No. 1

BASIC DESIGN STUDY
ON
THE PROJECT FOR REINFORCEMENT
OF
POWER DISTRIBUTION NETWORK IN ADDIS ABABA
IN
THE FEDERAL DEMOCRATIC REPUBLIC OF
ETHIOPIA

DECEMBER, 1997

JAPAN INTERNATIONAL COOPERATION AGENCY
YACHIYO ENGINEERING CO., LTD.

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PREFACE

In response to a request from the Government of the Federal Democratic Republic of Ethiopia, the Government of Japan decided to conduct a basic design study on the Project for Reinforcement of Power Distribution Network in Addis Ababa and entrusted the study to the Japan International Cooperation Agency (JICA).

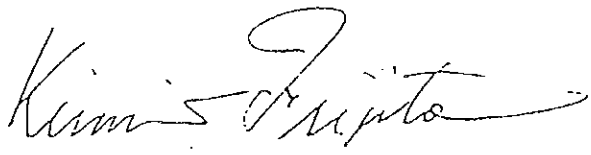
JICA sent to Ethiopia a study team from July 27 to August 30, 1997.

The team held discussions with the officials concerned of the Government of Ethiopia, and conducted a field study at the study area. After the team returned to Japan, further studies were made. Then, a mission was sent to Ethiopia in order to discuss a draft basic design, and as this result, the present report was finalized.

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

I wish to express my sincere appreciation to the officials concerned of the Government of the Federal Democratic Republic of Ethiopia for their close cooperation extended to the teams.

December, 1997



Kimio Fujita
President
Japan International Cooperation Agency

LETTER OF TRANSMITTAL

December, 1997

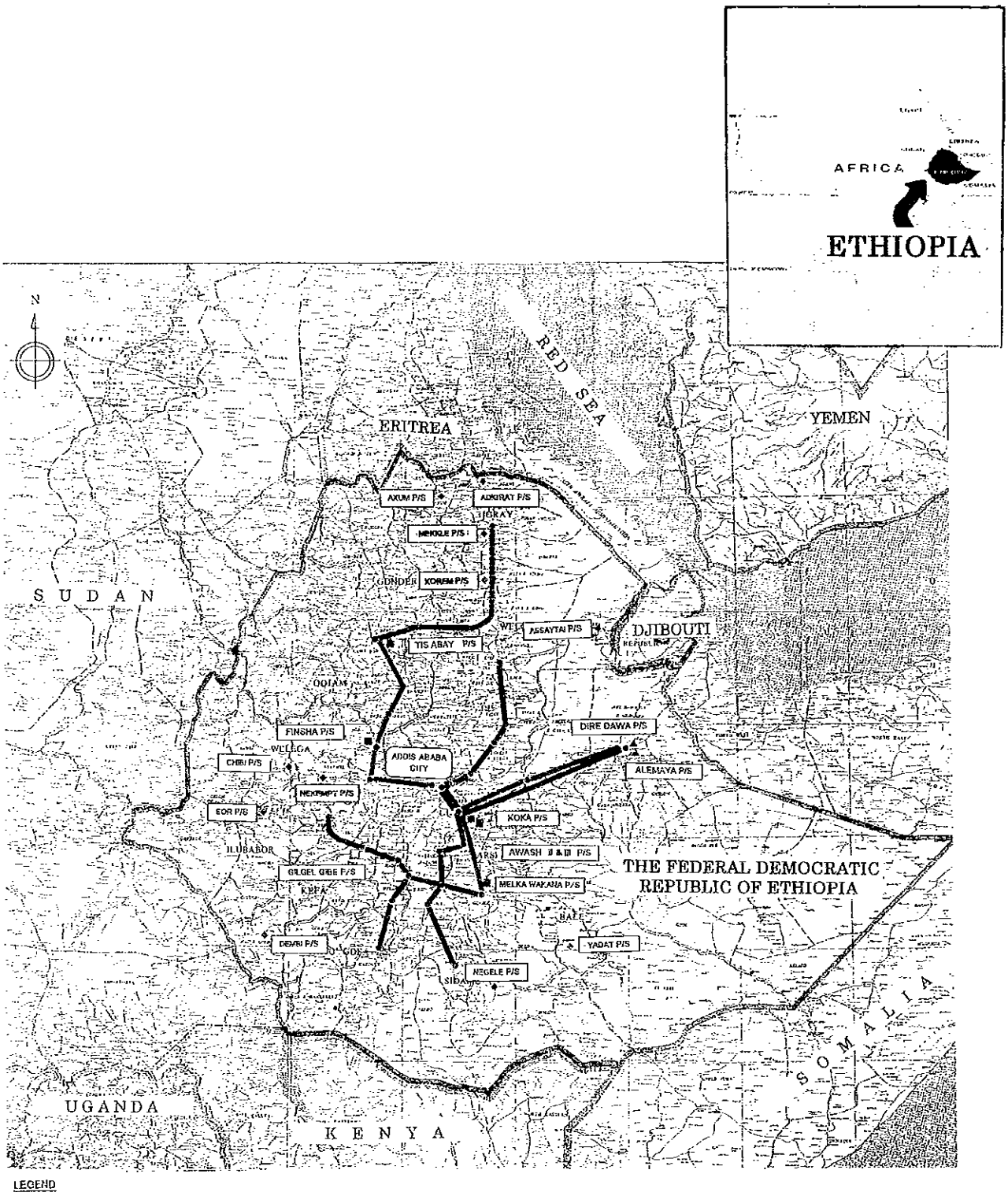
We are pleased to submit to you the basic design study report on the Project for Reinforcement of Power Distribution Network in Addis Ababa in the Federal Democratic Republic of Ethiopia.

This study was conducted by Yachiyo Engineering Co., Ltd., under a contract to JICA, during the period from July 9, 1997 to January 23, 1998. In conducting the study, we have examined the feasibility and rationale of the project with due consideration to the present situation of Ethiopia and formulated the most appropriate basic design for the project under Japan's grant aid scheme.

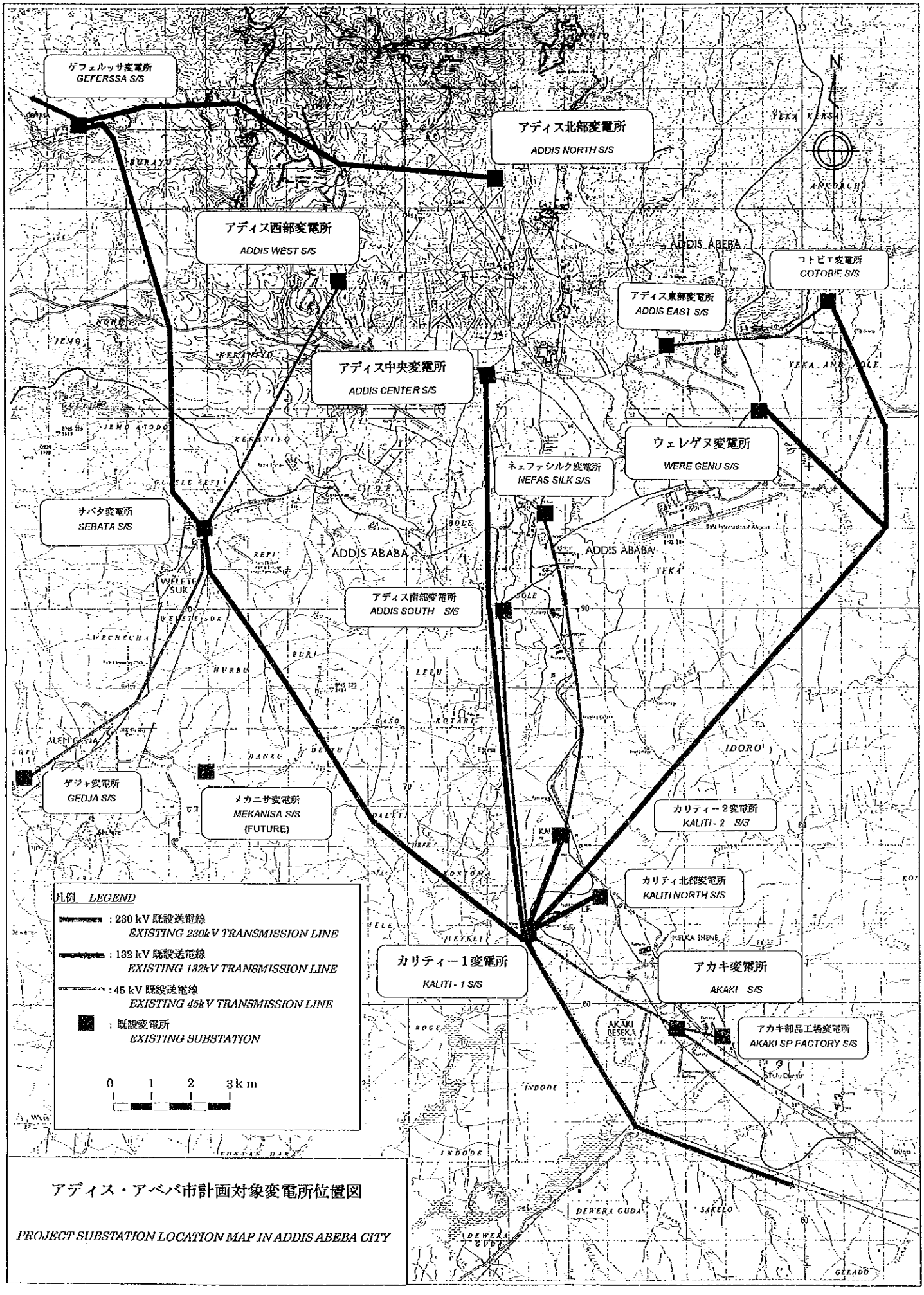
Finally, we hope that this report will contribute to further promotion of the project.

Very truly yours,

Mitsuhisa Nishikawa
Project Manager,
Basic design study team on
the Project for Reinforcement of Power
Distribution Network in Addis Ababa
Yachiyo Engineering Co., Ltd.

