stage)	UXO Survey & Clearance	1,000	500	1,500
	Consultant Fee	606,900	0	606,900
	Physical Contingency	917,500	220,500	1,138,000
	Price Contingency	275,250	176,400	451,650
	Sub-total	10,975,700	2,602,450	13,578,150
25～36 Months	Transmission Lines	7,502,600	1,993,750	9,496,350
	Substation Facilities	1,672,450	211,300	1,883,750
(Construction	Lands & ROW Compensation	0	0	0
Stage)	UXO Survey & Clearance	1,000	500	1,500
	Consultant Fee	606,900	0	606,900
	Physical Contingency	917,500	220,500	1,138,000
	Price Contingency	275,250	176,400	451,650
	Sub-total	10,975,700	2,602,450	13,578,150
	Ground Total	22,558,400	5,214,900	27,773,300

Table 6.2-3 Total Construction Cost of Transmission Lines for the Project

Item		Paxan - Thakhek					Thakhek - Pakbo					Total			
	Unit Wt[t]	No. of Tower	Tot. Wt[t]	FC [USD] 1,100	LC [USD]	Total [USD]	No. of Tower	Tot. Wt[t]	FC [USD] 1,100	LC [USD]	Total [USD]	Qty	FC [USD]	LC [USD]	Total [USD]
Towers															
A1: Suspention Type 1	5.0	490	2,450.0	2,695,000		2,695,000	275	1,375.0	1,512,500		1,512,500	3,825.0	4,207,500		4,207,500
A2: Suspension Type 2	6.2	10	62.0	68,200		68,200	0	0.0	0		0	62.0	68,200		68,200
B1: Tension 0-15	6.2	21	130.2	143,220		143,220	8	49.6	54,560		54,560	179.8	197,780		197,780
C1: Tension 0-30	7.0	16	112.0	123,200		123,200	8	56.0	61,600		61,600	168.0	184,800		184,800
D1: Tension 0-90 Type 1	9.2	15	138.0	151,800		151,800	7	64.4	70,840		70,840	202.4	222,640		222,640
D2: Tension 0-90 Type 2	11.0	2	22.0	24,200		24,200	0	0.0	0		0	22.0	24,200		24,200
DE: Dead End	9.4	4	37.6	41,360		41,360	2	18.8	20,680		20,680	56.4	62,040		62,040
Ga: Gantry	1.5	4	6.0	6,600		6,600	0	0.0	0		0	6.0	6,600		6,600
Total Tower		562	2,957.8	3,253,580		3,253,580	300	1,563.8	1,720,180		1,720,180	4,521.6	4,973,760		4,973,760
	[Unit]	Qty	Unit Price	FC [USD]	LC [USD]	Total [USD]	Qty	Unit Price	FC [USD]	LC [USD]	Total [USD]				
Conductors	[km]	1,226.0	2,600	3,187,600		3,187,600	662.8	2,600	1,723,280		1,723,280	1,888.8	4,910,880		4,910,880
Ground Wires	[km]	204.3	600	122,580		122,580	110.5	600	66,300		66,300	314.8	188,880		188,880
Insulators															
Sus. Strings	[Units]	30,840	18	555,120		555,120	16,620	18	299,160		299,160	47,460	854,280		854,280
Ten Strings	[Units]	7,680	18	138,240		138,240	3,000	18	54,000		54,000	10,680	192,240		192,240
Jumper Supporting (for Ga)	[Units]	240	18	4,320		4,320	0	18	0		0	240	4,320		4,320
Total Insulators		38,760		697,680		697,680	19,620		353,160		353,160	58,380	1,050,840		1,050,840
Strings Conductor															
Single Suspension	[Units]	2,916	50	145,800		145,800	1,638	50	81,900		81,900	4,554	227,700		227,700
Double Suspension	[Units]	84	75	6,300		6,300	12	75	900		900	96	7,200		7,200
Single Tension	[Units]	672	100	67,200		67,200	300	100	30,000		30,000	972	97,200		97,200
Double Tension	[Units]	48	100	4,800		4,800	0	100	0		0	48	4,800		4,800
V Structure (for Ga)	[Units]	12	150	1,800		1,800	0	150	0		0	12	1,800		1,800
Total Strings Conductor		3,732		225,900		225,900	1,950		112,800		112,800	5,682	332,100		338,700
Fittings															
Dampers Conductor	[Units]	6,720	20	134,400		134,400	3,600	20	72,000		72,000	10,320	206,400		206,400
Dampers GW	[Units]	1,120	10	11,200		11,200	600	10	6,000		6,000	1,720	17,200		17,200
Compresure Joints Conductor	[Units]	817	20	16,347		16,347	442	20	8,837		8,837	1,259	25,184		25,184
Compresure Joints GW	[Units]	68	10	681		681	37	10	368		368	105	1,049		1,049
GW Suspension Fittings	{Units]	500	25	12,500		12,500	275	25	6,875		6,875	775	19,375		19,375
GW Tension Fittings	[Units]	62	50	3,100		3,100	25	50	1,250		1,250	87	4,350		4,350
Total Fittings				178,228		178,228			95,331		95,331		273,558		273,558
Tower Earthing	[Units]	562	100	56,200		56,200	302	100	30,200		30,200	864	86,400		86,400
Tower Tests	[Units]	5	20,000	100,000		100,000	2	20,000	40,000		40,000		140,000		140,000
Spare Parts and Tools	[Lots]	1		411,700		411,700	1		218,000		218,000		629,700		629,700
Total Supply				**8,233,468**	**0**	**8,233,468**			**4,359,251**	**0**	**4,359,251**		**12,592,718**	**0**	**12,592,718**
Construction Works															
	Unit	Qty	Unit Price	FC [USD]	LC [USD]	Total [USD]		Unit Price	FC [USD]	LC [USD]	Total [USD]	Qty	FC [USD]	LC [USD]	Total [USD]
Preliminary Work															
Survey, Profile Drawing	[km]	194.6	1,200	70,056	163,464	233,520	105.2	1,200	37,872	88,368	126,240	299.8	107,928	251,832	359,760
Design & Engineering	[km]	194.6	1,200	70,056	163,464	233,520	105.2	1,200	37,872	88,368	126,240	299.8	107,928	251,832	359,760
Bush Clearing	[km]	159.6	1,000	47,872	111,700	159,572	78.9	1,000	23,670	55,230	78,900	238.5	71,542	166,930	238,472
Access Roads Construction	[km]	94.5	1,000	28,356	66,164	94,520	75.1	1,000	22,543	52,600	75,143	169.7	50,899	118,764	169,663
Soil Investigation	[Units]	558	100	16,740	39,060	55,800	300	100	9,000	21,000	30,000	858	25,740	60,060	85,800
Total Preliminaly				233,080	543,852	776,932			130,957	305,566	436,523		364,036	849,418	1,213,455
Foundation Work															
Pad-1 (A1, A2 Tower, Soil- 1)	[Units]	115	2,200	126,500	126,500	253,000	0	2,200	0	0	0	115	126,500	126,500	253,000
Pad-2 (B1, C1 Tower, Soil-1)	[Units]	8	3,800	15,200	15,200	30,400	0	3,800	0	0	0	8	15,200	15,200	30,400
Pad-3 (D1, D2, DE Tower, Soil-	[Units]	6	7,000	21,000	21,000	42,000	0	7,000	0	0	0	6	21,000	21,000	42,000
Pad-4 (A1, A2 Tower, Soil- 2)	[Units]	234	2,600	304,200	304,200	608,400	261	2,600	339,300	339,300	678,600	495	643,500	643,500	1,287,000
Pad-5 (B1, C1 Tower, Soil-2)	[Units]	17	5,300	45,050	45,050	90,100	16	5,300	42,400	42,400	84,800	33	87,450	87,450	174,900
Pad-6 (D1, D2, DE Tower, Soil-2	[Units]	12	10,300	61,800	61,800	123,600	8	10,300	41,200	41,200	82,400	20	103,000	103,000	206,000
Pad-7 (A1, A2 Tower, Soil- 3)	[Units]	151	3,700	279,350	279,350	558,700	14	3,700	25,900	25,900	51,800	165	305,250	305,250	610,500
Pad-8 (B1, C1 Tower, Soil-3)	[Units]	12	8,800	52,800	52,800	105,600	0	8,800	0	0	0	12	52,800	52,800	105,600
Pad-9 (D1, D2, DE Tower, Soil-	[Units]	3	17,400	26,100	26,100	52,200	1	17,400	8,700	8,700	17,400	4	34,800	34,800	69,600
Pad-10: (Ga: Gantry Structure)	[Units]	4	1,000	2,000	2,000	4,000	0	1,000	0	0	0	4	2,000	2,000	4,000
Total Foundation Work		562		934,000	934,000	1,868,000	300		457,500	457,500	915,000	862	1,391,500	1,391,500	2,783,000
Tower Erection															
A1: Suspention Type 1	[ton]	2,450.0	150	147,000	220,500	367,500	1,375.0	150	82,500	123,750	206,250	3,825	229,500	344,250	573,750
A2: Suspension Type 2	[ton]	62.0	150	3,720	5,580	9,300	0.0	150	0	0	0	62	3,720	5,580	9,300
B1: Tension 0-15	[ton]	130.2	150	7,812	11,718	19,530	49.6	150	2,976	4,464	7,440	180	10,788	16,182	26,970
C1: Tension 0-30	[ton]	112.0	150	6,720	10,080	16,800	56.0	150	3,360	5,040	8,400	168	10,080	15,120	25,200
D1: Tension 0-90 Type 1	[ton]	138.0	150	8,280	12,420	20,700	64.4	150	3,864	5,796	9,660	202	12,144	18,216	30,360
D2: Tension 0-90 Type 2	[ton]	22.0	150	1,320	1,980	3,300	0.0	150	0	0	0	22	1,320	1,980	3,300
DE: Dead End	[ton]	37.6	150	2,256	3,384	5,640	18.8	150	1,128	1,692	2,820	56	3,384	5,076	8,460
Ga: Gantry	[ton]	6.0	150	360	540	900	0.0	150	0	0	0	6	360	540	900
Total Tower Erection		2,957.8		177,468	266,202	443,670	1,563.8		93,828	140,742	234,570	4,522	271,296	406,944	678,240
Stringing and Sagging															
6 Conductors	[km]	194.6	2,500	194,600	291,900	486,500	105.2	2,500	105,200	157,800	263,000	299.8	299,800	449,700	749,500
1 Ground Wire	[km]	194.6	500	38,920	58,380	97,300	105.2	500	21,040	31,560	52,600	299.8	59,960	89,940	149,900
Total Stringing and Sagging				233,520	350,280	583,800			126,240	189,360	315,600		359,760	539,640	899,400
Earthing Work	[Units]	562	100	16,860	39,340	56,200	302	100	9,060	21,140	30,200	864	25,920	60,480	86,400
Inland Transportation															
Tower	[ton]	2,957.8	100	0	295,780	295,780	1,563.8	100	0	156,380	156,380	4,521.6	0	452,160	452,160
Conductors	[ton]	1,197.2	100	0	119,720	119,720	647.2	100	0	64,720	64,720	1,844.4	0	184,440	184,440
Ground Wires	[ton]	82.9	100	0	8,290	8,290	44.9	100	0	4,490	4,490	127.8	0	12,780	12,780
Insulators	[ton]	224.8	100	0	22,480	22,480	113.8	100	0	11,380	11,380	338.6	0	33,860	33,860
Strings Conductors	[ton]	74.6	100	0	7,460	7,460	39.0	100	0	3,900	3,900	113.6	0	11,360	11,360
Fittings	[ton]	84.1	100	0	8,410	8,410	45.0	100	0	4,500	4,500	129.1	0	12,910	12,910
Tower Earthings	[ton]	11.2	100	0	1,120	1,120	6.0	100	0	600	600	17.2	0	1,720	1,720
Spare Parts	[ton]	203.0	100	0	20,300	20,300	100.2	100	0	10,020	10,020	303.2	0	30,320	30,320
Total Inland Transportation		4,835.7		0	483,560	483,560	2,559.9		0	255,990	255,990	7,092.4	0	739,550	739,550
Total Construction Works				**1,594,928**	**2,617,234**	**4,212,162**			**817,585**	**1,370,298**	**2,187,883**		**2,412,512**	**3,987,532**	**6,400,045**
Total Construction Cost				***9,828,395***	***2,617,234***	***12,445,630***			***5,176,836***	***1,370,298***	***6,547,134***		***15,005,231***	***3,987,532***	***18,992,763***