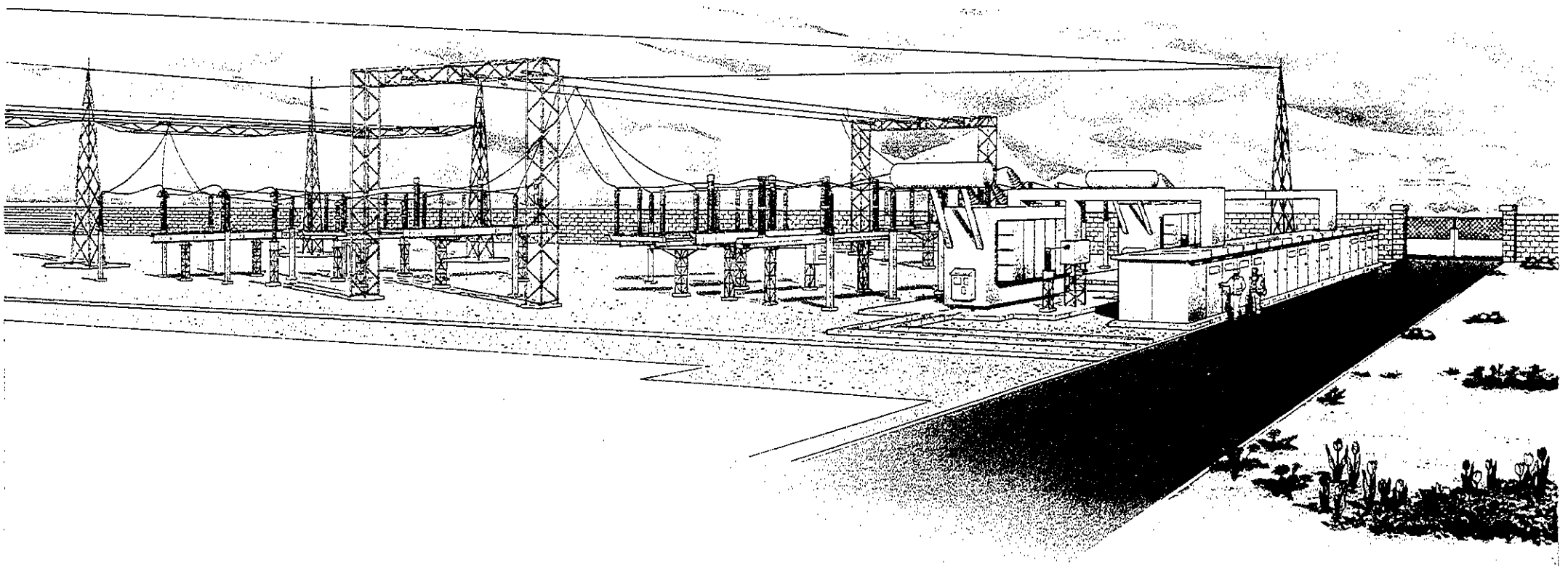


ETHIOPIA LOCATION MAP



アディス・アベバ市計画対象変電所位置図

PROJECT SUBSTATION LOCATION MAP IN ADDIS ABEBA CITY



The Project for Reinforcement of Power Distribution Network in Addis Ababa in the Federal Democratic Republic of Ethiopia

ABBREVIATIONS

C B D	Central Business District
E E P C O	Ethiopian Electric Power Corporation
E I B	Europian Investment Bank
E／N	Exchange of Notes
E P R D F	Ethiopian People's Revolutionary Democratic Front
E S M A P	Energy Sector Management Assistance Programme
G D P	Gross Domestic Product
G N P	Gross National Product
I C S	Inter-connected System
I E C	International Electrotechnical Commission
I M F	International Monetary Fund
J E A C	Japan Electric Association Code
J E C	Japanese Electrotechnical Committee
J E M	Standards of Japan Electrical Manufacturer's Association
J I C A	Japan International Cooperation Agency
J I S	Japanese Industrial Standards
N E M A	National Electrical Manufacturers Association
O&M	Operation and Maintenance
O J T	On the Job Training
O L T C	On-Load Tap Changer
S C A D A	Supervisory Control and Data Acquisition
S C S	Self-contained System
U N D P	United Nations Development Programme
U N I C E F	United Nations Children's Fund

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CHAPTER 1 BACKGROUND OF THE PROJECT

CHAPTER 1 BACKGROUND OF THE PROJECT

The Federal Democratic Republic of Ethiopia (hereinafter referred to as "Ethiopia") is located in the northeastern corner of Africa, i.e., an area called the Horn of Africa. It has a total land area of some 1,222,000 km^2, and a population of some 54.1 million (1994). Approximately two-thirds of the national land is located on the African Plateau, an altitude of which ranges from 1,500 m to 3,000 m. Addis Ababa, the capital of Ethiopia and the political and commercial center of the country, is also located on highland of some 2,500 m above sea level. As of 1994, Addis Ababa has a population of some 2.11 million, accounting for some 4% of the national population.

The entire power sector is run by the Ethiopian Electric Power Corporation (EEPCO), 100% owned by the government, whose work ranges from the planning and construction of generation, substation, transmission and distribution facilities to their operation and maintenance as well as collection of the electricity charge. While the power consumption of Addis Ababa accounts for approximately half of the national consumption, the supply situation is unstable due to deterioration of the distribution network and an insufficient distribution capacity to meet the demand. The resulting daily restrictions on the load hinders urban functions. The anticipated sharp increase in the city's population also necessitates urgent improvement of the distribution network.

Lake Tana, the source of the Blue Nile, is located in Ethiopia and has a large enough power generations potential for the government to plan the sale of electricity to neighbouring countries. A critical problem of the power supply is that the development of the distribution network in Addis Ababa, the center of the power demand, has been slow. Consolidation of the distribution network in Addis Ababa is important as this network plays a central role in the Inter-Connected System (ICS). Given such prominent importance, the five year national development plan for 1995 - 2000 (Programme of EPRDF for Development, Peace and Democracy 1995) adopts a target of "guaranteeing urgent economic growth to benefit all people" and promotes the development of infrastructure, including the distribution network, as part of the concrete measures to achieve "the urgent growth of the urban economy and improvement of the living conditions".

From the funding point of view, however, as the Government of Ethiopia is facing an tight public finance situation, it is forced to rely on foreign aid to fund distribution network development which demands a huge injection of budget. Under these circumstances, the Government of Ethiopia made a request to the Government of Japan for the provision of grant aid for the reinforcement of the distribution network in Addis Ababa (here in after referred to as "the Project").

Through the discussions between Japan and Ethiopia, it was found that the contents of the original Ethiopian request mainly consisted of the partial supply of equipment and materials to cover the

entire distribution network in Addis Ababa and contained a mixture of urgent measures and long-term measures to reinforce and expand the distribution network. Based on this finding, the Study Team conducted a field survey on the subjects area that a comprehensive review of the original request was necessary and proposed that the Government of Ethiopia revise the request to clearly present the actual contribution by Japanese grant aid by emphasising the following issues.

① Rehabilitation of the greatly deteriorated Addis Center Substation which is responsible for power supply for the key central areas of Addis Ababa

② Rehabilitation of the Akaki Substation which is responsible for power supply for residential commercial and industrial areas in the southern part of the city also where rapid industrialisation is taking place

③ Renewal of the transformers at the Addis North Substation and Addis West Substation, the power supply capacity of which has significantly declined due to breakdowns or aging of the existing transformers

④ Rehabilitation of the distribution lines which are suffering from voltage drops and/or power losses due to the insufficient size of the distribution conductors of the 15 kV distribution network in Addis Ababa and prevention of damage to the distribution facilities by lightning

The Government of Ethiopia showed a flexible response to the above proposal and agreed to withdraw the request for ① 230 kV switchgear of transmission line for the western part of the city, the urgency of which is not priority, and ② telecommunication equipment as the existing one is performing satisfactorily and also agreed to scale down the request for vehicles associated with the construction and maintenance of the distribution network to the minimum level to be covered by Japan's grant aid Project. Table 1-1 shows the contents of the original request and their revisions while Fig. 1-1 shows the position of the substations subject to the Project based on the revised request in the overall transmission network in Addis Ababa.

Table 1-1 Comparison of Original and Revised Requests

Subject Substation/ Item	Original Request	Revised Request
1. Addis Center Substation	—	Equipment procurement and installation 1) Main transformer (132/15 kV; 25/31.5 MVA): 2 units 2) 132 kV switchgear: 1 lot 3) 15 kV outgoing feeder panel: 13 feeders 4) Control and protection panels, fire extinguishers and cabling for the above: 1 lot 5) Foundations
	Equipment procurement • Renewal of 15 kV outgoing feeder cables (13 lines)	Equipment procurement • As left
2. Akaki Substation	Equipment procurement • Main transformer (45/15 kV, 12 MVA): 1 unit	Equipment procurement and installation 1) Main transformer (45/15 kV, 9/12 MVA): 1 unit 2) 45 kV switchgear: 1 lot 3) 15 kV outgoing feeder panel: 4 feeders 4) Control and protection panels, fire extinguishers and cabling for the above: 1 lot 5) Foundations and control building
3. Addis North Substation	Equipment procurement • Main transformer (132/15 kV, 20 MVA: 2 units)	Equipment procurement • Main transformer (132/15 kV, 20/25 MVA): 2 units
4. Addis East Substation	Equipment procurement • Main transformer (45/15 kV, 12 MVA): 1 unit	(Changed to Addis West Substation)
5. Addis West Substation	—	Equipment procurement • Main transformer (45/15 kV, 9/12 MVA): 1 unit
6. Exiting 15 kV Overhead Distribution Lines	Equipment procurement 1) 15 kV conductors and accessories: some 70 km 2) Surge arresters (15 kV, 10 kA): 2,000 units	Equipment procurement 1) Bare conductors to rehabilitate existing 15 kV overhead distribution lines: 77 km 2) Surge arresters for above: 2,000 units 3) 15 kV underground cable for Were Genu Substation: 50 m × 5 lines
7. Maintenance Vehicles and Tools	Equipment procurement • Work vehicles and tools: 1 set	Equipment procurement 1) Street lighting vehicle: 1 unit 2) Truck with five ton crane: 1 unit
8. Were Genu Substation	Equipment procurement • 15 kV overhead distribution conductors: 4 lines x 5 km = 20 km	Equipment procurement 1) Materials to construct 15 kV overhead distribution lines: 40 km in total 2) 15 kV outgoing feeder panels: 4 feeders
9. Kaliti-1 Substation	Equipment procurement • Main transformer (132/45/15 kV, 22 MVA): 1 unit	Equipment procurement • Main transformer (132/45/15 kV, 22/22/7.3 MVA): 1 unit
10. Switchgear for 230 kV Transmission Line	Equipment procurement • Switchgear for transmission line from Kaliti Substation to Sebata and Geferssa Substations	Withdrawn from the request
11. Telecommunication Equipment	Equipment procurement • Portable radio: 1 unit	Withdrawn from the request