Table 6.2-4 Cost of Foundation Work for the Project

Soil Type	Foundation Type	Compression and Uplift Loads [kN]	Concrete Volume [m3]	Excavation Volume [m3]	Foundation Work	UNIT	Quantity /Tower	Unit Price [USD]	Total [USD]
Soil -I	Pad-1	～200	0.6	3.4	Excavation	m3	13.6	5	68
					Reinforcement	ton	0.2	700	168
					Concrete	m3	2.4	80	192
					Backfilling	m3	11.2	20	224
					Miscellaneous	Lots	1	1,500	1,500
					subtotal				**2,200**
	Pad-2	200～400	2.0	12.1	Excavation	m3	48.4	5	242
					Reinforcement	ton	0.8	700	560
					Concrete	m3	8.0	80	640
					Backfilling	m3	40.4	20	808
					Miscellaneous	Lots	1	1,500	1,500
					subtotal				**3,800**
	Pad-3	400～600	5.1	28.2	Excavation	m3	112.8	5	564
					Reinforcement	ton	2.0	700	1,428
					Concrete	m3	20.4	80	1,632
					Backfilling	m3	92.4	20	1,848
					Miscellaneous	Lots	1	1,500	1,500
					subtotal				**7,000**
Soil -II	Pad-4	～200	0.9	6.3	Excavation	m3	25.2	5	126
					Reinforcement	ton	0.4	700	252
					Concrete	m3	3.6	80	288
					Backfilling	m3	21.6	20	432
					Miscellaneous	Lots	1	1,500	1,500
					subtotal				**2,600**
	Pad-5	200～400	3.5	19.8	Excavation	m3	79.2	5	396
					Reinforcement	ton	1.4	700	980
					Concrete	m3	14.0	80	1,120
					Backfilling	m3	65.2	20	1,304
					Miscellaneous	Lots	1	1,500	1,500
					subtotal				**5,300**
	Pad-6	400～600	8.8	41.9	Excavation	m3	167.6	5	838
					Reinforcement	ton	3.5	700	2,464
					Concrete	m3	35.2	80	2,816
					Backfilling	m3	132.4	20	2,648
					Miscellaneous	Lots	1	1,500	1,500
					subtotal				**10,300**
Soil -III	Pad-7	～200	1.5	14.2	Excavation	m3	56.8	5	284
					Reinforcement	ton	0.6	700	420
					Concrete	m3	6.0	80	480
					Backfilling	m3	50.8	20	1,016
					Miscellaneous	Lots	1	1,500	1,500
					subtotal				**3,700**
	Pad-8	200～400	6.3	40.7	Excavation	m3	162.8	5	814
					Reinforcement	ton	2.5	700	1,764
					Concrete	m3	25.2	80	2,016
					Backfilling	m3	137.6	20	2,752
					Miscellaneous	Lots	1	1,500	1,500
					subtotal				**8,800**
	Pad-9	400～600	15.6	77.7	Excavation	m3	310.8	5	1,554
					Reinforcement	ton	6.2	700	4,368
					Concrete	m3	62.4	80	4,992
					Backfilling	m3	248.4	20	4,968
					Miscellaneous	Lots	1	1,500	1,500
					subtotal				**17,400**

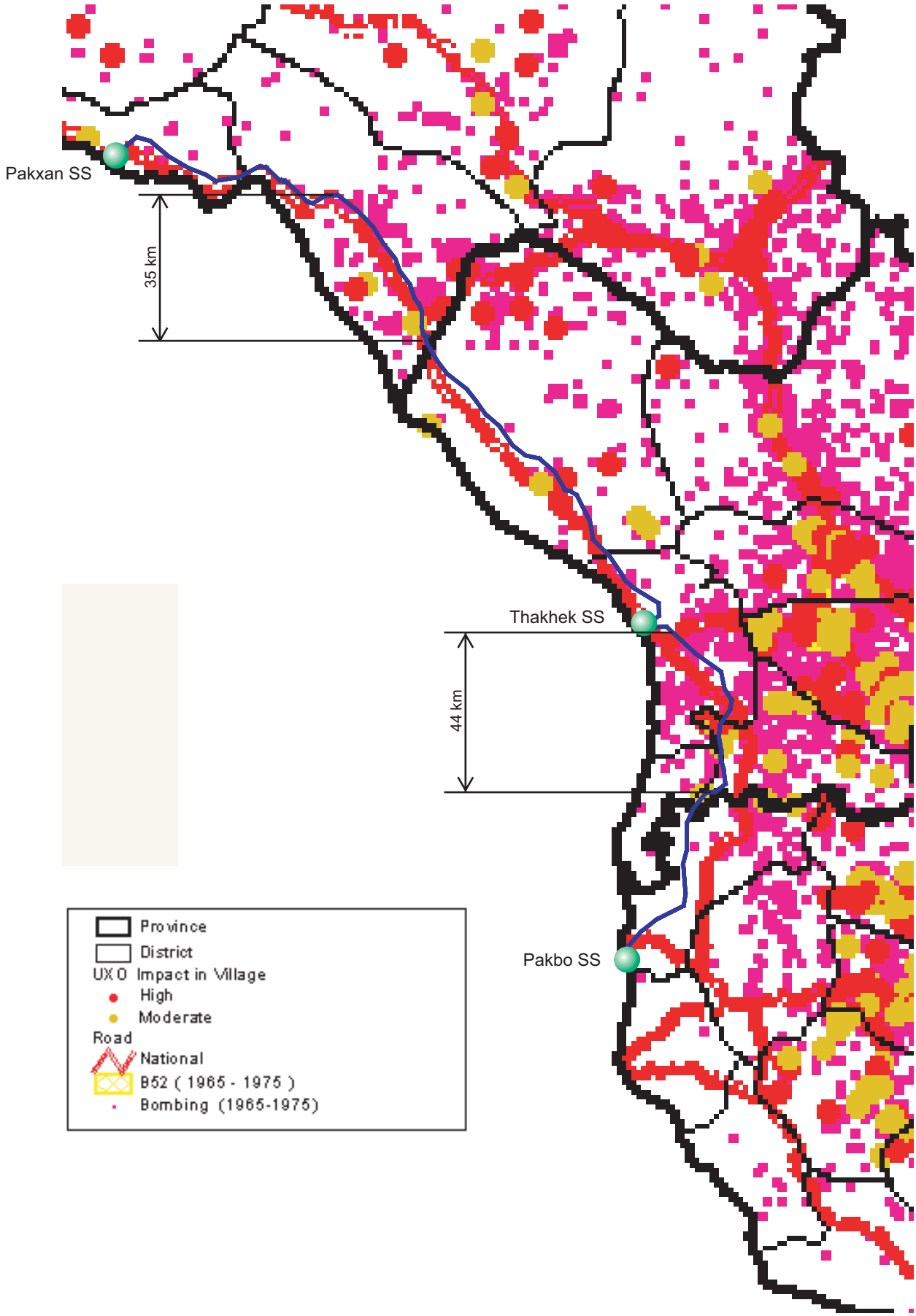
Table 6.3-2 Construction Cost of Substation Facilities

1. Plant and equipment including inland transportation

	Items	unit	CIF ($)	Pakxan SS		Thakhek SS		Pakbo SS	
				Q'ty	Total Price	Q'ty	Total Price	Q'ty	Total Price
1.1	**115 kV outdoor switchyard**								
1	Circuit breaker	pcs	61,653.00	2	123,306.00	4	246,612.00	3	184,959.00
2	Isolator	pcs	10,302.00	4	41,208.00	8	82,416.00	9	92,718.00
3	Isolator with earthing switch	pcs	12,240.00	2	24,480.00	4	48,960.00	2	24,480.00
4	Current transformer	pcs	6,069.00	6	36,414.00	12	72,828.00	6	36,414.00
5	Capacitive voltage transformer	pcs	4,488.00	6	26,928.00	12	53,856.00	9	40,392.00
6	Lightning arrester	pcs	2,193.00	6	13,158.00	12	26,316.00	6	13,158.00
7	Line trap	pcs	6,834.00	4	27,336.00	8	54,672.00	4	27,336.00
8	Steel structure	lot	20,000.00	1	20,000.00	1.5	30,000.00	3	60,000.00
9	Accessories, insulators, buswork	lot	40,000.00	1	40,000.00	1.5	60,000.00	3	120,000.00
1.2	**Control and Monitoring Equipment**								
1	Local control, bay unit	lot	106,080.00	1	106,080.00	2	212,160.00	2	212,160.00
1.3	**Protection 115 kV**								
1	Line feeder	pcs	43,110.00	1	43,110.00	2	86,220.00	2	86,220.00
2	Bus bar protection (integration in the existing system)	pcs	12,699.00	1	12,699.00	1	12,699.00	1	12,699.00
1.4	**Communication and SCADA**								
1	Extension of ex. SCADA/PLC system	lot	46,410.00	1	46,410.00	1	46,410.00	1	46,410.00
1.5	**MV, LV cables**								
1	Control cables and LV power cables	lot	25,000.00	1	25,000.00	2	50,000.00	2	50,000.00
2	Cable supporting structures	lot	1,000.00	1	1,000.00	2	2,000.00	2	2,000.00
1.6	**0.4 kV AC installations**								
1	Integration into the existing AC system	lot	4,947.00	1	4,947.00	1	4,947.00	1	4,947.00
1.7	**Earthing, Lighting, Lightning**								
1	Earthing system (integration in the existing system)	lot	17,750.00	1	17,750.00	1	17,750.00	1	17,750.00
2	Lightning system (integration in the existing system)	lot	6,612.00	1	6,612.00	1	6,612.00	1	6,612.00
3	Lighting and socket system (integration in the existing system)	lot	2,958.00	1	2,958.00	1	2,958.00	1	2,958.00
1.8	**Spare Parts**								
	5% of Total above	lot			31,000.00		55,900.00		52,100.00
					650,396.00		1,173,316.00		1,093,313.00