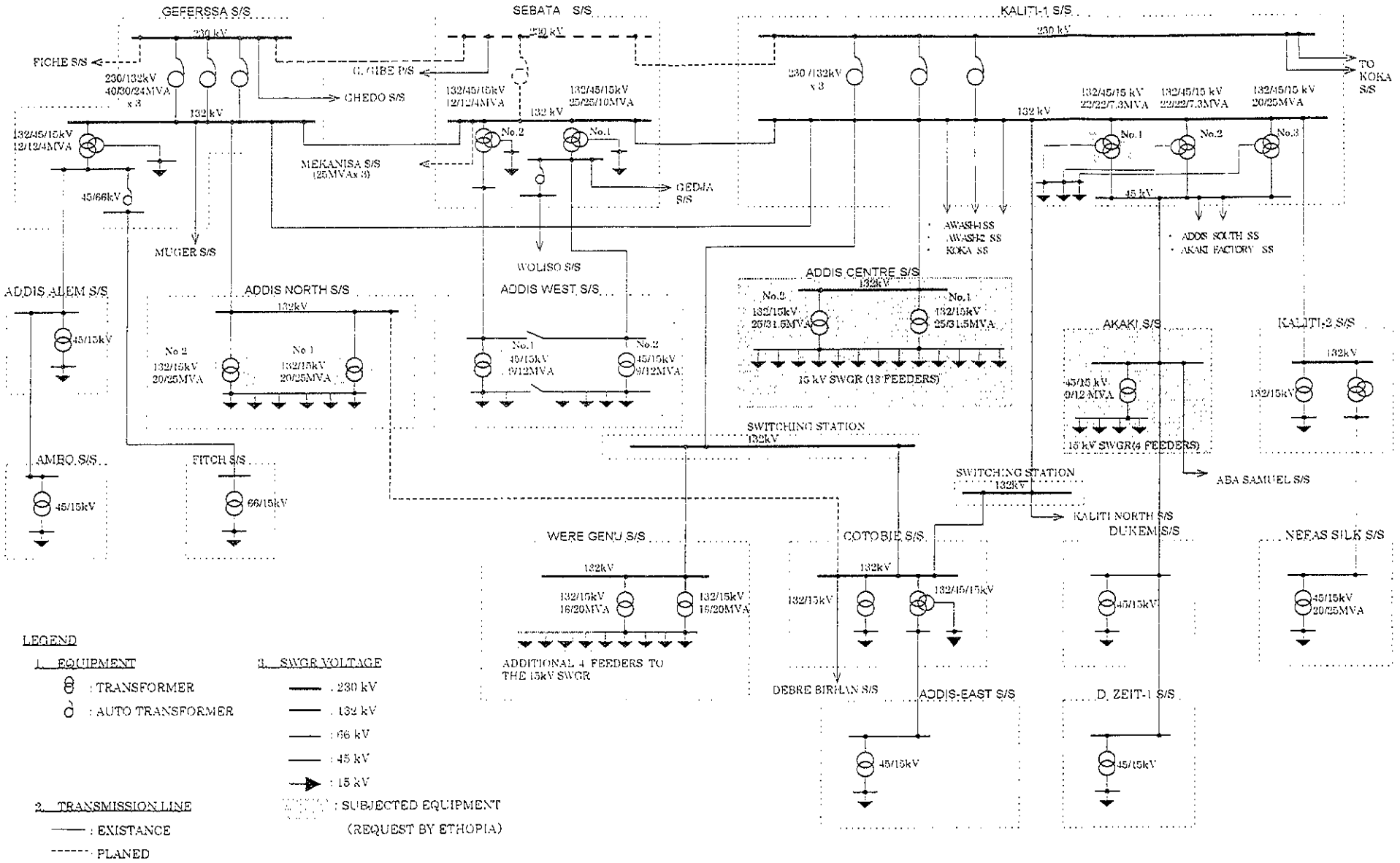

Fig. 1-1 Position of Substations Subject to the Project in the Addis Ababa Transmission System

CHAPTER 2 CONTENTS OF THE PROJECT

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2-1 Objectives of the Project

The Government of Ethiopia has adopted the improvement of living conditions, mainly featuring growth of the urban economy and infrastructure development, as the main target of the Five Year National Development Plan in order to urgently restore the domestic socioeconomic conditions which have been impoverished due to the civil war.

The objectives of the Project are to improve the living conditions of residents of Addis Ababa, the capital of Ethiopia, and to ensure the stability of its urban functions by means of rehabilitating distribution substations and strengthening/expanding the distribution network with a view to establishing a stable power supply system in the capital region which is a task to be materialized by the power sector to achieve the above-mentioned national target.

2-2 Basic Concept of the Project

The achievement of rapid economic growth in Ethiopia is aimed at under the new political regime established in 1992 and the development of the power supply network is considered an urgent task together with the development of road, water supply and telecommunication networks as a measure "to ensure urgent economic growth benefitting all Ethiopians" which is a target adopted by the Five Year National Development Plan.

In particular, the capital, Addis Ababa, which accounts for some 50% of the total electricity consumption in Ethiopia, has recorded growth of the electricity demand of some 165% in the last five years (average annual rate of 10.5%) and this trend of an ever increasing electricity demand appears to be continuing in view of the demographic forecast and trend of economic activities. The demand forecast of the Study Team suggests that the Addis Ababa power demand in the year 2005 will be approximately 1.6 times (maximum demand: approximately 317 MW) the current level in 1997. Consequently, urgent improvement of the distribution network to support the forecast demand for Addis Ababa is essential to successfully achieve the target adopted by the Five Year National Development Plan (refer to Appendix-6).

Despite the need to effectively meet the growing power demand, the existing distribution network in Addis Ababa was largely constructed between 1958 and 1982 and shows signs of serious deterioration. In addition, the lack of capacity of the transformers at the distribution substations and also of the 15 kV distribution lines to meet the growing power demand and the lack of lightning protection facilities for distribution lines have led to almost daily restrictions on the load

as well as faults involving distribution lines, resulting in a very tight electricity supply situation. Concern is expressed in regard to the decline of urban functions and the delay of, among others, socioeconomic development in Addis Ababa.

The basic concept of the Project requested by Ethiopia is to urgently improve the current electricity supply situation for the entire city of Addis Ababa by means of replacing the highly deteriorated existing substation and distribution facilities to alleviate the severe load restrictions and faults involving distribution lines and also to contribute to the creation of a stable distribution capacity upto the year 2005 and the following components of the Project have been finalized by examining the contents of the final request made by the Ethiopian side shown in Table 1-1 while referring to the findings of the field survey as well as analysis in Japan.

(1) Rehabilitation of Addis Centre Substation

This substation is responsible for supplying power to the central area of Addis Ababa. Although the demand forecast for the year 2005 is put at approximately 63 MVA, the current output of the transformers has declined to the some 50% (33 MVA) level of the required output due to aging (the existing equipment was manufactured 39 years ago). In addition, almost all control, protective and instrumentation equipment is out of order, making the operation of the substation extremely dangerous. Under these circumstances, rehabilitation of the entire substation as requested by the Ethiopian side is deemed appropriate and, therefore, full-scale rehabilitation of the substation to meet the demand forecast will be conducted under the Project.

Two new 31.5 MVA transformers meeting IEC standards will be installed at the substation to meet the demand forecast for 2005 of approximately 63 MVA and the necessary switchgear and other auxiliary equipment will be provided. On completion of the rehabilitation work, the substation will be capable of providing a reliable and stable power supply to the central area of Addis Ababa.

(2) Renewal of Transformer at Addis West Substation

Of the two existing transformers, the output of one transformer has declined to some 54% of the rated capacity (12 MVA) while producing an abnormally high temperature. In addition, the same transformer causes the circuit breaker to trip whenever it is operated continuously for a certain length of time, making normal operation of the substation practically impossible. As it is judged that this transformer is completely beyond repair, the Ethiopian side's requested renewal of the transformer is appropriate. Accordingly, a new transformer will be procured under the Project as a replacement.

Given the demand forecast for this substation in 2005 of approximately 23.5 MVA, the capacity of the new transformer will be the same as the capacity of the existing deteriorated one (12 MVA). The existing healthy transformer (12 MVA) which can continue to be used to provide a combined output the new transformer which meets the demand forecast for 2005. With the renewal of one transformer, therefore, consumers in the area will receive a stable power supply.

(3) Renewal of Transformer at Kaliti-1 Substation

The transformer of which renewal has been requested is 32 years old and suffers from continuous oil leakage from the flange part of the neutral bushing due to aging, creating a fire hazard. As it is judged that this transformer is completely beyond repair, the Ethiopian side's requested renewal of the transformer is appropriate. Accordingly, a new transformer will be procured under the Project as a replacement.

Given the demand forecast for the 15 kV distribution network of the Kaliti-1 Substation in 2005 of approximately 23.5 MVA, the capacity of the new transformer will be the same as the existing deteriorated one (22/22/7.3 MVA). Two other existing healthy transformers (22/22/7.3 MVA) which can continue to be used to provide a combined output with the new transformer which meets the demand forecast for 2005. The procurement and installation of a new transformer will not only provide a stable power supply for consumers in the area but will also ensure reliable power transmission to six secondary substations linked to the Kaliti-1 Substation.

(4) Renewal of Transformers at Addis North Substation

The output of the two existing transformers (12 MVA each) at the Addis North Substation which have been in operation for the past 15 years has declined to approximately 60% of the rated output and the current power demand in the area is barely met by the use of a mobile transformer (16 MVA).

The demand forecast for the Addis North Substation in 2005 of approximately 50 MVA means that the existing transformers are incapable of meeting the demand even if they operate at the rated capacity, making the Ethiopian side's request for the renewal of these transformers appropriate. Accordingly, two new transformers (25 MVA each) will be procured under the Project to meet the demand forecast for 2005 (50 MVA). With their procurement, consumers will be free from load restrictions and regular power cuts to enjoy a stable supply of power.

(5) Rehabilitation of Akaki Substation

It is more than 39 years since the Akaki Substation commenced operation and not only the transformers (3 units with a rated output of 3 MVA each but a current total output of 4 MVA) but also all other equipment are very aged, failing to perform adequately, and the continuous operation of the substation is dangerous. As the total rehabilitation of the substation as requested by the Ethiopian side is highly appropriate, the substation will be totally rehabilitated under the Project to meet the demand forecast for 2005 (12 MVA).

One 12 MVA transformer meeting IEC standards will be installed to meet the demand forecast for 2005 of approximately 12 MVA and switchgear, an outgoing feeder panel and other auxiliary equipment will also be provided as required. With the completion of this rehabilitation work, the Akaki Substation will be able to provide a highly reliable and stable power supply to residential as well as industrial quarters in the Akaki area.

(6) Procurement of Equipment and Materials to Rehabilitate 15 kV Overhead Distribution Network

1) Improvement of 15 kV Overhead Distribution Lines

The existing 15 kV distribution network in Addis Ababa has a total length of some 560 km. As it was constructed 15 - 40 years ago, most parts of the network face frequent faults due to aging and a shortage of the distribution capacity compared to the actual demand level. The resulting voltage drop causes power loss and fails to start many electric motors.

The Ethiopian side has already completed a survey on distribution lines of which the distribution capacity is substantially below the demand and which require urgent improvement and has made a request to the Government of Japan to improve these lines based on the survey findings. During the field survey, the Study Team confirmed the suitability of the request and that the total length of 15 kV distribution lines requiring urgent improvement is 77 km. Accordingly, aluminium conductors (AAC 95 mm^2) which will double the distribution capacity of the existing conductors will be procured for a total length of 231 km (77 km x three phases) to improve the existing distribution network.

2) Installation of Surge Arresters

Of the some 2,000 distribution transformers installed along the 15 kV distribution lines in Addis Ababa, some 650 do not have a surge arrester. As the Project area has a high elevation of some 2,500 m with a mountain climate, surge arresters to protect

transformers from lightning are essential to ensure the reliability and proper operation of the distribution network. In view of this consideration, the Ethiopian side's request for surge arresters is appropriate and, therefore, 2,000 pieces of 15 kV surge arresters (650 x three phases plus 50 spares) will be procured under the Project to protect the distribution transformers.

(7) Procurement of Maintenance Vehicles

The new aluminium conductors and surge arresters to be procured under the Project to improve the 15 kV distribution network will be installed and maintained by the Ethiopian side. The vehicles currently owned by the Ethiopian side for the installation and maintenance of distribution lines (four street lighting vehicles and four trucks with a crane), however, suffer from chronic breakdowns due to aging, a shortage of spare parts and excessive use, in turn caused by the small number of available vehicles, making it difficult to quickly respond to faults and accidents involving distribution lines or to prevent the spread of the adverse effects of such faults and accidents. Consequently, it is deemed extremely difficult for the existing fleet of maintenance vehicles to complete the planned installation work within specified the project period. In addition, maintenance after installation may well fall short of a satisfactory level.

Under these circumstances, the Ethiopian side's request for new vehicles with a view to improving the efficiency of the work to install the new conductors and surge arresters to achieve the intended positive effects of the cooperation within the specified project period and also to ensure reliable maintenance after completion of the installation work is judged to be highly appropriate. Accordingly, one street lighting vehicle and one truck with a crane will be provided under the Project.

(8) Procurement of Equipment and Materials to Improve Were Genu Substation

The Were Genu Substation is responsible for the supply of power to the eastern part of Addis Ababa where the construction of a new housing complex as well as an industrial park is in progress and where the international airport is located. While its current total transformer output of 40 MVA is capable of meeting the demand forecast for 2005 of 39 MVA, the inadequate distribution network to cater for new consumers makes it difficult to supply sufficient power to new users. In addition, the distribution capacity of the underground cabling which connected the substation to the existing distribution network is insufficient, frequently causing load restrictions and regular power cuts in areas where an adequate distribution network is in place.

In order to improve the above situation, the Ethiopian side has already prepared a plan to construct new distribution lines to the new housing complex and industrial park and has made a request to the Government of Japan for the provision of the equipment and materials required by the plan. The request comprises the procurement of four 15 kV outgoing feeder panels, materials for 40 km of new distribution lines (120 km of aluminium conductors, 2,400 pin insulators, 100 pieces of 15 kV surge arresters and 100 pieces of 15 kV fuse switches) for the new distribution network and the procurement of 250 m ground cabling to link the substation to the existing distribution network. Through the field survey and analysis in Japan, the Study Team has confirmed the appropriateness of the Ethiopian side's request and all of the requested equipment and materials will be procured under the Project.

Based on the above examination results, the basic plan for the Project is prepared in line with the final request by the Ethiopian side shown in Table 1-1.

2-3 Basic Design

2-3-1 Design Concept

(1) Natural Conditions

1) Altitude

The Project area is located on highland with an altitude ranging from 2,300 m to 2,600 m. In general, the insulation level of electrical equipment decreases by 1% per 100 m above an altitude of 1,000 m. This makes the selection of equipment and materials with appropriate insulation level for high altitudes and with emphasis on the safety and durability of the selected equipment and materials essential.

2) Rainfall

The Project area has a rainy season in July and August with monthly rainfall of approximately 300 mm while the annual rainfall is some 1,500 mm. Substation and distribution equipment require daily inspection as well as regular recording of the power demand and constant monitoring of the distribution system. These requirements make it necessary to carefully decide the system configuration to include an indoor-type remote control panel in addition to distribution panels and other equipment in view of the easy and safe implementation of operation and maintenance of the distribution system even at the time of rain.

Moreover, rainwater drainage facilities will be introduced on substation premises to prevent disruption of the operation and maintenance of substation equipment by standing rainwater.

3) Relative Humidity

The relative humidity level in the Project area is generally low, seldom causing an unpleasant situation. However, the introduction of a space heater is considered for sealed substation and distribution equipment to prevent condensation due to fluctuation of the temperature.

(2) Local Construction Industry

Although major construction work, including the construction of hotels, is in progress in Addis Ababa, large-scale work is mainly contracted to foreign construction companies with local companies working as sub-contractors. Accordingly, it is possible to place a direct order to a local construction company on the small scale of work, the recruitment of local workers, transport vehicles for materials and construction machinery.

Work involving electric facilities tends to be commissioned to foreign companies in the case of large projects, such as substations construction, while the EEPCO is often directly involved in the construction of substations and distribution line installation on a relatively small scale.

When a foreign company directly conducts construction work in Ethiopia, it is necessary, in principle, for it to register its business and to obtain a construction work permit. A foreign company new to Ethiopia must register its business at the competent office in Addis Ababa and renew its registration every year. The company registration and permit acquisition processes are, however, unnecessary when a foreign contractor, such as a trading company, with a local agent entrusts the work to an Ethiopian construction company or when a public organization, such as the EEPCO, conducts the work itself.

(3) Use of Local Construction Companies and Equipment and Materials

1) Use of Local Construction Companies

There are some 10 general construction companies run by Ethiopians and Italians, etc., in Ethiopia. The size of the workforce of these companies widely varies from several hundred to some 3,000 and all workers are Ethiopians. In the case of major construction projects, these companies provide construction machinery and labour as sub-contractors for foreign construction companies while the latter are responsible for project

management, including quality control and schedule control as already described in (3) above.

Given the above situation, it will be necessary to dispatch engineers from Japan in regard to quality control, schedule control, safety control, testing and adjustment, etc. while using local construction companies mainly for the supply of construction machinery and labour for the construction of substations under the Project.

2) Use of Local Equipment and Materials

In preparing the work plan for the Project, emphasis is placed on the procurement of local equipment and materials as long as the quantity and quality are acceptable. Aggregate, cement, reinforcing bars, etc., for civil and building work are available in Ethiopia and, therefore, these materials will be procured locally for the Project. Meanwhile, materials such as structural steel, cables, insulators, etc., for the substation construction are currently imported and, therefore, their procurement from Japan or a third country will be planned.

3) Procurement from Third Countries

As far as the existing transmission, distribution and substation facilities are concerned, the equipment and materials in use was procured from various countries, including Italy, Germany, Sweden, Japan, etc., depending on the actual project funding source. There are few manufacturers with agents in Ethiopia to provide after-services, ranging from the repair of defects to the supply of spare parts. According to the field survey by the Basic Design Study Team, manufacturers in Italy, Germany, Sweden, Japan, etc., provide reliable after-services. Consequently, Italy, Germany, Sweden, etc., will be considered for third country procurement and the actual supplier (or suppliers) will be selected from these countries, taking the price, delivery time, ease of obtaining spare parts following the commencement of operation and after-service reliability into consideration.

(4) Maintenance and Management Capability of Project Implementation Body

The EEPCO was established in July, 1997 after reorganization of the EELPA (Ethiopian Electric Light and Power Authority) following the enforcement of a Presidential decree. The operation and maintenance of the new substation and distribution facilities of the Project will be conducted by the Regional Operation Department and Power System Operation Department under the supervision of the Deputy General Manager (Operation). The official staffing level and detailed assignment of the staff members of each of these departments have not yet been formally decided as it is not long since the reorganization. However, it is

anticipated that some 70% of the total staff members (8,247 in 1996) will be assigned to these two departments.

The state of the maintenance of the existing facilities suggests that operators have sufficient expertise in regard to the maintenance of general substation and distribution facilities but may lack a good understanding of the latest facilities. OJT (On-the-Job Training) on the operation and maintenance of substation facilities will be conducted by Japanese engineers despatched by the Japanese contractor during the construction period to ensure the effective and efficient operation and maintenance of the new facilities constructed under the Project.

(5) Scope and Grade of Facilities and Equipment

The scope of procurement and the technical level of the equipment and materials under the Project will be decided based on the following principles, taking the conditions described in (1) through (5) above into consideration.

1) Scope of Facilities and Equipment

The configuration of the facilities and the equipment specifications should be decided to meet the minimum requirements in regard to the rehabilitation of substations to ensure safe and stable distribution to central areas of commercial and other economic activities and also to key areas of noticeable industrialisation in Addis Ababa. And also in regard to the procurement of distribution transformers, cables and other materials to ensure stable distribution to all consumers in the Addis Ababa for the Project, of which target year is 2005.

2) Grade

Special care should be taken in regard to the substation and distribution facilities to be procured under the Project so that their grades are not beyond the technical capability of the EEPCO which will be responsible for their operation and maintenance following the completion of the Project. Further consideration should be given to the selection of equipment and materials which are appropriate in terms of the level of construction technology on the Ethiopian side as the EEPCO will be responsible for the installation of some transformers and distribution facilities.

(6) Construction Schedule

The Project intends the urgent improvement of the distribution network in entire Addis Ababa, including central areas of commercial and economic activities, and will be

implemented in two phases based on the current conditions and improvement urgency of each district.

Considering the tight implementation schedule of the Project, all the rehabilitation work of Akaki and Addis center substations will be done by Japanese side, and other installation work will be done by the Ethiopian side.

Phase 1

Rehabilitation of substations which are highly deteriorated; strengthening of the distribution network, making the best use of the existing substation facilities and distribution network; procurement of equipment and materials for improvement

① Rehabilitation of the Akaki Substation

② Procurement of transformers for the Addis North Substation

③ Procurement of a transformer for the Addis West Substation

④ Procurement of equipment and materials for rehabilitation of the 15 kV overhead distribution lines

⑤ Procurement of vehicles for maintenance of the distribution network

⑥ Procurement of equipment and materials for improvement of the Were Genu Substation

Phase 2

Rehabilitation of substations in central areas of the capital and renewal of defective transformers for stable operation of distribution network

① Rehabilitation of the Addis Center Substation

② Procurement of a transformer for the Kaliti-1 Substation

2-3-2 Basic Design

(1) General Plan

1) Design Conditions

The following design conditions are set following examination of the various conditions described in 2-3-1 above regarding the scale and specifications for the Project.

① Attitude : 2,500 m above sea level
(2,600 m for the Addis North Substation)

② Climatic conditions

a) Design temperature : 40°C (maximum)
-5°C (minimum)

b) Design relative humidity : 80% (maximum)

c) Design wind load : 52 kg/m^2

d) Annual rainfall : 1,500 mm (mean)

e) Annual number of days of thunderstorms (IKL) : 37 (assumed)

f) Salt deposition equivalent density : 0.01 mg/cm^2 (assumed)

g) Seismic force (assumed) : equipment: 0.2 G (horizontal)
0.125G (vertical)
foundations: 0.1 G (horizontal)

h) Soil resistivity : 10 ohm/m (assumed)

③ Bearing capacity of soil : 10 tons/m^2 (assumed)

④ Codes and Standards Applied

a) JIS (Japanese Industrial Standards) : applicable to industrial products in general

b) JEC (Standards of Japanese Electro Technical Committee) : applicable to electrical products in general

c) JEM (Standards of Japanese Manufacturing Association) : as above

d) JCS (Japanese Cable Maker's Association Standards) : applicable to electrical wires and cables

e) Technical standards for electrical facilities : applicable to electrical installation work in general

f) IEC (International Electro-technical Commission) : applicable to electrical products in general

g) Other standards comparable to the above standards

⑤ Units : international unit system (SI units)

⑥ Electrical system : electrical system shown in Table 2-3-1

Table 2-3-1 Electrical System

Item	Transmission System		Distribution System
Nominal Voltage	132 kV	45 kV	15 kV
Maximum Voltage	143 kV	52.5 kV	17.5 kV
Wiring System	3 phase, 3 wire	3 phase, 3 wire	3 phase, 3 wire
Frequency	50 Hz	50 Hz	50 Hz
Neutral Grounding System	direct grounding	direct grounding	via grounding transformer

Table 2-3-2 Outline of Basic Design

Categories		Phase 1		Phase 2	
Procurement and Installation Work	Rehabilitation of Substation	(1) For Akaki Substation 1) Main transformer (45/15 kV, 9/12 MVA) 2) 45 kV switchgear 3) 15 kV outgoing feeder panel 4) Control and protection panels, fire extinguisher and cables, etc., required for above three items 5) Construction of foundations, control building and equipment installation work	 : 1 unit : 1 lot : 4 feeders : 1 lot : 1 lot	(1) For Addis Center Substation 1) Main transformer (132/15 kV, 25/31.5 MVA) 2) 132 kV switchgear 3) 15 kV outgoing feeder panel 4) Control and protection panels, fire extinguisher and cables, etc., required for above three items 5) Foundation and equipment installation work	 : 2 units : 1 lot : 13 feeders : 1 lot : 1 lot
	OJT	OJT on operation and maintenance technique for above facilities by engineers dispatched by Japanese contractor		Same as left	
Procurement Work	Substation Facilities	(1) For Addis North Substation • Main transformer (132/15 kV, 20/25 MVA) (2) For Addis West Substation • Main transformer (45/15 kV, 9/12 MVA)	 : 2 units : 1 unit	(1) For Kaliti-1 Substation • Main transformer (132/45/15kV, 22/22/7.3 MVA)	: 1 unit
	Distribution Facilities	(1) Procurement of following equipment, etc., for rehabilitation of 15 kV overhead distribution lines 1) Conductor 2) Lightning arrester 3) 15 kV underground cable for Were Genu Substation (2) For Were Genu Substation 1) Equipment and materials, to construct 15 kV overhead distribution lines 2) 15 kV outgoing feeder panel (3) Procurement of vehicles required for construction and maintenance of distribution lines subject to the Project 1) Street lighting vehicle 2) Truck with five ton crane	 : 77 km : 2,000 pcs : 50 m x 5 lines : 40 km in total : 4 feeders : 1 unit : 1 unit	(1) Addis Center Substation • 15 kV out going feeder cables	: 13 lines

(3) Substation Rehabilitation Plan

Particular attention is paid to the following issues in connection with the plan to rehabilitate the Akaki Substation and Addis Center Substation.