2. Civil and erection works

	Items		FC (US$)	LC (US$)	Total (US$)
2.1	Civil works				
	Pakxan SS	lot	9,100.00	33,000.00	42,100.00
	Thakhek SS	lot	18,200.00	66,000.00	84,200.00
	Pakbo SS	lot	14,100.00	71,800.00	85,900.00
2.2	Erection works				
	Pakxan SS	lot	15,000.00	54,900.00	69,900.00
	Thakhek SS	lot	30,000.00	104,500.00	134,500.00
	Pakbo SS	lot	30,000.00	92,400.00	122,400.00



Electricite du Laos	Japan International Cooperation Agency (JICA) Joint Venture Nippon Koei Co., Ltd. & Tokyo Electric Power Company	The Study on Master Plan of Transmission Line and Substation System	**Figure No.** 6.1-1 **Title** UXO Map along Pakxan SS to Pakbo SS Transmission Line

CHAPTER VII

PROJECT EVALUATION

Chapter 7 Project Evaluation

7.1 Evaluation Criteria

7.1.1 Criteria for Economic Evaluation

The economic efficiency of the Project would be proved by comparison of the Economic Internal Rate of Return (EIRR) of the Project to the Opportunity Cost of Capital (OCC) for Lao PDR to be 11%.

Following were the assumptions to estimate EIRR of the Project.

(1) Both cost and benefits will be expressed in real terms, valued at 2002 constant prices.

(2) The evaluation will be carried out for thirty years in economic terms of the Project facilities. All costs will be discounted to the beginning of 2003. The evaluation period is 2003 to 2032 including detailed design stage and construction period of 2003 –2005.

(3) The evaluation of the cost stream for EIRR includes the following:
   (a) The construction costs of the Project include consultant fee, UXO investigation and clearance at tower sites only, and physical contingency as detailed in Tables 6.4-1 and 6.5-1of Part II and summarized in Table 7.1-1 below.
   (b) The annual operation and maintenance costs of the Project facilities are estimated to be 1% of the investment costs for transmission line and 1.5% for substations.
   (c) In the similar procedure as applied for the analysis in Section 7.7.3 of Part I, the local portion of the Project costs is converted into investment flow valued at economic prices with SCF (Standard Conversion Factor) of 0.9.
   (d) Depreciation, interest charges, other taxes and duties were excluded.

(4) The evaluation of the benefit stream for EIRR includes the following.
   (a) The Project will activate power interconnection between Central 1 and Central 2 regions, and in the future with Southern region. Its benefits will be the substitute for imported electricity from the EGAT system of Thailand.
   (b) The Project will accrue benefits due to avoided wheeling fee assumed for the EIRR analysis to be US cent 1.0 per kWh after 2005, as advised by EDL. Imported electricity to be saved by completion of the Project is forecasted in Table 5.5-1 of Part I and summarized in Table 7.1-2.
   (c) Electricity demand at Xepon mines during the period from 2005 to 2012 is also met by imported electricity without the project case. It was assumed that after 2013 the electricity

supply to the mine will be from different domestic source like Xepon PS and/or Nam Theun 2 IPP. Therefore, avoided wheeling fee as US cent 1.0 per kWh is applied to estimate the project benefit by the year 2012.

Table 7.1-1 Construction Costs (Project and MV/LV Networks)

(unit: 1,000 US$)

Year	115 kV						MV & LV									
	T/L		S/S		Consult.		Thakhek		Pakbo		Kengkok		Total		Consult.	
	FC	LC	FC	LC	FC	LC	FC	LC	FC	LC	FC	LC	FC	LC	FC	LC
2003					607	0										
2004	8,254	2,194	1,840	232	607	0	231	58	249	62	424	106	904	226	79	0
2005	8,254	2,194	1,840	232	607	0	231	58	249	62	424	106	904	226	79	0
2006							231	58	249	62	424	106	904	226	79	0
2007							231	58	249	62	424	106	904	226	79	0
2008							231	58	249	62	424	106	904	226	79	0
2009							443	112	311	78	175	44	929	234	81	0
2010							443	112	311	78	175	44	929	234	81	0
2011							443	112	311	78	175	44	929	234	81	0
2012							443	112	311	78	175	44	929	234	81	0
2013							443	112	311	78	175	44	929	234	81	0
2014							477	119	507	127	187	47	1,171	293	102	0
2015							477	119	507	127	187	47	1,171	293	102	0
2016							477	119	507	127	187	47	1,171	293	102	0
2017							477	119	507	127	187	47	1,171	293	102	0
2018							477	119	507	127	187	47	1,171	293	102	0
2019							336	84	454	113	206	52	996	249	87	0
2020							336	84	454	113	206	52	996	249	87	0
Total	16,508	4,398	3,680	464	1,821	0	6,427	1,613	6,243	1,561	4,342	1,089	17,012	4,263	1,489	0

(115 kV from Tables 6.4-1 and 6.5-1 of Part I. MV & LV from Table 3.5 in Appendix: FC 80%, LC 20%, Consult. 7% of investment)

Table 7.1-2 Energy by Substations

(unit: GWh)

Year	Thakhek SS	Pakbo SS	Kengkok SS	Xepon SS(*)	Total	Mine	Increment
2005	121.8	88.6	53.9	18.4	282.7	210.0	-
2006	135.5	96.7	60.0	29.2	321.4	210.0	27.9
2007	148.4	117.4	67.7	30.6	364.1	210.0	69.2
2008	180.4	127.2	74.4	32.1	414.1	330.0	117.7
2009	195.7	137.0	81.2	33.5	447.4	340.0	149.6
2010	212.0	166.3	88.5	44.9	511.7	340.0	202.5
2011	227.7	182.5	101.0	47.7	558.9	340.0	246.9
2012	245.9	197.6	111.5	51.1	606.1	340.0	290.7
2013	270.0	212.1	122.1	54.5	658.7	(340.0)	339.9
2014	285.1	227.0	131.8	67.0	710.9	(410.0)	379.6
2015	341.3	278.2	143.2	70.2	832.9	(410.0)	498.4
2016	358.8	292.3	153.4	73.4	877.9	(410.0)	540.2
2017	381.4	308.1	164.2	76.5	930.2	(410.0)	589.4
2018	401.0	324.2	175.8	79.3	980.3	(410.0)	636.7
2019	424.8	342.2	189.3	100.5	1,056.8	(410.0)	692.0
2020	447.7	396.7	202.3	103.5	1,150.2	(410.0)	782.4
After	Constant	Constant	Constant	Constant	Constant		except XPN & Mine

(From Table 5.5-1 of Part I. (*) Half demand of Table 5.5-1 excluding the mine demand)

7.1.2 Criteria for Financial Evaluation

Following are the assumptions to estimate FIRR of the Project.

(1) Both costs and benefits will be expressed in real terms valued at 2002 constant prices.

(2) The evaluation will be carried out for thirty years in economic terms of the Project facilities. All costs will be discounted to the beginning of 2003. The evaluation period is 2003 to 2032 including detailed design stage and construction stage of 2003 - 2005.

(3) The evaluation of the cost stream for FIRR includes the following.
   (a) The construction costs of transmission lines and substations for the Project are the same as those estimated in Table 7.1-1.
   (b) As the benefits are based on sales to end consumers, the costs for MV and LV distribution networks related the substations are added to the Project costs. The costs are estimated in Tables 3.3 to 3.5 of Appendix to the Report and supplemented by additional transformers and switchgear to meet growing demand. The costs for MV and LV facilities are also summarized in Table 7.1-1.
   (c) The annual operation and maintenance costs of the Project facilities are estimated to be 1% of the investment costs for transmission line, 1.5% for substations and 1% for distribution networks.
   (d) Depreciation, interest charges, other taxes and duties are excluded.

(4) The evaluation of benefit stream for FIRR includes the following.
   (a) FIRR analysis will be based on the incremental sales revenues to EDL from the demand at Thakhek, Savannakhet, and Kengkok that are immediately deliverable from the Project. The demand at Xepon mines and Xepon SS are excluded from FIRR analysis, because cost for the transmission line and substation facilities in the area are not counted.
   (b) Energy sales revenue corresponding to the Project FIRR's benefit stream were estimated at 40% of the total sales revenues, since investment share of transmission and distribution system is around 40% of total system investment.
   (c) The tariff applied for all category of demand is 2.068 US cent/kWh (40 % of 5.17 US cents per kWh, average selling price for all customers). The incremental demands for each related substation are summarized in Table 7.1-2.

7.2 Results of Evaluation and Sensitivity Analysis

EIRR and FIRR of the Project were computed under the criteria set in the above section. Following are the computed results.

7.2.1 Economic Internal Rate of Return

The cash flow was computed to estimate the EIRR of the Project resulting in 23.93% for the base case. The sensitivity analyses were also computed for the following assumptions.

(a) 15 % higher Investment Cost

(b) 10 % lower Tariffs

(c) 50 % higher O & M Cost

(d) 30 % lower Revenue （variation of forecasted demand, collected amount of sold energy, exchanged rate of Kip to US$, etc.）

Table 7.2-1 shows the detailed cash flows of EIRR, and the results are summarized in Table 7.2-2.

Table 7.2-2 Results of Computation for EIRR

	EIRR (%)	NPV_{2002} (1,000 US$)
Base Case	23.93	31,347
Investment + 15 %	21.35	28,024
Project tariff –10 %	21.96	25,997
O & M Cost + 50 %	23.58	30,485
Energy sold –30 %	17.80	15,295

The Project is higher than 11% OCC, and considered viable in economic terms.

7.2.2 Financial Internal Rate of Return

Table 7.2-3 shows the detailed cash flows of FIRR, and the results are summarized in Table 7.2-4.

Table 7.2-4 Results of Computation for FIRR

	FIRR (%)	NPV_{2002}
Base Case	14.87	52,137
Investment + 15 %	13.44	50,238
Project tariff –10 %	13.79	45,651
O & M Cost + 50 %	14.56	50,461
Energy sold –30 %	11.35	32,698

Based on the Base Case FIRR of 14.87 % the Project is financially viable. In addition, it is understood that the emerging national grid will have high long term financial benefits by bringing cheaper hydropower to load centers in Central 2 region and further all over the country.