1) Basic Issues

① Safe and Easy Operation

The specifications of the operating and monitoring equipment for substations should not exceed the levels of those of existing substation equipment with which EEPCO engineers are familiar to ensure safe and easy operation and maintenance.

② Economic Efficiency of Equipment

The equipment specifications should, in principle, be based on the use of standard products to ensure econimic efficiency and the variety of the equipment and components should be minimised.

③ Safe and Easy Maintenance

The standard specifications used by the EEPCO should be followed as much as possible for the equipment and materials to be procured under the Project.

2) Layout Plan

④ Akaki Substation

The planned substation equipment under the Project will be installed on the present Akaki Substation premises and the following equipment configuration is adopted in line with that of existing similar substations.

a) Outdoor Equipment

The 45 kV switchgear and the main transformer will be installed outdoor.

b) Indoor Equipment

As there is no existing building which can be used as a control room, a new control building will be constructed in order to install the following equipment.

- 15 kV outgoing feeder panel
- Control and monitoring panels of 45 kV switchgear
- DC power supply equipment

② Addis Center Substation

The new facilities will be introduced to the vacant site owned by the EEPCO which is located adjacent to the existing Addis Center Substation premises and the existing building. However, special attention should be paid to the following points due to constraints imposed by the existing premises and building.

a) Site Clearance

The existing unused garage will be demolished to ensure the sufficient space for a new substation. This demolition work will be conducted by the EEPCO prior to the commencement of the Project-related work by the Japanese side.

b) Use of Outdoor-Type 15 kV Outgoing Feeder Panel

As the existing building lacks space to accommodate a new 15 kV outgoing feeder panel, an outdoor-type panel will be employed with an indoor-type remote control panel installed inside the existing building to ensure safe and easy operation and maintenance.

3) Connection to Existing Systems

① Akaki Substation

a) 45 kV Transmission System

As part of the Project, the Japanese side will procure and install a dead-end tower on the premises for the transmission lines from the Kaliti-1, Aba Samuel and Dukem Substations. The work to connect 45 kV transmission lines to this dead-end tower will be completed by the EEPCO prior to the field test for the Project.

b) 15 kV Distribution System

As part of the Project, the Japanese side will procure and install 15 kV cables between the 15 kV outgoing feeder panels and existing overhead 15 kV distribution pole (four lines) located inside the substation premises.

② Addis Center Substation

a) 132 kV Transmission System

As part of the Project, the Japanese side will procure and install overhead cables for connection between the new 132 kV switchgear and existing 132 kV bus line in the existing substation premises.

b) 15 kV Distribution System

As part of the Project, the Japanese side will procure 15 kV cables for connection between the 15 kV outgoing feeder panel and overhead distribution connection points (13 in total) outside the substation premises. The installation and connection work of these cables will be completed by the EEPCO prior to the field test of the Project.

4) Connection to SCADA System

As the EEPCO plans to install the SCADA system at the Addis Center Substation in the future, a terminal board for the SCADA system will be installed on the 132 kV control and monitoring panel to be procured under the Project for the Addis Center Substation.

The facilities and equipment for these substations are planned based on the items listed in the following tables.

- Akaki Substation : Table 2-3-3
- Addis Central Substation : Table 2-3-4

(4) Substation Equipment Procurement Plan

Particular attention should be paid to the following issues in relation to the equipment plan for the Addis North, Addis West and Kaliti-1 Substations.

1) Basic Issues

① Removal and Installation Work

Removal of the existing equipment and installation of the new equipment procured under the Project will be conducted by the EEPCO.

② Re-Use of Existing Foundations

In principle, the existing foundations will be re-used although the strength and safety will be examined by the EEPCO with a view to conducting reinforcement work if found necessary by the EEPCO.

③ Transformer Wheels

Wheels which are suitable for the existing rail gauges will be fitted to the base of the main transformers procured under the Project.

2) Terminal Point with Existing Equipment

① Transformer Tap Indication

A tap position indicator for OLTC (On-Load Tap Changer) of transformers to be procured under the Project will be installed by the EEPCO to the existing transformer tap indication panel.

② Announciaters for Transformer

The existing panel will be used to display the status of the transformers to be procured under the Project.

③ Power Source for Auxiliary Equipment and Control

The power for auxiliary equipment and control will be supplied by the existing power source with the following voltage levels.

Power : AC 380/220 V
Control : DC 110 V

④ Low Voltage Cables

The existing cables for power supply to and control of the transformers will, in principle, be used. However, the EEPCO will procure and install/connect new cables to the auxiliary and control equipment for the new transformers if found necessary.

The equipment, etc., to be procured for each substation will be planned based on the contents of the following tables.

- Addis North Substation : Table 2-3-5
- Addis West Substation : Table 2-3-6
- Kaliti-1 Substation : Table 2-3-7

(5) Equipment Procurement Plan for Distribution System

Special attention should be paid to the following issues in preparing the distribution equipment procurement plan.

1) Basic Issues

① Safe and Easy Operations and Maintenance

The specifications of the equipment and materials, should not exceed the levels of the existing distribution facilities with which EEPCO engineers are familiar to ensure safe and easy operations and maintenance.

② Economic Efficiency

Standard products complying with international standards will be used to ensure an economical design. The variety of products should be kept to a minimum while ensuring the interchangeability of equipment.

③ Use of Standard Specifications of EEPCO

The specifications of the equipment and materials to be procured under the Project should follow the standard specifications of the EEPCO as much as possible to avoid surpassing the technical levels specified by the EEPCO.

2) Plan for Distribution Lines

① Types of Wires and Cables

The wire and cable types will be aluminium stranded conductors (AAC) 95 mm^2 and XLPE 3C-120 mm^2 to ensure compatibility with the standard specifications of the EEPCO.

② Protection of Distribution Transformers

15 kV lightning arresters will be procured for the existing 15 kV distribution lines to protect the distribution transformers from lightning. In the case of the new 15 kV distribution line (40 km) from the Were Genu Substation, disconnectors equipped with a high voltage fuse will be procured under the Project to protect the new transformers to be procured and installed by the EEPCO from overloading.

The distribution equipment and materials will be planned based on the contents of the following tables.

- Reinforcement of existing 15 kV distribution lines : Table 2-3-8
- Vehicles for maintenance of distribution line : Table 2-3-9
- Improvement of the Were Genu Substation : Table 2-3-10

Table 2-3-3 Basic Specifications of Rehabilitation for Akaki Substation

No.	Item	Quantity	Specification
(1)	Construction of control building	1	
			-Concrete block, one-story
			-Total floor space 98m^2
			-Lighting and outlet
			-Ventilation
(2)	Construction of premises facilities		
1)	Premises road	1 lot	
2)	Gravel	1 lot	
3)	Rain water drainage	1 lot	
4)	Earthing mesh	1 lot	Bare copper wire
5)	Outdoor lighting	1 lot	
6)	Foundation of Equipment	1 lot	
(3)	Supply and installation of Main Transformer	1 unit	
1)	Type		Outdoor use, oil-immersed, self-cooled (ONAN) forced air-cooled(ONAF)and core type with on-load tap changer
2)	Number of phases		3
3)	Rated frequency		50Hz
4)	Rated primary voltage		45,000V
5)	Rated secondary voltage		15,000V
6)	Rated capacity		9MVA(ONAN)/12MVA(ONAF)
7)	Tap voltage		45kV +10%, -10%
8)	Number of taps		17 taps
9)	Step voltage		1.25%
10)	Winding connection		
	(primary)		Star with a neutral point brought out
	(secondary)		Delta
11)	Phase displacement		YNd11
12)	Temperature rise		
	(winding)		65°C
	(oil)		60°C
13)	Short circuit impedance		8.0% at 12MVA base
14)	Accessories		-Nameplate
			-Conservator
			-Oil level indicator
			-Buchholz relay
			-Dial thermometer with alarm contact
			-Neutral bushing current transformer
			-Control cabinet
			-Earthing terminals
			-Wheels
			-Other necessary accessories
(4)	Supply and installation of 45kV Circuit breaker	4 units	
1)	Type		Outdoor use, three-pole, insulator, SF6 gas type
2)	Rated voltage		52kV or more
3)	Rated current		630A

No.	Item	Quantity	Specification
4)	Rated short circuit breaking current		12.5kA
5)	Rated duration of short circuit		3 seconds
6)	Rated operating sequence		0-0.3sec.-CO-3min.-CO
7)	Interrupting time		5 cycles
8)	Control circuit voltage		DC 110V
9)	Accessories		-Nameplate -Control cabinet -Earthing terminal -Other necessary accessories
(5)	Supply and installation of 45kV Disconnecting switch	6 units	
1)	Type		Outdoor use, three-pole, horizontal double break rotating insulator type Transmission line side disconnecting switch(3 units) shall be equipped with a grounding switch
2)	Rated voltage		52kV or more
3)	Rated current		630A
4)	Rated short-time withstand current		12.5kA
5)	Rated duration of short circuit		3 seconds
6)	Operation		Mechanically manual
7)	Control circuit voltage		DC 110V
8)	Accessories		-Nameplate -Earthing terminal -Other necessary accessories
(6)	Supply and installation of 45kV Current transformer	12 units	
1)	Type		Outdoor use, single-phase, oil-filed porcelain type, single core, double ratio and hermetically sealed type
2)	Rated voltage		47kV
3)	Rated primary current		600A(3 units), 200A (9 units)
4)	Rated secondary current		5-5A
5)	Rated burden		40VA
6)	Accuracy class		1P
7)	Rated short-time withstand current		12.5kA for 1 second
8)	Accessories		-Nameplate -Earthing terminal -Other necessary accessories
(7)	Supply and installation of 45kV Potential transformer	9 units	
1)	Type		Outdoor use, single-phase, oil-filled hermetically sealed type
2)	Rated primary voltage		$45/\sqrt{3}$kV
3)	Rated secondary voltage		$100/\sqrt{3}$V
4)	Rated secondary burden		200VA
5)	Polarity		Subtractive
6)	Accuracy class		1P
7)	Accessories		-Nameplate -Earthing terminal -Other necessary accessories

No.	Item	Quantity	Specification
(8)	Supply and installation of 45kV Lightning arrester	12 units	
1)	Type		Outdoor use, metal oxide type
2)	Rated voltage		42kV
3)	Nominal discharge current		10kA
4)	Accessories		-Nameplate -Surge counter -Earthing terminal -Other necessary accessories
(9)	Supply and installation of 15kV Earthing transformer	1 unit	
1)	Type		Outdoor use, oil-immersed, self-cooled type
2)	Rated voltage		15kV
3)	Rated current and duration time		200A, 10 seconds
4)	Accessories		-Nameplate -Earthing terminal -Embedded materials -Neutral current transformer -Other necessary accessories
(10)	Supply and installation of 15kV Lightning arrester	3 units	
1)	Type		Outdoor use, metal oxide type
2)	Rated voltage		15kV
3)	Nominal discharge current		10kA
4)	Accessories		-Nameplate -Earthing terminal -Other necessary accessories
(11)	Supply and installation of 15kV (Outgoing feeder panel)	1 lot	
1)	Type		Indoor use, air insulated metal-enclosed switchgear
2)	Number of cubicle		-12MVA TR secondary (1 No.) -Feeder panel (4 Nos.) -Station service panel (1 No.) -Aux. transformer panel (1 No.) -GPT panel (1 No.) -Spare feeder panel (1 No.)
3)	Composition of main components		
	①15kV Circuit breaker		
	a) Type		Indoor use, three-pole, horizontal drawout, vacuum type
	b) Rated voltage		15kV
	c) Rated current		630A
	d) Rated short circuit breaking current		12.5kA
	e) Rated duration of short circuit		2 seconds
	f) Rated operating sequence		0-1min.-CO-3mins.-CO
	g) Rated interrupting time		5 cycles
	h) Control circuit voltage		DC 110V
	②15kV Current transformer		
	a) Type		Indoor use, single phase, epoxy resin molded, core type

No.	Item	Quantity	Specification
	b) Ratings		600A/5A/5A(incoming) 150(300)A/5A/5A(distribution)
	③15kV Lightning arrester		
	a) Type		Indoor use, metal oxide type
	b) Rated voltage		15kV
	c) Nominal discharge current		10kA
	④15kV Potential transformer		
	a) Type		Indoor use, epoxy resin molded, core type
	b) Rated primary voltage		15/√3kV
	c) Rated secondary voltage		100/√3V
	d) Rated tertiary voltage		100/3V
	⑤Station service transformer		
	a) Type		Indoor use, dry type
	b) Number of phases		3
	c) Rated frequency		50Hz
	d) Rated primary voltage		15kV
	e) Rated secondary voltage		400-230V
	f) Rated capacity		50kVA
	g) Tap voltage		15kV ±2 x 2.5%
	⑥Low voltage distribution board		
	a) Type		Indoor use, molded case circuit breakers
	b) Rated voltage		380-220V
4)	Accessories		-Nameplate -Drawing device for circuit breaker -Earthing terminal -Other necessary accessories
(12)	Supply and installation of 15kV Control and protection panel	1 lot	
1)	Type		Indoor use, metal-enclosed and self-standing type
2)	Composition of main components		
	① Operation switch		For circuit breaker
	② Condition indicator		For circuit breaker, Disconnecting switch
	③ Alarm indicator		
	④ Meter		
	⑤ Relay		
	⑥ Controller for on-load tap changer		
3)	Accessories		-Nameplate -Earthing terminal -Other necessary accessories
(13)	Supply and installation of DC supply equipment	1 lot	
1)	Type		Lead acid type
2)	Output voltage		DC 110V
3)	Composition of main components		
	① Storage Batteries		
	② Battery charger		
	③ DC distribution board		
4)	Accessories		-Nameplate

No.	Item	Quantity	Specification
			-Stand for batteries -Maintenance tools for batteries -Earthing terminal -Other necessary accessories
(14)	Supply and installation of Fire extinguisher	1 unit	
1)	Type		Portable type with wheels
2)	Capacity		40kg
(15)	Supply and installation of 45kV Main bus materials		
1)	Structure	1 lot	
2)	Main bus	1 lot	
3)	Insulator	1 lot	
4)	Terminal	1 lot	
(16)	Supply and installation of Wiring materials		
1)	15kV cable	1 lot	
	① Type		XLPE insulated, wire or tape armored, PVC outer sheathed, copper conductor cable
	② Rated voltage		8.7/15kV
	③ Size		3Cx120mm^2 (distribution), 3cx200mm^2 (transformer secondary)
2)	Low voltage cable	1 lot	600/1,000V XLPE insulated, PVC outer sheathed, copper conductor cable
3)	Control cable	1 lot	600/1,000V PVC insulated, PVC outer sheathed copper conductor cable

Table 2-3-4 Basic Specifications of Rehabilitation for Addis Center Substation

No.	Item	Quantity	Specification
(1)	Modification of control room	1 lot	The modification work(including lighting, outlets and ventilations) of existing control room shall be carried out by EEPCO.
(2)	Construction of civil work		
1)	Gravel	1 lot	
2)	Rain water drainage	1 lot	
3)	Earthing mesh	1 lot	Bare copper wire
4)	Outdoor lighting	1 lot	
5)	Foundation of equipment	1 lot	
(3)	Supply and installation of Main transformer	2 units	
1)	Type		Outdoor use, oil-immersed, self-cooled(ONAN)forced air-cooled(ONAF) and core type with on-load tap changer
2)	Number of phases		3
3)	Rated frequency		50Hz
4)	Rated primary voltage		132,000V
5)	Rated secondary voltage		15,000V
6)	Rated capacity		25MVA(ONAN)/31.5MVA(ONAF)
7)	Tap voltage		132kV +10%, -10%
8)	Number of taps		17 taps
9)	Step voltage		1.25%
10)	Winding connection		
	(primary)		Star with a neutral point brought out
	(secondary)		Delta
11)	Phase displacement		YNd11
12)	Temperature rise		
	(winding)		65°C
	(oil)		60°C
13)	Short circuit impedance		13.0% at 31.5MVA base
14)	Accessories		-Nameplate -Conservator -Oil level indicator -Buchholz relay -Dial thermometer with alarm contact -Neutral bushing current transformer -Control cabinet -Earthing terminals -Wheels -Other necessary accessories
(4)	Supply and installation of 132kV Circuit breaker	2 units	
1)	Type		Outdoor use, three-pole, porcelain, SF6 gas type
2)	Rated voltage		145kV
3)	Rated current		1,250A
4)	Rated short circuit breaking current		20kA
5)	Rated duration of short circuit		3 seconds
6)	Rated operating sequence		0-0.3sec.-CO-3min.-CO
7)	Interrupting time		3 cycles
8)	Control circuit voltage		DC 110V
9)	Accessories		-Nameplate -Control cabinet -Earthing terminal -Other necessary accessories

No.	Item	Quantity	Specification
(5)	Supply and installation of 132kV Disconnecting switch	3 units	
1)	Type		Outdoor use, three-pole, horizontal double break rotating insulator type Transmission line side disconnecting switch shall be equipped with a grounding switch
2)	Rated voltage		145kV
3)	Rated current		1,250A
4)	Rated short-time withstand current		20kA
5)	Rated duration of short circuit		3 seconds
6)	Operation		Mechanically manual
7)	Control circuit voltage		DC 110V
8)	Accessories		-Nameplate -Earthing terminal -Other necessary accessories
(6)	Supply and installation of 132kV Current transformer	9 units	
1)	Type		Outdoor use, single-phase, oil-filed porcelain type, single core, double ratio and hermetically sealed type
2)	Rated voltage		145kV
3)	Rated primary current		300A
4)	Rated secondary current		5-5A
5)	Rated burden		40VA
6)	Accuracy class		1P
7)	Rated short-time withstand current		12.5kA for 1 second
8)	Accessories		-Nameplate -Earthing terminal -Other necessary accessories
(7)	Supply and installation of 132kV Potential transformer (CVT)	3 units	
1)	Type		Outdoor use, single-phase, oil-filled hermetically sealed type
2)	Rated primary voltage		$132/\sqrt{3}$kV
3)	Rated secondary voltage		$100/\sqrt{3}$V
4)	Rated secondary burden		200VA
5)	Polarity		Subtractive
6)	Accuracy class		1P
7)	Accessories		-Nameplate -Earthing terminal -Other necessary accessories (including a connection box for PLC)
(8)	Supply and installation of 132kV Lightning arrester	3 units	
1)	Type		Outdoor use, metal oxide type
2)	Rated voltage		120kV
3)	Nominal discharge current		10kA
4)	Accessories		-Nameplate -Earthing terminal -Other necessary accessories

No.	Item	Quantity	Specification
(9)	Supply and installation of 15kV Earthing transformer	2 units	
1)	Type		Outdoor, oil-immersed, self-cooled type
2)	Rated voltage		15kV
3)	Rated current and duration time		200A, 10 seconds
4)	Accessories		-Nameplate -Embedded materials -Earthing terminal -Other necessary accessories
(10)	Supply and installation of 15kV (Outgoing feeder panel)	1 lot	
1)	Type		Indoor use, metal-enclosed switchgear, air insulated cubicle type
2)	Number of cubicle		-31.5MVA TR secondary (2 No.) -Feeder panel (13 Nos.) -Station service panel (1 No.) -Aux. transformer panel (1 No.) -GPT panel (1 No.) -Spare feeder panel (2 No.)
3)	Composition of main components		
	①15kV Circuit breaker		
	a) Type		Indoor use, three-pole, horizontal drawout, vacuum type
	b) Rated voltage		15kV
	c) Rated current		630A, 2,000A
	d) Rated short circuit breaking current		12.5kA(TR secondary), 25kA(feeder)
	e) Rated duration of short circuit		2 seconds
	f) Rated operating sequence		0-1min.-CO-3mins.-CO
	g) Rated interrupting time		5 cycles
	h) Control circuit voltage		DC 110V
	②15kV Current transformer		
	a) Type		Indoor use, single phase, epoxy resin molded, core type
	b) Ratings		1,500/5/5/5A(incoming) 300(600)/5/5A(feeder)
	③15kV Lightning arrester		
	a) Type		Indoor use, metal oxide type
	b) Rated voltage		15kV
	c) Nominal discharge current		10kA
	④15kV Potential transformer		
	a) Type		Indoor use, epoxy resin molded, core type
	b) Rated primary voltage		$15/\sqrt{3}$kV
	c) Rated secondary voltage		$100/\sqrt{3}$V
	d) Rated tertiary voltage		100/3V
	⑤Station service transformer		
	a) Type		Indoor use, dry type
	b) Number of phases		3

No.	Item	Quantity	Specification
	c) Rated frequency		50Hz
	d) Rated primary voltage		15kV
	c) Rated secondary voltage		400-230V
	f) Rated capacity		100kVA
	g) Tap voltage		15kV ±2 x 2.5%
	⑥Low voltage distribution board		
	a) Type		Indoor use, molded case circuit breakers
	b) Rated voltage		380-220V
4)	Accessories		-Nameplate
			-Drawing device for circuit breaker
			-Earthing terminal
			-Other necessary accessories
(11)	Supply and installation of 132kV Control and protection panel	1 lot	
1)	Type		Indoor use, metal-enclosed and self-standing type
2)	Composition of main components		
	a) Operation switch		For circuit breaker
	b) Condition indicator		For circuit breaker, Disconnecting switch
	c) Alarm indicator		
	d) Meter		
	e) Relay		
	f) Controller for on-load tap changer		
3)	Accessories		-Nameplate
			-Terminals for SCADA
			-Earthing terminal
			-Other necessary accessories
(12)	Supply and installation of 15kV Control panel	1 lot	
1)	Type		Indoor use, metal-enclosed and self-standing type
2)	Composition of main components		
	a) Operation switch		For circuit breaker
	b) Condition indicator		For circuit breaker
	c) Alarm indicator		
	d) Meter		
3)	Accessories		-Nameplate
			-Earthing terminal
			-Other necessary accessories
(13)	Supply and installation of DC supply equipment	1 lot	
1)	Type		Lead acid type
2)	Output voltage		DC 110V
3)	Composition of main components		
	① Storage batteries		
	② Battery charger		
	③ DC distribution board		

No.	Item	Quantity	Specification
4)	Accessories		-Nameplate -Stand for batteries -Maintenance tools for batteries -Earthing terminal -Other necessary accessories
(14)	Supply and installation of Fire extinguisher	1 unit	
1)	Type		Portable type with wheels
2)	Capacity		40kg
(15)	Supply and installation of 132kV Main line materials		
1)	Structure	1 lot	
2)	Main line	1 lot	
3)	Insulator	1 lot	
4)	Terminal	1 lot	
(16)	Supply and installation of Wiring material		
1)	Low voltage cable	1 lot	600/1,000V XLPE insulated, PVC outer sheathed, copper conductor cable
2)	Control cable	1 lot	600/1,000V PVC insulated, PVC outer sheathed, copper conductor cable
(17)	Supply of 15kV Cable	11km	
1)	Type		XLPE insulated, wire or tape armored, PVC outer sheathed, copper conductor cable
2)	Rated voltage		8.7/15kV
3)	Size		3Cx120mm^2
(18)	Supply of Straight joint	15 sets	For above item (17). (1set for 3phases. 2sets for spare.)
(19)	Supply of Termination kit	28 sets	For above item (17). (1set for 3phases. 2sets for spare.)