Table 7.2-1 (1) EIRR of the Project (Base Case)

(US$ 1,000)

Year	115 kV Facilities					Total Capital		O & M Cost			Energy		Benefit			NPV
	TL Investment		SS Investment		Consult.			TL	SS	Total	4 SS	Mine	4 SS	Mine	Total	
	FC	LC	FC	LC	FC	FC	LC	FC+LC	FC+LC	FC+LC	(MWh)	(MWh)	($10/MWh)	($10/MWh)		
2003	0.00	9.00	0.00	0.00	607.00	607.00	9.00	0.00	0.00	0.00						-616
2004	8,253.86	1,974.27	1,839.70	209.19	606.90	10,700.46	2,183.45	0.00	0.00	0.00						-12,884
2005	8,253.86	1,974.27	1,839.70	209.19	606.90	10,700.46	2,183.45	0.00	0.00	0.00						-12,884
2006						0.00	0.00	209.05	62.16	271.21	321,400	210,000	3,214	2,100	5,314	5,043
2007						0.00	0.00	209.05	62.16	271.21	364,100	210,000	3,641	2,100	5,741	5,470
2008						0.00	0.00	209.05	62.16	271.21	414,100	330,000	4,141	3,300	7,441	7,170
2009						0.00	0.00	209.05	62.16	271.21	447,400	340,000	4,474	3,400	7,874	7,603
2010						0.00	0.00	209.05	62.16	271.21	511,700	340,000	5,117	3,400	8,517	8,246
2011						0.00	0.00	209.05	62.16	271.21	558,900	340,000	5,589	3,400	8,989	8,718
2012						0.00	0.00	209.05	62.16	271.21	606,100	340,000	6,061	3,400	9,461	9,190
2013						0.00	0.00	209.05	62.16	271.21	658,700		6,587		6,587	6,316
2014						0.00	0.00	209.05	62.16	271.21	710,900		7,109		7,109	6,838
2015						0.00	0.00	209.05	62.16	271.21	832,900		8,329		8,329	8,058
2016						0.00	0.00	209.05	62.16	271.21	877,900		8,779		8,779	8,508
2017						0.00	0.00	209.05	62.16	271.21	930,200		9,302		9,302	9,031
2018						0.00	0.00	209.05	62.16	271.21	980,300		9,803		9,803	9,532
2019						0.00	0.00	209.05	62.16	271.21	1,056,800		10,568		10,568	10,297
2020						0.00	0.00	209.05	62.16	271.21	1,150,200		11,502		11,502	11,231
2021						0.00	0.00	209.05	62.16	271.21	1,150,200		11,502		11,502	11,231
2022						0.00	0.00	209.05	62.16	271.21	1,150,200		11,502		11,502	11,231
2023						0.00	0.00	209.05	62.16	271.21	1,150,200		11,502		11,502	11,231
2024						0.00	0.00	209.05	62.16	271.21	1,150,200		11,502		11,502	11,231
2025						0.00	0.00	209.05	62.16	271.21	1,150,200		11,502		11,502	11,231
2026						0.00	0.00	209.05	62.16	271.21	1,150,200		11,502		11,502	11,231
2027						0.00	0.00	209.05	62.16	271.21	1,150,200		11,502		11,502	11,231
2028						0.00	0.00	209.05	62.16	271.21	1,150,200		11,502		11,502	11,231
2029						0.00	0.00	209.05	62.16	271.21	1,150,200		11,502		11,502	11,231
2030						0.00	0.00	209.05	62.16	271.21	1,150,200		11,502		11,502	11,231
2032						0.00	0.00	209.05	62.16	271.21	1,150,200		11,502		11,502	11,231
2032						0.00	0.00	209.05	62.16	271.21	1,150,200		11,502		11,502	11,231
2033						0.00	0.00	209.05	62.16	271.21	1,150,200		11,502		11,502	11,231
2034						0.00	0.00	209.05	62.16	271.21	1,150,200		11,502		11,502	11,231
2035						0.00	0.00	209.05	62.16	271.21	1,150,200		11,502		11,502	11,231
Total	16,507.72	3,957.53	3,679.40	418.37	1,820.80	22,007.92	4,375.91				27,674,600	2,110,000				
											Economic IRR for the Project (%)					23.93
											Net Present Value (at 11%)					31,347

Table 7.2-1 (2) EIRR of the Project (Sensitivity Analysis : Construction Cost +15%)

(US$ 1,000)

Year	115 kV Facilities					Total Capital		O & M Cost			Energy		Benefit			NPV
	TL Investment		SS Investment		Consult.			TL	SS	TTL	4 SS	Mine	4 SS	Mine	Total	
	FC	LC	FC	LC	FC	FC	LC	FC+LC	FC+LC	FC+LC	(MWh)	(MWh)	($10/MWh)	($10/MWh)		
2003	0.00	10.35	0.00	0.00	698.05	698.05	10.35	0.00	0.00	0.00						-708
2004	9,491.94	2,270.41	2,115.66	240.57	697.94	12,305.53	2,510.97	0.00	0.00	0.00						-14,817
2005	9,491.94	2,270.41	2,115.66	240.57	697.94	12,305.53	2,510.97	0.00	0.00	0.00						-14,817
2006						0.00	0.00	240.41	71.49	311.90	321,400	210,000	3,214	2,100	5,314	5,002
2007						0.00	0.00	240.41	71.49	311.90	364,100	210,000	3,641	2,100	5,741	5,429
2008						0.00	0.00	240.41	71.49	311.90	414,100	330,000	4,141	3,300	7,441	7,129
2009						0.00	0.00	240.41	71.49	311.90	447,400	340,000	4,474	3,400	7,874	7,562
2010						0.00	0.00	240.41	71.49	311.90	511,700	340,000	5,117	3,400	8,517	8,205
2011						0.00	0.00	240.41	71.49	311.90	558,900	340,000	5,589	3,400	8,989	8,677
2012						0.00	0.00	240.41	71.49	311.90	606,100	340,000	6,061	3,400	9,461	9,149
2013						0.00	0.00	240.41	71.49	311.90	658,700		6,587		6,587	6,275
2014						0.00	0.00	240.41	71.49	311.90	710,900		7,109		7,109	6,797
2015						0.00	0.00	240.41	71.49	311.90	832,900		8,329		8,329	8,017
2016						0.00	0.00	240.41	71.49	311.90	877,900		8,779		8,779	8,467
2017						0.00	0.00	240.41	71.49	311.90	930,200		9,302		9,302	8,990
2018						0.00	0.00	240.41	71.49	311.90	980,300		9,803		9,803	9,491
2019						0.00	0.00	240.41	71.49	311.90	1,056,800		10,568		10,568	10,256
2020						0.00	0.00	240.41	71.49	311.90	1,150,200		11,502		11,502	11,190
2021						0.00	0.00	240.41	71.49	311.90	1,150,200		11,502		11,502	11,190
2022						0.00	0.00	240.41	71.49	311.90	1,150,200		11,502		11,502	11,190
2023						0.00	0.00	240.41	71.49	311.90	1,150,200		11,502		11,502	11,190
2024						0.00	0.00	240.41	71.49	311.90	1,150,200		11,502		11,502	11,190
2025						0.00	0.00	240.41	71.49	311.90	1,150,200		11,502		11,502	11,190
2026						0.00	0.00	240.41	71.49	311.90	1,150,200		11,502		11,502	11,190
2027						0.00	0.00	240.41	71.49	311.90	1,150,200		11,502		11,502	11,190
2028						0.00	0.00	240.41	71.49	311.90	1,150,200		11,502		11,502	11,190
2029						0.00	0.00	240.41	71.49	311.90	1,150,200		11,502		11,502	11,190
2030						0.00	0.00	240.41	71.49	311.90	1,150,200		11,502		11,502	11,190
2032						0.00	0.00	240.41	71.49	311.90	1,150,200		11,502		11,502	11,190
2032						0.00	0.00	240.41	71.49	311.90	1,150,200		11,502		11,502	11,190
2033						0.00	0.00	240.41	71.49	311.90	1,150,200		11,502		11,502	11,190
2034						0.00	0.00	240.41	71.49	311.90	1,150,200		11,502		11,502	11,190
2035						0.00	0.00	240.41	71.49	311.90	1,150,200		11,502		11,502	11,190
Total	18,983.88	4,551.16	4,231.31	481.13	2,093.92	25,309.11	5,032.29				27,674,600	2,110,000				
															Economic IRR for the Project (%)	21.35
															Net Present Value (at 11%)	28,024

Table 7.2-1 (3) EIRR of the Project (Sensitivity Analysis : Project Tariff -10%)

(US$ 1,000)

Year	115 kV Facilities					Total Capital		O & M Cost			Energy		Benefit			NPV
	TL Investment		SS Investment		Consult.			TL	SS	TTL	4 SS	Mine	4 SS	Mine	Total	
	FC	LC	FC	LC	FC	FC	LC	FC+LC	FC+LC	FC+LC	(MWh)	(MWh)	($9/MWh)	($9/MWh)		
2003	0.00	9.00	0.00	0.00	607.00	607.00	9.00	0.00	0.00	0.00						-616
2004	8,253.86	1,974.27	1,839.70	209.19	606.90	10,700.46	2,183.45	0.00	0.00	0.00						-12,884
2005	8,253.86	1,974.27	1,839.70	209.19	606.90	10,700.46	2,183.45	0.00	0.00	0.00						-12,884
2006						0.00	0.00	209.05	62.16	271.21	321,400	210,000	2,893	1,890	4,783	4,511
2007						0.00	0.00	209.05	62.16	271.21	364,100	210,000	3,277	1,890	5,167	4,896
2008						0.00	0.00	209.05	62.16	271.21	414,100	330,000	3,727	2,970	6,697	6,426
2009						0.00	0.00	209.05	62.16	271.21	447,400	340,000	4,027	3,060	7,087	6,815
2010						0.00	0.00	209.05	62.16	271.21	511,700	340,000	4,605	3,060	7,665	7,394
2011						0.00	0.00	209.05	62.16	271.21	558,900	340,000	5,030	3,060	8,090	7,819
2012						0.00	0.00	209.05	62.16	271.21	606,100	340,000	5,455	3,060	8,515	8,244
2013						0.00	0.00	209.05	62.16	271.21	658,700		5,928		5,928	5,657
2014						0.00	0.00	209.05	62.16	271.21	710,900		6,398		6,398	6,127
2015						0.00	0.00	209.05	62.16	271.21	832,900		7,496		7,496	7,225
2016						0.00	0.00	209.05	62.16	271.21	877,900		7,901		7,901	7,630
2017						0.00	0.00	209.05	62.16	271.21	930,200		8,372		8,372	8,101
2018						0.00	0.00	209.05	62.16	271.21	980,300		8,823		8,823	8,551
2019						0.00	0.00	209.05	62.16	271.21	1,056,800		9,511		9,511	9,240
2020						0.00	0.00	209.05	62.16	271.21	1,150,200		10,352		10,352	10,081
2021						0.00	0.00	209.05	62.16	271.21	1,150,200		10,352		10,352	10,081
2022						0.00	0.00	209.05	62.16	271.21	1,150,200		10,352		10,352	10,081
2023						0.00	0.00	209.05	62.16	271.21	1,150,200		10,352		10,352	10,081
2024						0.00	0.00	209.05	62.16	271.21	1,150,200		10,352		10,352	10,081
2025						0.00	0.00	209.05	62.16	271.21	1,150,200		10,352		10,352	10,081
2026						0.00	0.00	209.05	62.16	271.21	1,150,200		10,352		10,352	10,081
2027						0.00	0.00	209.05	62.16	271.21	1,150,200		10,352		10,352	10,081
2028						0.00	0.00	209.05	62.16	271.21	1,150,200		10,352		10,352	10,081
2029						0.00	0.00	209.05	62.16	271.21	1,150,200		10,352		10,352	10,081
2030						0.00	0.00	209.05	62.16	271.21	1,150,200		10,352		10,352	10,081
2032						0.00	0.00	209.05	62.16	271.21	1,150,200		10,352		10,352	10,081
2032						0.00	0.00	209.05	62.16	271.21	1,150,200		10,352		10,352	10,081
2033						0.00	0.00	209.05	62.16	271.21	1,150,200		10,352		10,352	10,081
2034						0.00	0.00	209.05	62.16	271.21	1,150,200		10,352		10,352	10,081
2035						0.00	0.00	209.05	62.16	271.21	1,150,200		10,352		10,352	10,081
Total	16,507.72	3,957.53	3,679.40	418.37	1,820.80	22,007.92	4,375.91				27,674,600	2,110,000				
															Economic IRR for the Project (%)	21.96
															Net Present Value (at 11%)	25,997