Table 2-3-5 Basic Specifications of Procurement of Transformers for Addis North Substation

No.	Item	Quantity	Specification
(1)	Supply of Main transformer	2 units	
1)	Type		Outdoor use, oil-immersed, self-cooled(ONAN)/forced air-cooled(ONAF) and core type with on-load tap changer
2)	Number of phases		3
3)	Rated frequency		50Hz
4)	Rated primary voltage		132,000V
5)	Rated secondary voltage		15,000V
6)	Rated capacity		20MVA(ONAN)/25MVA(ONAF)
7)	Tap voltage		132kV +10%, -10%
8)	Number of taps		17 taps
9)	Step voltage		1.25%
10)	Winding connection		
	(primary)		Star with a neutral point brought out
	(secondary)		Delta
11)	Phase displacement		YNd11
12)	Temperature rise		
	(winding)		65°C
	(oil)		60°C
13)	Short circuit impedance		12.5% at 25MVA base
14)	AC supply source		400/230V (existing power source)
15)	DC supply source		110V (existing power source)
16)	Accessories		-Nameplate -Conservator -Oil level indicator -Buchholz relay -Dial thermometer with alarm contact -Neutral bushing current transformer -Control cabinet -Earthing terminals -Wheels -Other necessary accessories
(2)	Tap position indicator for On-load tap changer	1 lot	Tap position indicator for on-load tap changer shall be loose supply and mounted on the existing control panel by EEPCO.

Table 2-3-6 Basic Specifications of Procurement of Transformers for Addis West Substation

No.	Item	Quantity	Specification
(1)	Supply of Main transformer	1 unit	
1)	Type		Outdoor use, oil-immersed, self-cooled(ONAN)/forced air-cooled(ONAF) and core type with on-load tap changer
2)	Number of phases		3
3)	Rated frequency		50Hz
4)	Rated primary voltage		45,000V
5)	Rated secondary voltage		15,000V
6)	Rated capacity		9MVA(ONAN)/12MVA(ONAF)
7)	Tap voltage		45kV +10%, -10%
8)	Number of taps		11 taps
9)	Step voltage		2%
10)	Winding connection		
	(primary)		Star with a neutral point brought out
	(secondary)		Delta
11)	Phase displacement		YNd11
12)	Temperature rise		
	(winding)		65°C
	(oil)		60°C
13)	Short circuit impedance		8.18% at 12MVA base
14)	AC supply source		400/230V(existing power source)
15)	DC supply source		110V(existing power source)
16)	Accessories		-Nameplate -Conservator -Oil level indicator -Buchholz relay -Dial thermometer with alarm contact -Neutral bushing current transformer -Control cabinet -Earthing terminals -Wheels -Other necessary accessories
(2)	Tap position indicator for On-load tap changer	1 lot	Tap position indicator for on-load tap changer shall be loose supply and mounted on the existing control panel by EEPCO.

Table 2-3-7 Basic Specifications of Procurement of Transformers for Kaliti-1 Substation

No.	Item	Quantity	Specification
(1)	Supply of Main transformer	1 unit	
1)	Type		Outdoor use, oil-immersed, self-cooled(ONAN)forced air-cooled(ONAF) and core type with on-load tap changer
2)	Number of phases		3
3)	Rated frequency		50Hz
4)	Rated primary voltage		135,000V
5)	Rated secondary voltage		45,000V
6)	Rated tertiary voltage		16,000V
7)	Rated capacity		18/18/6MVA(ONAN) 22/22/7.3MVA(ONAF)
8)	Tap voltage		135kV +12% -12%
9)	Number of taps		13 taps
10)	Step voltage		2.7%
11)	Winding connection		
	(primary)		Star with a neutral point brought out
	(secondary)		Star with a neutral point brought out
	(tertiary)		Delta
12)	Phase displacement		YNyn0d11
13)	Temperature rise		
	(winding)		65°C
	(oil)		60°C
14)	Short circuit impedance		13.98% at 22MVA base
15)	AC supply source		380/220V(existing power source)
16)	DC supply source		110V(existing power source)
17)	Accessories		-Nameplate -Conservator -Oil level indicator -Buchholz relay -Dial thermometer with alarm contact -Neutral bushing current transformer -Control cabinet -Earthing terminals -Wheels -Other necessary accessories
(2)	Tap position indicator for On-load tap changer	1 lot	Tap position indicator for on-load tap changer shall be loose supply and mounted on the existing control panel by EEPCO.

Table 2-3-8 Basic Specifications of Equipment and Materials for Rehabilitation of 15kV Overhead Distribution line

No.	Item	Quantity	Specification
(1)	Supply of Conductor Type Size	231 km	(77kmx3) AAC 95mm^2
(2)	Supply of 15kV Lightning arrester with mounting bracket	2,000 pcs.	
1)	Type		Outdoor use, Non-liner metal oxide
2)	Rated voltage		15kV
3)	Nominal discharge current		10kA
(3)	Supply of 15kv cable for Were Genu substation	250 m	(50m x 5 circuits)
1)	Type		XLPE insulated, wire or tape armored, PVC outer sheathed, copper conductor cable
2)	Rated voltage		8.7/15kV
3)	Size		3C x 120mm^2
(4)	Supply of 15kV cable termination kit	11sets.	For above item (3). (each set for 3phases. 1set for spare.)

Table 2-3-9 Basic Specifications of Vehicles for Maintenance of Distribution Network

No.	Item	Quantity	Specification
(1)	Supply of Street lighting vehicle	1 set	
1)	Adapted Vehicle (chassis)		2.8-3.2 ton truck (5.5-5.8m(L)x1.8-1.9m(W)x3.2m(H))
2)	Bucket		-Supporting weight : Min.2 persons or 200kg -Supporting height : Approx. 12m -Size : Approx. 750mm(L)x1,200mm(W)x900mm(H) -Turing angle : Approx. left 100°~ right 100°
3)	Boom		-Moving angle : Vertical -15° ~ +80°, Horizontal 360°
(2)	Supply of Truck with 5 ton crane	1 set	
1)	Number of crane boom steps		4 steps
2)	Crane capacity		Approx. 5.0tons x 2.5m = 12.5ton · m
3)	Max. hang up capacity		Approx. 5.0tons
4)	Crane suspended height		Approx. 10.0m from ground level
5)	Crane max. working radius		Approx. 9.0m

Table 2-3-10 Basic Specifications of Equipment and Materials for Improvement of Were Genu Substation

No.	Item	Quantity	Specification
(1)	Supply of Conductor	120 km	(40kmx3)
1)	Type		AAC
2)	Size		95mm^2
(2)	Supply of Insulator	2,400 pcs.	
1)	Type		Pin type
(3)	Supply of 15kV Lightning arrester with mounting bracket	300 pcs.	
1)	Type		Outdoor use, Non-linear metal oxide
2)	Rated voltage		15kV
3)	Nominal discharge current		10kA
(4)	Supply of Disconnectors	100 pcs.	
1)	Type		Fuse switch
2)	Rated voltage		15kV
3)	Rated current		For 315kVA transformers
(5)	Supply of Outgoing feeder panel (Expansion)	4 nos.	
1)	Type		Indoor use, metal-enclosed switchgear, with vacuum circuit breaker (VCB)
2)	Rated voltage		15kV
3)	Rated current		630A
4)	Accessories		-Nameplate -Drawing device for circuit breaker -Connecting materials(between existing panel and new one) -Earthing terminal -Other necessary accessories

(6) Basic Design Drawings

The basic design drawings for the Project are listed below.