Table 7.2-1 (4) EIRR of the Project (Sensitivity Analysis : O & M Cost +50%)

(US$ 1,000)

Year	115 kV Facilities					Total Capital		O & M Cost			Energy		Benefit			NPV
	TL Investment		SS Investment		Consult.			TL	SS	TTL	4 SS	Mine	4 SS	Mine	Total	
	FC	LC	FC	LC	FC	FC	LC	FC+LC	FC+LC	FC+LC	(MWh)	(MWh)	($10/MWh)	($10/MWh)		
2003	0.00	9.00	0.00	0.00	607.00	607.00	9.00	0.00	0.00	0.00						-616
2004	8,253.86	1,974.27	1,839.70	209.19	606.90	10,700.46	2,183.45	0.00	0.00	0.00						-12,884
2005	8,253.86	1,974.27	1,839.70	209.19	606.90	10,700.46	2,183.45	0.00	0.00	0.00						-12,884
2006						0.00	0.00	313.57	93.25	406.82	321,400	210,000	3,214	2,100	5,314	4,907
2007						0.00	0.00	313.57	93.25	406.82	364,100	210,000	3,641	2,100	5,741	5,334
2008						0.00	0.00	313.57	93.25	406.82	414,100	330,000	4,141	3,300	7,441	7,034
2009						0.00	0.00	313.57	93.25	406.82	447,400	340,000	4,474	3,400	7,874	7,467
2010						0.00	0.00	313.57	93.25	406.82	511,700	340,000	5,117	3,400	8,517	8,110
2011						0.00	0.00	313.57	93.25	406.82	558,900	340,000	5,589	3,400	8,989	8,582
2012						0.00	0.00	313.57	93.25	406.82	606,100	340,000	6,061	3,400	9,461	9,054
2013						0.00	0.00	313.57	93.25	406.82	658,700		6,587		6,587	6,180
2014						0.00	0.00	313.57	93.25	406.82	710,900		7,109		7,109	6,702
2015						0.00	0.00	313.57	93.25	406.82	832,900		8,329		8,329	7,922
2016						0.00	0.00	313.57	93.25	406.82	877,900		8,779		8,779	8,372
2017						0.00	0.00	313.57	93.25	406.82	930,200		9,302		9,302	8,895
2018						0.00	0.00	313.57	93.25	406.82	980,300		9,803		9,803	9,396
2019						0.00	0.00	313.57	93.25	406.82	1,056,800		10,568		10,568	10,161
2020						0.00	0.00	313.57	93.25	406.82	1,150,200		11,502		11,502	11,095
2021						0.00	0.00	313.57	93.25	406.82	1,150,200		11,502		11,502	11,095
2022						0.00	0.00	313.57	93.25	406.82	1,150,200		11,502		11,502	11,095
2023						0.00	0.00	313.57	93.25	406.82	1,150,200		11,502		11,502	11,095
2024						0.00	0.00	313.57	93.25	406.82	1,150,200		11,502		11,502	11,095
2025						0.00	0.00	313.57	93.25	406.82	1,150,200		11,502		11,502	11,095
2026						0.00	0.00	313.57	93.25	406.82	1,150,200		11,502		11,502	11,095
2027						0.00	0.00	313.57	93.25	406.82	1,150,200		11,502		11,502	11,095
2028						0.00	0.00	313.57	93.25	406.82	1,150,200		11,502		11,502	11,095
2029						0.00	0.00	313.57	93.25	406.82	1,150,200		11,502		11,502	11,095
2030						0.00	0.00	313.57	93.25	406.82	1,150,200		11,502		11,502	11,095
2032						0.00	0.00	313.57	93.25	406.82	1,150,200		11,502		11,502	11,095
2032						0.00	0.00	313.57	93.25	406.82	1,150,200		11,502		11,502	11,095
2033						0.00	0.00	313.57	93.25	406.82	1,150,200		11,502		11,502	11,095
2034						0.00	0.00	313.57	93.25	406.82	1,150,200		11,502		11,502	11,095
2035						0.00	0.00	313.57	93.25	406.82	1,150,200		11,502		11,502	11,095
Total	16,507.72	3,957.53	3,679.40	418.37	1,820.80	22,007.92	4,375.91				27,674,600	2,110,000				
															Economic IRR for the Project (%)	23.58
															Net Present Value (at 11%)	30,485

Table 7.2-1 (5) EIRR of the Project (Sensitivity Analysis : Energy sold -30%)

(US$ 1,000)

Year	115 kV Facilities					Total Capital		O & M Cost			Energy		Benefit			NPV
	TL Investment		SS Investment		Consult.			TL	SS	Total	4 SS	Mine	4 SS	Mine	Total	
	FC	LC	FC	LC	FC	FC	LC	FC+LC	FC+LC	FC+LC	(MWh)	(MWh)	($10/MWh)	($10/MWh)		
2003	0.00	9.00	0.00	0.00	607.00	607.00	9.00	0.00	0.00	0.00						-616
2004	8,253.86	1,974.27	1,839.70	209.19	606.90	10,700.46	2,183.45	0.00	0.00	0.00						-12,884
2005	8,253.86	1,974.27	1,839.70	209.19	606.90	10,700.46	2,183.45	0.00	0.00	0.00						-12,884
2006						0.00	0.00	209.05	62.16	271.21	224,980	147,000	2,250	1,470	3,720	3,449
2007						0.00	0.00	209.05	62.16	271.21	254,870	147,000	2,549	1,470	4,019	3,747
2008						0.00	0.00	209.05	62.16	271.21	289,870	231,000	2,899	2,310	5,209	4,937
2009						0.00	0.00	209.05	62.16	271.21	313,180	238,000	3,132	2,380	5,512	5,241
2010						0.00	0.00	209.05	62.16	271.21	358,190	238,000	3,582	2,380	5,962	5,691
2011						0.00	0.00	209.05	62.16	271.21	391,230	238,000	3,912	2,380	6,292	6,021
2012						0.00	0.00	209.05	62.16	271.21	424,270	238,000	4,243	2,380	6,623	6,351
2013						0.00	0.00	209.05	62.16	271.21	461,090		4,611		4,611	4,340
2014						0.00	0.00	209.05	62.16	271.21	497,630		4,976		4,976	4,705
2015						0.00	0.00	209.05	62.16	271.21	583,030		5,830		5,830	5,559
2016						0.00	0.00	209.05	62.16	271.21	614,530		6,145		6,145	5,874
2017						0.00	0.00	209.05	62.16	271.21	651,140		6,511		6,511	6,240
2018						0.00	0.00	209.05	62.16	271.21	686,210		6,862		6,862	6,591
2019						0.00	0.00	209.05	62.16	271.21	739,760		7,398		7,398	7,126
2020						0.00	0.00	209.05	62.16	271.21	805,140		8,051		8,051	7,780
2021						0.00	0.00	209.05	62.16	271.21	805,140		8,051		8,051	7,780
2022						0.00	0.00	209.05	62.16	271.21	805,140		8,051		8,051	7,780
2023						0.00	0.00	209.05	62.16	271.21	805,140		8,051		8,051	7,780
2024						0.00	0.00	209.05	62.16	271.21	805,140		8,051		8,051	7,780
2025						0.00	0.00	209.05	62.16	271.21	805,140		8,051		8,051	7,780
2026						0.00	0.00	209.05	62.16	271.21	805,140		8,051		8,051	7,780
2027						0.00	0.00	209.05	62.16	271.21	805,140		8,051		8,051	7,780
2028						0.00	0.00	209.05	62.16	271.21	805,140		8,051		8,051	7,780
2029						0.00	0.00	209.05	62.16	271.21	805,140		8,051		8,051	7,780
2030						0.00	0.00	209.05	62.16	271.21	805,140		8,051		8,051	7,780
2032						0.00	0.00	209.05	62.16	271.21	805,140		8,051		8,051	7,780
2032						0.00	0.00	209.05	62.16	271.21	805,140		8,051		8,051	7,780
2033						0.00	0.00	209.05	62.16	271.21	805,140		8,051		8,051	7,780
2034						0.00	0.00	209.05	62.16	271.21	805,140		8,051		8,051	7,780
2035						0.00	0.00	209.05	62.16	271.21	805,140		8,051		8,051	7,780
Total	16,507.72	3,957.53	3,679.40	418.37	1,820.80	22,007.92	4,375.91				19,372,220	1,477,000				
											Economic IRR for the Project (%)					17.80
											Net Present Value (at 11%)					15,296

Table 7.2-3 (1) FIRR of the Project (Base case)

(US$ 1,000)

Year	115 kV Facilities					MV & LV Facilities			Total Capital		O & M Cost				Incremental Energy & Revenue		NPV
	TL Investment		SS Investment		Consult.	Investment		Consult.			TL	SS	MV & LV	Total	Energy	Revenue	
	FC	LC	FC	LC	FC	FC	LC	FC	FC	LC	FC+LC	FC+LC	FC+LC	FC+LC	(MWh)	($20.68/MWh)	
2003	0.00	10.00	0.00	0.00	607.00	0.00	0.00	0.00	607.00	10.00	0.00	0.00	0.00	0.00			-617
2004	8,253.86	2,193.63	1,839.70	232.43	606.90	904.00	226.00	79.10	11,683.56	2,652.06	0.00	0.00	0.00	0.00			-14,336
2005	8,253.86	2,193.63	1,839.70	232.43	606.90	904.00	226.00	79.10	11,683.56	2,652.06	0.00	0.00	0.00	0.00			-14,336
2006						904.00	226.00	79.10	983.10	226.00	209.05	62.16	22.60	293.81	27,900	577	-926
2007						904.00	226.00	79.10	983.10	226.00	209.05	62.16	33.90	305.11	69,200	1,431	-83
2008						904.00	226.00	79.10	983.10	226.00	209.05	62.16	45.20	316.41	117,700	2,434	909
2009						929.00	234.00	81.41	1,010.41	234.00	209.05	62.16	56.50	327.71	149,600	3,094	1,522
2010						929.00	234.00	81.41	1,010.41	234.00	209.05	62.16	68.13	339.34	202,500	4,188	2,604
2011						929.00	234.00	81.41	1,010.41	234.00	209.05	62.16	79.76	350.97	246,900	5,106	3,511
2012						929.00	234.00	81.41	1,010.41	234.00	209.05	62.16	91.39	362.60	290,700	6,012	4,405
2013						929.00	234.00	81.41	1,010.41	234.00	209.05	62.16	103.02	374.23	339,900	7,029	5,410
2014						1,171.00	293.00	102.48	1,273.48	293.00	209.05	62.16	114.65	385.86	379,600	7,850	5,898
2015						1,171.00	293.00	102.48	1,273.48	293.00	209.05	62.16	129.29	400.50	498,400	10,307	8,340
2016						1,171.00	293.00	102.48	1,273.48	293.00	209.05	62.16	143.93	415.14	540,200	11,171	9,190
2017						1,171.00	293.00	102.48	1,273.48	293.00	209.05	62.16	143.93	415.14	589,400	12,189	10,207
2018						1,171.00	293.00	102.48	1,273.48	293.00	209.05	62.16	158.57	429.78	636,700	13,167	11,171
2019						996.00	249.00	87.15	1,083.15	249.00	209.05	62.16	173.21	444.42	692,000	14,311	12,534
2020						996.00	249.00	87.15	1,083.15	249.00	209.05	62.16	185.66	456.87	782,400	16,180	14,391
2021									0.00	0.00	209.05	62.16	198.11	469.32	782,400	16,180	15,711
2022									0.00	0.00	209.05	62.16	198.11	469.32	782,400	16,180	15,711
2023									0.00	0.00	209.05	62.16	198.11	469.32	782,400	16,180	15,711
2024									0.00	0.00	209.05	62.16	198.11	469.32	782,400	16,180	15,711
2025									0.00	0.00	209.05	62.16	198.11	469.32	782,400	16,180	15,711
2026									0.00	0.00	209.05	62.16	198.11	469.32	782,400	16,180	15,711
2027									0.00	0.00	209.05	62.16	198.11	469.32	782,400	16,180	15,711
2028									0.00	0.00	209.05	62.16	198.11	469.32	782,400	16,180	15,711
2029									0.00	0.00	209.05	62.16	198.11	469.32	782,400	16,180	15,711
2030									0.00	0.00	209.05	62.16	198.11	469.32	782,400	16,180	15,711
2032									0.00	0.00	209.05	62.16	198.11	469.32	782,400	16,180	15,711
2032									0.00	0.00	209.05	62.16	198.11	469.32	782,400	16,180	15,711
2033									0.00	0.00	209.05	62.16	198.11	469.32	782,400	16,180	15,711
2034									0.00	0.00	209.05	62.16	198.11	469.32	782,400	16,180	15,711
2035									0.00	0.00	209.05	62.16	198.11	469.32	782,400	16,180	15,711
Total	16,507.72	4,397.26	3,679.40	464.86	1,820.80	17,012.00	4,263.00	1,489.25	40,509.17	9,125.12					17,299,100		
														Financial IRR for the Project			14.87
														Net Present Value (at 11%)			52,137

Table 7.2-3 (2) FIRR of the Project (Sensitivity Analysis : Construction Cost +15%)

(US$ 1,000)

Year	115 kV Facilities					MV & LV Facilities			Total Capital		O & M Cost				Incremental Energy & Revenue		NPV
	TL Investment		SS Investment		Consult.	Investment		Consult.			TL	SS	MV & LV	Total	Energy	Revenue	
	FC	LC	FC	LC	FC	FC	LC	FC	FC	LC	FC+LC	FC+LC	FC+LC	FC+LC	(MWh)	($20.68/MWh)	
2003	0.00	11.50	0.00	0.00	698.05	0.00	0.00	0.00	698.05	11.50	0.00	0.00	0.00	0.00			-710
2004	9,491.94	2,522.67	2,115.66	267.29	697.94	1,039.60	259.90	90.97	13,436.09	3,049.87	0.00	0.00	0.00	0.00			-16,486
2005	9,491.94	2,522.67	2,115.66	267.29	697.94	1,039.60	259.90	90.97	13,436.09	3,049.87	0.00	0.00	0.00	0.00			-16,486
2006						1,039.60	259.90	90.97	1,130.57	259.90	240.41	71.49	25.99	337.89	27,900	577	-1,151
2007						1,039.60	259.90	90.97	1,130.57	259.90	240.41	71.49	38.99	350.88	69,200	1,431	-310
2008						1,039.60	259.90	90.97	1,130.57	259.90	240.41	71.49	51.98	363.88	117,700	2,434	680
2009						1,068.35	269.10	93.62	1,161.97	269.10	240.41	71.49	64.98	376.87	149,600	3,094	1,286
2010						1,068.35	269.10	93.62	1,161.97	269.10	240.41	71.49	78.35	390.25	202,500	4,188	2,366
2011						1,068.35	269.10	93.62	1,161.97	269.10	240.41	71.49	91.72	403.62	246,900	5,106	3,271
2012						1,068.35	269.10	93.62	1,161.97	269.10	240.41	71.49	105.10	416.99	290,700	6,012	4,164
2013						1,068.35	269.10	93.62	1,161.97	269.10	240.41	71.49	118.47	430.37	339,900	7,029	5,168
2014						1,346.65	336.95	117.85	1,464.50	336.95	240.41	71.49	131.85	443.74	379,600	7,850	5,605
2015						1,346.65	336.95	117.85	1,464.50	336.95	240.41	71.49	148.68	460.58	498,400	10,307	8,045
2016						1,346.65	336.95	117.85	1,464.50	336.95	240.41	71.49	165.52	477.42	540,200	11,171	8,892
2017						1,346.65	336.95	117.85	1,464.50	336.95	240.41	71.49	165.52	477.42	589,400	12,189	9,910
2018						1,346.65	336.95	117.85	1,464.50	336.95	240.41	71.49	182.36	494.25	636,700	13,167	10,871
2019						1,145.40	286.35	100.22	1,245.62	286.35	240.41	71.49	199.19	511.09	692,000	14,311	12,268
2020						1,145.40	286.35	100.22	1,245.62	286.35	240.41	71.49	213.51	525.40	782,400	16,180	14,123
2021									0.00	0.00	240.41	71.49	227.83	539.72	782,400	16,180	15,640
2022									0.00	0.00	240.41	71.49	227.83	539.72	782,400	16,180	15,640
2023									0.00	0.00	240.41	71.49	227.83	539.72	782,400	16,180	15,640
2024									0.00	0.00	240.41	71.49	227.83	539.72	782,400	16,180	15,640
2025									0.00	0.00	240.41	71.49	227.83	539.72	782,400	16,180	15,640
2026									0.00	0.00	240.41	71.49	227.83	539.72	782,400	16,180	15,640
2027									0.00	0.00	240.41	71.49	227.83	539.72	782,400	16,180	15,640
2028									0.00	0.00	240.41	71.49	227.83	539.72	782,400	16,180	15,640
2029									0.00	0.00	240.41	71.49	227.83	539.72	782,400	16,180	15,640
2030									0.00	0.00	240.41	71.49	227.83	539.72	782,400	16,180	15,640
2032									0.00	0.00	240.41	71.49	227.83	539.72	782,400	16,180	15,640
2032									0.00	0.00	240.41	71.49	227.83	539.72	782,400	16,180	15,640
2033									0.00	0.00	240.41	71.49	227.83	539.72	782,400	16,180	15,640
2034									0.00	0.00	240.41	71.49	227.83	539.72	782,400	16,180	15,640
2035									0.00	0.00	240.41	71.49	227.83	539.72	782,400	16,180	15,640
Total	18,983.88	5,056.85	4,231.31	534.59	2,093.92	19,563.80	4,902.45	1,712.64	46,585.55	10,493.89					17,299,100		
														Financial IRR for the Project			13.44
														Net Present Value (at 11%)			50,238

Table 7.2-3 (3) FIRR of the Project (Sensitivity Analysis : Project Tariff -10%)

(US$ 1,000)

Year	115 kV Facilities					MV & LV Facilities			Total Capital		O & M Cost				Incremental Energy & Revenue		NPV
	TL Investment		SS Investment		Consult.	Investment		Consult.			TL	SS	MV & LV	Total	Energy	Revenue	
	FC	LC	FC	LC	FC	FC	LC	FC	FC	LC	FC+LC	FC+LC	FC+LC	FC+LC	(MWh)	($18.61/MWh)	
2003	0.00	10.00	0.00	0.00	607.00	0.00	0.00	0.00	607.00	10.00	0.00	0.00	0.00	0.00			-617
2004	8,253.86	2,193.63	1,839.70	232.43	606.90	904.00	226.00	79.10	11,683.56	2,652.06	0.00	0.00	0.00	0.00			-14,336
2005	8,253.86	2,193.63	1,839.70	232.43	606.90	904.00	226.00	79.10	11,683.56	2,652.06	0.00	0.00	0.00	0.00			-14,336
2006						904.00	226.00	79.10	983.10	226.00	209.05	62.16	22.60	293.81	27,900	519	-984
2007						904.00	226.00	79.10	983.10	226.00	209.05	62.16	33.90	305.11	69,200	1,288	-226
2008						904.00	226.00	79.10	983.10	226.00	209.05	62.16	45.20	316.41	117,700	2,190	665
2009						929.00	234.00	81.41	1,010.41	234.00	209.05	62.16	56.50	327.71	149,600	2,784	1,212
2010						929.00	234.00	81.41	1,010.41	234.00	209.05	62.16	68.13	339.34	202,500	3,769	2,185
2011						929.00	234.00	81.41	1,010.41	234.00	209.05	62.16	79.76	350.97	246,900	4,595	2,999
2012						929.00	234.00	81.41	1,010.41	234.00	209.05	62.16	91.39	362.60	290,700	5,410	3,803
2013						929.00	234.00	81.41	1,010.41	234.00	209.05	62.16	103.02	374.23	339,900	6,326	4,707
2014						1,171.00	293.00	102.48	1,273.48	293.00	209.05	62.16	114.65	385.86	379,600	7,064	5,112
2015						1,171.00	293.00	102.48	1,273.48	293.00	209.05	62.16	129.29	400.50	498,400	9,275	7,308
2016						1,171.00	293.00	102.48	1,273.48	293.00	209.05	62.16	143.93	415.14	540,200	10,053	8,071
2017						1,171.00	293.00	102.48	1,273.48	293.00	209.05	62.16	143.93	415.14	589,400	10,969	8,987
2018						1,171.00	293.00	102.48	1,273.48	293.00	209.05	62.16	158.57	429.78	636,700	11,849	9,853
2019						996.00	249.00	87.15	1,083.15	249.00	209.05	62.16	173.21	444.42	692,000	12,878	11,102
2020						996.00	249.00	87.15	1,083.15	249.00	209.05	62.16	185.66	456.87	782,400	14,560	12,771
2021									0.00	0.00	209.05	62.16	198.11	469.32	782,400	14,560	14,091
2022									0.00	0.00	209.05	62.16	198.11	469.32	782,400	14,560	14,091
2023									0.00	0.00	209.05	62.16	198.11	469.32	782,400	14,560	14,091
2024									0.00	0.00	209.05	62.16	198.11	469.32	782,400	14,560	14,091
2025									0.00	0.00	209.05	62.16	198.11	469.32	782,400	14,560	14,091
2026									0.00	0.00	209.05	62.16	198.11	469.32	782,400	14,560	14,091
2027									0.00	0.00	209.05	62.16	198.11	469.32	782,400	14,560	14,091
2028									0.00	0.00	209.05	62.16	198.11	469.32	782,400	14,560	14,091
2029									0.00	0.00	209.05	62.16	198.11	469.32	782,400	14,560	14,091
2030									0.00	0.00	209.05	62.16	198.11	469.32	782,400	14,560	14,091
2032									0.00	0.00	209.05	62.16	198.11	469.32	782,400	14,560	14,091
2032									0.00	0.00	209.05	62.16	198.11	469.32	782,400	14,560	14,091
2033									0.00	0.00	209.05	62.16	198.11	469.32	782,400	14,560	14,091
2034									0.00	0.00	209.05	62.16	198.11	469.32	782,400	14,560	14,091
2035									0.00	0.00	209.05	62.16	198.11	469.32	782,400	14,560	14,091
Total	16,507.72	4,397.26	3,679.40	464.86	1,820.80	17,012.00	4,263.00	1,489.25	40,509.17	9,125.12					17,299,100		
														Financial IRR for the Project			13.79
														Net Present Value (at 11%)			45,651

Table 7.2-3 (4) FIRR of the Project (Sensitivity Analysis : O & M Cost +50%)

(US$ 1,000)

Year	115 kV Facilities					MV & LV Facilities			Total Capital		O & M Cost				Incremental Energy & Revenue		NPV
	TL Investment		SS Investment		Consult.	Investment		Consult.			TL	SS	MV & LV	Total	Energy	Revenue	
	FC	LC	FC	LC	FC	FC	LC	FC	FC	LC	FC+LC	FC+LC	FC+LC	FC+LC	(MWh)	($20.68/MWh)	
2003	0.00	10.00	0.00	0.00	607.00	0.00	0.00	0.00	607.00	10.00	0.00	0.00	0.00	0.00			-617
2004	8,253.86	2,193.63	1,839.70	232.43	606.90	904.00	226.00	79.10	11,683.56	2,652.06	0.00	0.00	0.00	0.00			-14,336
2005	8,253.86	2,193.63	1,839.70	232.43	606.90	904.00	226.00	79.10	11,683.56	2,652.06	0.00	0.00	0.00	0.00			-14,336
2006						904.00	226.00	79.10	983.10	226.00	313.57	93.25	33.90	440.72	27,900	577	-1,073
2007						904.00	226.00	79.10	983.10	226.00	313.57	93.25	50.85	457.67	69,200	1,431	-236
2008						904.00	226.00	79.10	983.10	226.00	313.57	93.25	67.80	474.62	117,700	2,434	750
2009						929.00	234.00	81.41	1,010.41	234.00	313.57	93.25	84.75	491.57	149,600	3,094	1,358
2010						929.00	234.00	81.41	1,010.41	234.00	313.57	93.25	102.20	509.02	202,500	4,188	2,434
2011						929.00	234.00	81.41	1,010.41	234.00	313.57	93.25	119.64	526.46	246,900	5,106	3,335
2012						929.00	234.00	81.41	1,010.41	234.00	313.57	93.25	137.09	543.91	290,700	6,012	4,223
2013						929.00	234.00	81.41	1,010.41	234.00	313.57	93.25	154.53	561.35	339,900	7,029	5,223
2014						1,171.00	293.00	102.48	1,273.48	293.00	313.57	93.25	171.98	578.80	379,600	7,850	5,705
2015						1,171.00	293.00	102.48	1,273.48	293.00	313.57	93.25	193.94	600.76	498,400	10,307	8,140
2016						1,171.00	293.00	102.48	1,273.48	293.00	313.57	93.25	215.90	622.72	540,200	11,171	8,982
2017						1,171.00	293.00	102.48	1,273.48	293.00	313.57	93.25	237.86	644.68	589,400	12,189	9,978
2018						1,171.00	293.00	102.48	1,273.48	293.00	313.57	93.25	259.82	666.64	636,700	13,167	10,934
2019						996.00	249.00	87.15	1,083.15	249.00	313.57	93.25	281.78	688.60	692,000	14,311	12,290
2020						996.00	249.00	87.15	1,083.15	249.00	313.57	93.25	300.45	707.27	782,400	16,180	14,141
2021									0.00	0.00	313.57	93.25	319.13	725.95	782,400	16,180	15,454
2022									0.00	0.00	313.57	93.25	319.13	725.95	782,400	16,180	15,454
2023									0.00	0.00	313.57	93.25	319.13	725.95	782,400	16,180	15,454
2024									0.00	0.00	313.57	93.25	319.13	725.95	782,400	16,180	15,454
2025									0.00	0.00	313.57	93.25	319.13	725.95	782,400	16,180	15,454
2026									0.00	0.00	313.57	93.25	319.13	725.95	782,400	16,180	15,454
2027									0.00	0.00	313.57	93.25	319.13	725.95	782,400	16,180	15,454
2028									0.00	0.00	313.57	93.25	319.13	725.95	782,400	16,180	15,454
2029									0.00	0.00	313.57	93.25	319.13	725.95	782,400	16,180	15,454
2030									0.00	0.00	313.57	93.25	319.13	725.95	782,400	16,180	15,454
2032									0.00	0.00	313.57	93.25	319.13	725.95	782,400	16,180	15,454
2032									0.00	0.00	313.57	93.25	319.13	725.95	782,400	16,180	15,454
2033									0.00	0.00	313.57	93.25	319.13	725.95	782,400	16,180	15,454
2034									0.00	0.00	313.57	93.25	319.13	725.95	782,400	16,180	15,454
2035									0.00	0.00	313.57	93.25	319.13	725.95	782,400	16,180	15,454
Total	16,507.72	4,397.26	3,679.40	464.86	1,820.80	17,012.00	4,263.00	1,489.25	40,509.17	9,125.12					17,299,100		
														Financial IRR for the Project			14.56
														Net Present Value (at 11 %)			50,461

Table 7.2-3 (5) FIRR of the Project (Sensitivity Analysis : Energy sold - 30%)

(US$ 1,000)

Year	115 kV Facilities					MV & LV Facilities			Total Capital		O & M Cost				Incremental Energy & Revenue		NPV
	TL Investment		SS Investment		Consult.	Investment		Consult.			TL	SS	MV & LV	Total	Energy	Revenue	
	FC	LC	FC	LC	FC	FC	LC	FC	FC	LC	FC+LC	FC+LC	FC+LC	FC+LC	(MWh)	($20.68/MWh)	
2003	0.00	10.00	0.00	0.00	607.00	0.00	0.00	0.00	607.00	10.00	0.00	0.00	0.00	0.00			-617
2004	8,253.86	2,193.63	1,839.70	232.43	606.90	904.00	226.00	79.10	11,683.56	2,652.06	0.00	0.00	0.00	0.00			-14,336
2005	8,253.86	2,193.63	1,839.70	232.43	606.90	904.00	226.00	79.10	11,683.56	2,652.06	0.00	0.00	0.00	0.00			-14,336
2006						904.00	226.00	79.10	983.10	226.00	209.05	62.16	22.60	293.81	19,530	404	-1,099
2007						904.00	226.00	79.10	983.10	226.00	209.05	62.16	33.90	305.11	48,440	1,002	-512
2008						904.00	226.00	79.10	983.10	226.00	209.05	62.16	45.20	316.41	82,390	1,704	178
2009						929.00	234.00	81.41	1,010.41	234.00	209.05	62.16	56.50	327.71	104,720	2,166	593
2010						929.00	234.00	81.41	1,010.41	234.00	209.05	62.16	68.13	339.34	141,750	2,931	1,348
2011						929.00	234.00	81.41	1,010.41	234.00	209.05	62.16	79.76	350.97	172,830	3,574	1,979
2012						929.00	234.00	81.41	1,010.41	234.00	209.05	62.16	91.39	362.60	203,490	4,208	2,601
2013						929.00	234.00	81.41	1,010.41	234.00	209.05	62.16	103.02	374.23	237,930	4,920	3,302
2014						1,171.00	293.00	102.48	1,273.48	293.00	209.05	62.16	114.65	385.86	265,720	5,495	3,543
2015						1,171.00	293.00	102.48	1,273.48	293.00	209.05	62.16	129.29	400.50	348,880	7,215	5,248
2016						1,171.00	293.00	102.48	1,273.48	293.00	209.05	62.16	143.93	415.14	378,140	7,820	5,838
2017						1,171.00	293.00	102.48	1,273.48	293.00	209.05	62.16	143.93	415.14	412,580	8,532	6,551
2018						1,171.00	293.00	102.48	1,273.48	293.00	209.05	62.16	158.57	429.78	445,690	9,217	7,221
2019						996.00	249.00	87.15	1,083.15	249.00	209.05	62.16	173.21	444.42	484,400	10,017	8,241
2020						996.00	249.00	87.15	1,083.15	249.00	209.05	62.16	185.66	456.87	547,680	11,326	9,537
2021									0.00	0.00	209.05	62.16	198.11	469.32	547,680	11,326	10,857
2022									0.00	0.00	209.05	62.16	198.11	469.32	547,680	11,326	10,857
2023									0.00	0.00	209.05	62.16	198.11	469.32	547,680	11,326	10,857
2024									0.00	0.00	209.05	62.16	198.11	469.32	547,680	11,326	10,857
2025									0.00	0.00	209.05	62.16	198.11	469.32	547,680	11,326	10,857
2026									0.00	0.00	209.05	62.16	198.11	469.32	547,680	11,326	10,857
2027									0.00	0.00	209.05	62.16	198.11	469.32	547,680	11,326	10,857
2028									0.00	0.00	209.05	62.16	198.11	469.32	547,680	11,326	10,857
2029									0.00	0.00	209.05	62.16	198.11	469.32	547,680	11,326	10,857
2030									0.00	0.00	209.05	62.16	198.11	469.32	547,680	11,326	10,857
2032									0.00	0.00	209.05	62.16	198.11	469.32	547,680	11,326	10,857
2032									0.00	0.00	209.05	62.16	198.11	469.32	547,680	11,326	10,857
2033									0.00	0.00	209.05	62.16	198.11	469.32	547,680	11,326	10,857
2034									0.00	0.00	209.05	62.16	198.11	469.32	547,680	11,326	10,857
2035									0.00	0.00	209.05	62.16	198.11	469.32	547,680	11,326	10,857
Total	16,507.72	4,397.26	3,679.40	464.86	1,820.80	17,012.00	4,263.00	1,489.25	40,509.17	9,125.12					12,109,370		
														Financial IRR for the Project			11.35
														Net Present Value (at 11%)			32,698

CHAPTER VIII

CONCLUSION AND RECOMMENDATION

Chapter 8 Conclusion and Recommendation

Part I of this report selected the section of Pakxan-Thakhek-Pakbo for the highest priority project among the formulated optimum transmission and substation system by the year 2020 in Lao PDR. This chapter summarizes the results of facility design of the highest priority project and the recommendation on the works pre-established by EDL towards implementation of the project.

8.1 Conclusion

(1) Location of 115 kV Substations

Locations of the substations under the Project were determined in consideration of the existing substations and a planned substation of EDL.

Pakxan substation under the Project was selected to be at the existing 115 kV Pakxan substation that is to be reinforced with a new transformer under SPRE project of IDA. Layout of new 115 kV bays for the 115 kV transmission line to Thakhek substation will be constructed in the premises of this existing Pakxan substation coordinating with the SPRE reinforcement plan.

EDL has a specific plan to construct a new 115 kV substation in the suburb of Thakhek City for supplying imported energy for construction use of Nam Theun 2 hydropower station and for the existing 22 kV substation in the town. Adequate land for the new substation has been secured by EDL, and the substation is to be completed in the year 2004. In the premises of the new Thakhek substation, the facilities under the Project will be arranged for interconnection with Pakxan and Pakbo substations.

The new 115 kV line from Thakhek under the Project was determined to be connected with the existing EDL 115 kV Pakbo substation. Additional transmission line bays and extension of the existing building in the substation are required under the Project.

(2) Selection of 115 kV Transmission Line

The 115 kV transmission line route was selected in careful examinations on the environmental protection law of the Government of Lao PDR, MIH's regulation on EA for electricity projects, regional development plans, general regulation for land use, remnant situation of UXO, and others.

Information and advice of EDL branch offices for security of the facilities, avoidance of villages and

schools, circumvention of NBCA or protective woods, etc. were referred to selection of the route. The selected route runs principally along Route 13. The line passes mostly in flat area covered by paddy field and bush except a particular section. Since soil condition along the selected route deems firm, application of special foundation to towers is not anticipated. Owing to easy approach to the route from the national route and flat terrain, serious difficulties for construction and maintenance of the line are not found if the construction works will be scheduled taking into account the field condition in rainy season.

(3) Design of Transmission Line and Substation Facilities

The Project constitutes a part of the national trunk power system as discussed in Chapter 6 of Part I. In this light, N-1 criterion was applied for stability of the system. Facilities for the Project were designed on the bases of examination results of local climatic records, results of the system analysis conducted by the team, Laotian Electric Power Technical Standard established by JICA STEP team, and international standards applied for the similar projects in Lao PDR.

Total length of 115 kV line providing with double circuits of ACSR 240 mm^2 for Pakxan - Thakhek - Pakbo section is approximately 300 km on the 1:100,000 maps. Total number of towers in the section was estimated at 860 for a standard span length of 350 m, 775 towers out of which are of suspension type and 85 towers of tension/terminal type. The team worked out sample designs of standard towers and their foundations, figured by minimum ground clearance and minimum insulation clearance of power conductors. Insulation design of 115 kV transmission line examined in Part I was confirmed appropriate.

Design of the substations was achieved for extension of the existing facilities as stated above. Transformers for Pakxan and Pakbo substations are to be reinforced under the SPRE project, and new transformers for Thakhek substation are to be installed also under the SPRE project before anticipated completion of the Project. The Project will not need additional transformers for the substations, but will add and modify transmission line bays with the related switchgear and ancillaries required for the planned system interconnection at the substations.

(4) Project Cost and Cost Disbursement Schedule

Following table summarizes the Project cost estimated for required facilities. Costs were estimated on the bases of those for the recent ICB contracts for the similar projects in Lao PDR and the current trend of materials in the world market. Total Project cost was estimated at approximately US$ 27.7 million.

Table 8.1-1 Estimated Project Cost

Items	FC (US$)	LC (US$)	Total (US$)
Transmission Lines	15,005,200	3,987,500	18,992,700
Substation Facilities	3,344,900	422,600	3,767,500
Sub-total	18,350,100	4,410,100	22,760,200
Lands & ROW Compensation	0	10,000	10,000
UXO Survey & Clearance	2,000	1,000	3,000
Consultant Fee	1,820,800	0	1,820,800
Physical Contingency	1,835,000	441,000	2,276,000
Price Contingency	550,500	352,800	903,300
Ground Total	22,558,400	5,214,900	27,773,300

With reference to anticipated implementation schedule for the Project, disbursement of the project cost was scheduled in the following table.

Table 8.1-2 Estimated Disbursement Schedule of Project Cost

Year	FC (US$)	LC (US$)	Total (US$)
1st	607,000	10,000	617,000
2nd	10,975,700	2,602,450	13,578,150
3rd	10,975,700	2,602,450	13,578,150
Total	22,558,400	5,214,900	27,773,300

(5) Project Implementation Schedule

The Project will be completed through the following steps.

Table 8.1-3 Project Implementation Schedule

Stage		Major Works
Detailed Design	:	(a) Route survey and investigation (including UXO investigation) (b) Preparation of Detailed Design Report and approval (c) Preparation of Bid Documents and invitation to bidders (d) Acceptance of EA and land procurement/compensation
Bid Floating	:	Preparation of proposals by bidders and submission to EDL
Evaluation of Bids	:	Evaluation on bids, evaluation report and approval by authorities
Contracts	:	Conclusion of contract and approval of the documents
Contractors' Design	:	Design of equipment and materials by manufacturers
Local Construction	:	All field erection works by contractors
Commission. Tests	:	Comprehensive commissioning test of line and substations

It will take minimum 13 months for preparatory stage covering the period from the detailed study to approval of the contracts after assignment of the consultants. Further, a period of minimum 23 months is scheduled from approval of contract documents with the suppliers to completion of the commissioning test. Total 36 months will be needed for completion of the Project after assignment of the project consultants.

(6) Effect of Project

As described in Section 8.5 of Part I, major effects of the Project are (i) efficient utilization of surplus electric energy through the interconnection system, (ii) saving of foreign exchange owing to reduction of imported energy, (iii) contribution to about 980 thousand electrified beneficiaries, (iv) improvement of social circumstance in the related regions, (v) economic impact to the project area, (vi) start-up of development of domestic transmission system, and others.

(7) Economic and Financial Evaluation of Project

Evaluation of the Project was examined in comparison of EIRR and FIRR with OCC for Lao PDR to be 11 %.

The Project will activate power interconnection between Central 1 and Central 2 regions, and in the future with Southern region. Its benefits will be the substitute for imported electricity from the EGAT system of Thailand. The Project will accrue benefits due to avoided wheeling fee assumed for the EIRR analysis. While, FIRR analysis will be based on the incremental sales revenues to EDL from the demand at Thakhek, Pakbo, and Kengkok that are immediately deliverable from the Project.

Following table shows the results of EIRR, FIRR and sensitivity analyses for the Highest Priority Project. The Project in any case is higher than 11% OCC, and considered viable in both economic and financial terms.

Results of Computation for EIRR and FIRR

	Economic IRR		Financial IRR	
	EIRR (%)	NPV_{2002}	FIRR (%)	NPV_{2002}
Base Case	23.93	31,347	14.87	52,137
Investment + 15 %	21.35	28,024	13.44	50,238
Project tariff –10 %	21.96	25,997	13.79	45,651
O & M Cost + 50 %	23.58	30,485	14.56	50,461
Energy sold –30 %	17.80	15,295	11.35	32,698

8.2 Recommendation

Implementation of the Project is necessary for its effect and results of the evaluation on it. However, there are several particulars to clear in advance of commencement of development. Following are proposal and/or recommendation of the study team to MIH/EDL for clearing the particulars and for the proper operation plan of the Project after its completion.

(1) Environmental Assessment

In accordance with the MIH regulation, EA (Environmental Assessment) for the Project should be

immediately carried out for STEA's approval of the Project. It will take 45 days at least for obtaining the environmental certificate. Supposing additional examination or assessment to the Project is required by STEA, it will take further 147 days as ruled in the regulation. EDL is recommended to submit EA report immediately for securing the possibility of project realization. Most information necessary for preparing the EA report is available in this report.

(2) Securing of Land for Project

Land issue for 3 substations will not exist, since all facilities of substations under the Project are to be installed in the premises of existing substations. The transmission line route selected referring to information and advice of EDL branch offices is shown on the enclosed 1:100,000 maps. The basic route is selected avoiding villages and urban districts, number of houses to be resettled will be limited as of June 2002. Final number of houses for resettlement will be disclosed after completion of topographic field survey carried out during the detailed design stage. However, securement of land and right-of-way for the transmission line is possible referring to the route maps. The team proposes EDL to arrange the securement works with the authorities of Project area in an adequate advance.

(3) Arrangement of Project Finance

It is also an urgent particular that MIH/EDL should request the project finance to a certain international supporting organization. The estimated project cost is approximately US$ 27.7 Million on the basis of ICB. All information necessary for preparing the application documents for the request is available in this report.

(4) Operation Plan of Project after Completion

In light of the rapid development of new EDL 115 kV, MV and LV facilities, the team reviewed the present EDL's operation and maintenance system of the facilities. Results of the review and recommendation on reinforcement of the system, urgent development of manpower for operation and maintenance of facilities utilizing EDL training center, and others are discussed in Chapter 5 of Part II. Following are main recommendations of the team.

(a) Designation of full responsibility for operation and & maintenance system
(b) Reinforcement of TSD in Distribution Division
(c) Arrangement of substation maintenance group to EDL branch office
(d) Increase of and education to manpower for operation and maintenance of facilities
(e) Re-education of present manpower
(f) Establishment of LDC for comprehensive management of power system in the country