1) Rehabilitation of Akaki Substation

AKA-1 : Single Line Diagramme

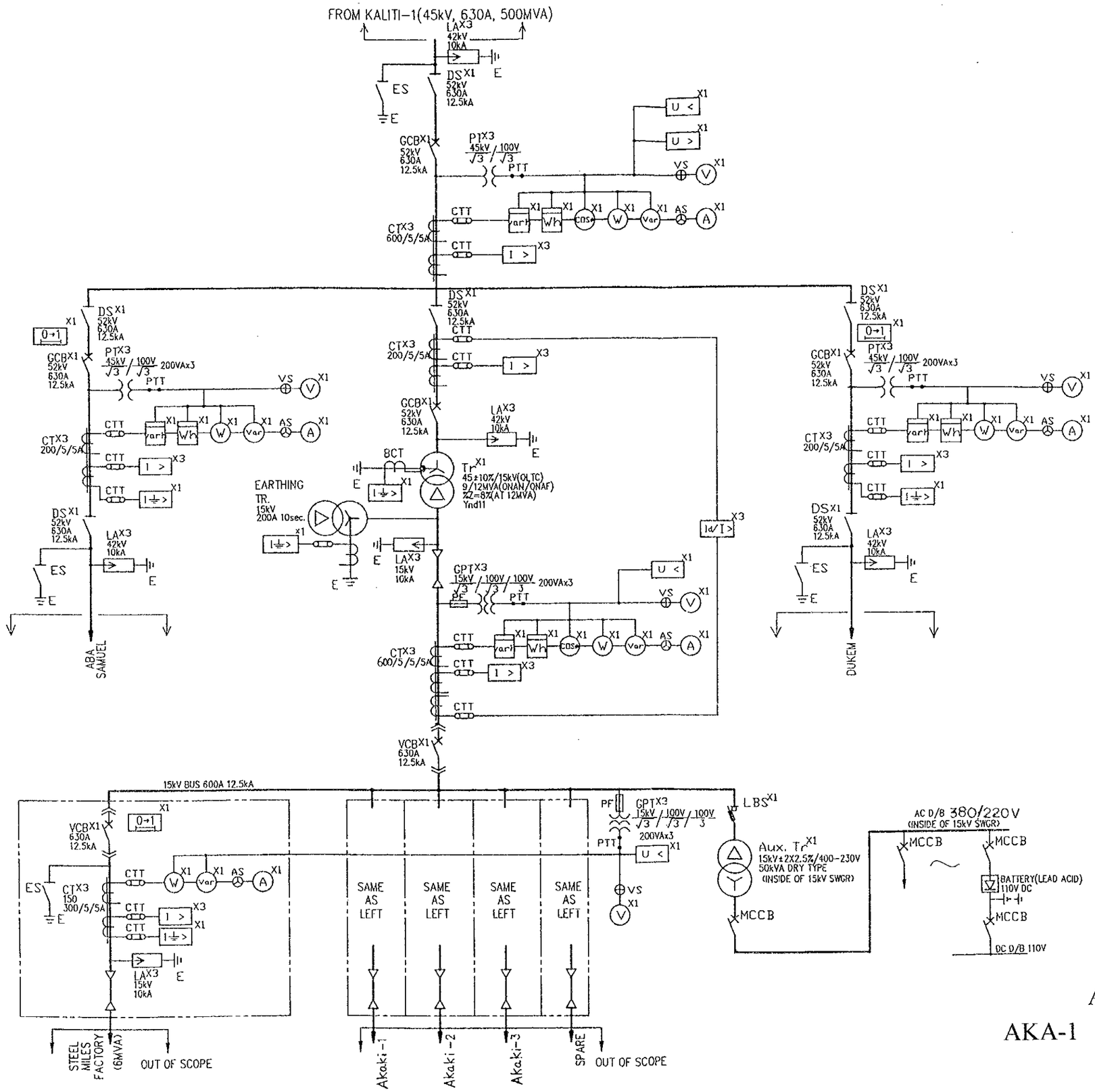
AKA-2 : Layout Plan · Section

AKA-3 : Control Building Plan · Section

2) Rehabilitation of Addis Center Substation

ADC-1 : Single Line Diagramme

ADC-2 : Layout Plan · Section



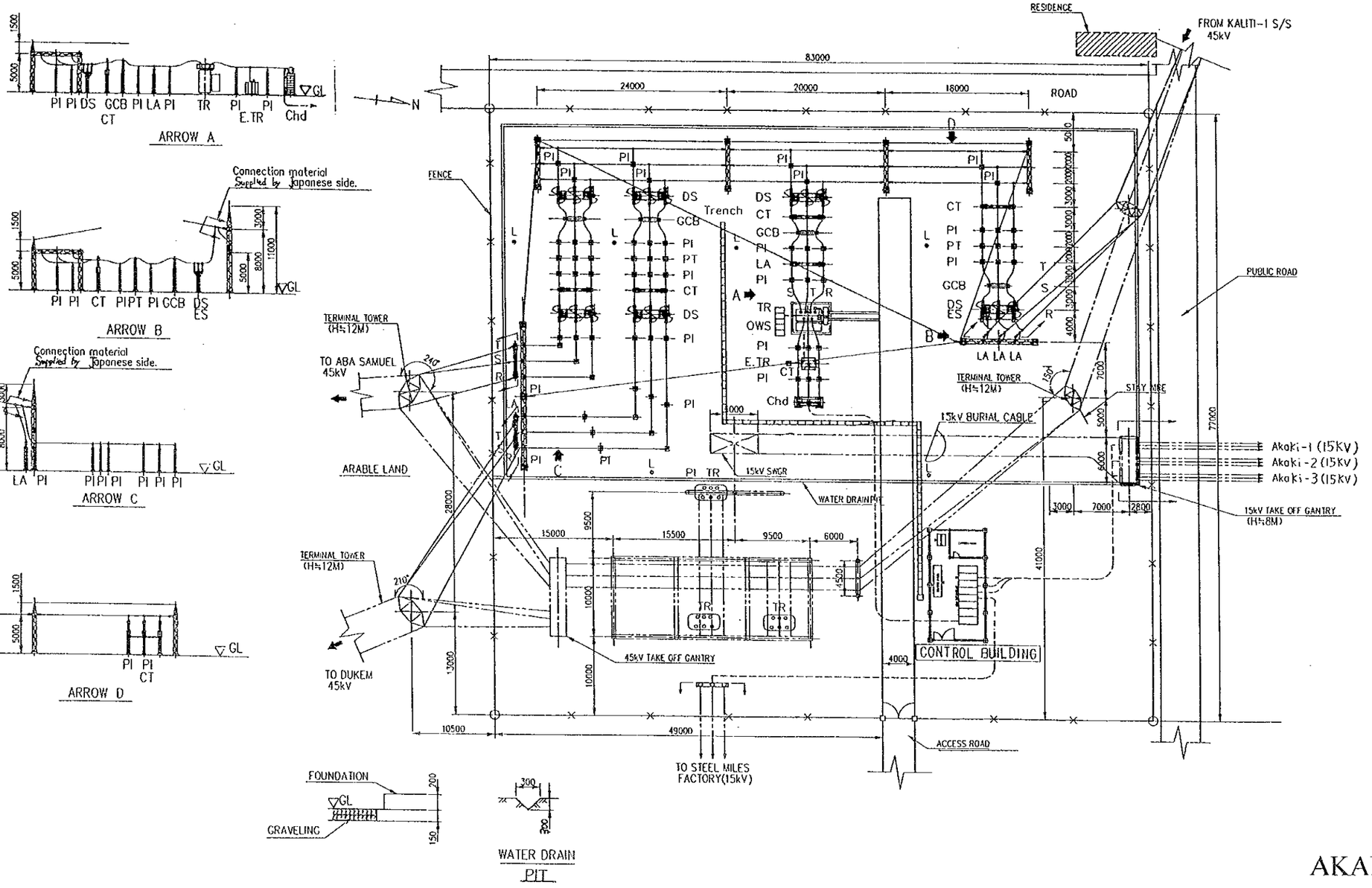
LEGEND

SYMBOL	DESCRIPTION	記 述
CT	Current transformer	計器用変流器
PT	Potential transformer	計器用変圧器
GCB	Gas-type circuit breaker	ガス遮断器
DS ES	Disconnecting switch with earth switch	接地付断路器
LA	Lightning arrester	避雷器
TR	Transformer	変圧器
⌐ ⌙	ETHIOPIA SIDE	エチオピア側

AKAKI SUBSTATION
AKA-1 SINGLE LINE DIAGRAM

LEGEND

SYMBOL	DESCRIPTION	記 述
CT	Current transformer	計器用変流器
PT	Potential transformer	計器用変圧器
GCB	Gas-type circuit breaker	ガス遮断器
DS ES	Disconnecting switch with earth switch	接地付断路器
LA	Lightning arrester	避雷器
TR	Transformer	変圧器
E.TR	Earthing transformer	接地変圧器
PI	Post insulator	碍子受け柱
Chd	Cable head	ケーブル端末
⌐ L_	ETHIOPIA SIDE	エチオピア側
OWS	Oil water separator	油水分離装置
L	Lighting	照明
----------	Existing facilty	既設
----------	New facilty	新設



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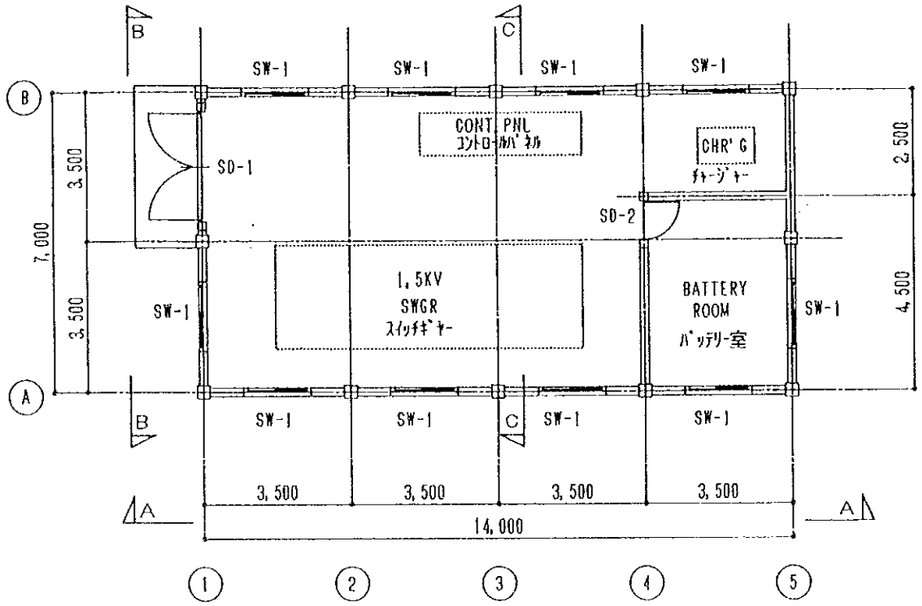
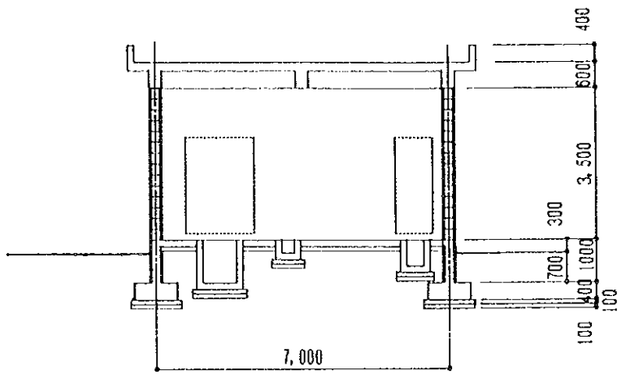
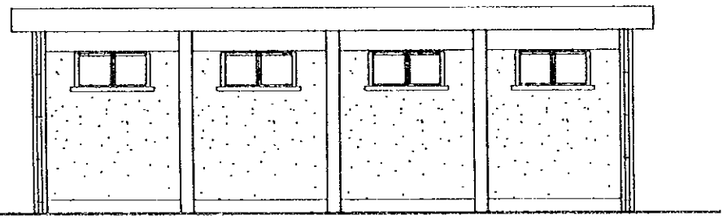
AKAKI SUBSTATION
AKA-2 LAYOUT PLAN・SECTION



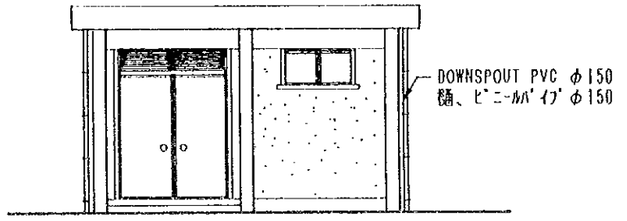
GROUND FLOOR PLAN
1 階平面図 1/100



SECTION C-C
断面図 C-C



ELEVATION A-A
立面図 A-A



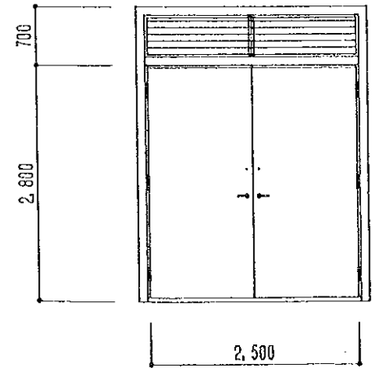
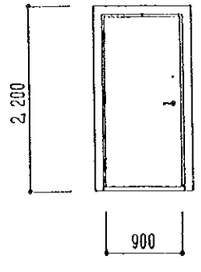
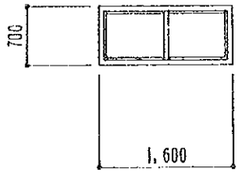
ELEVATION B-B
立面図 B-B

FINISHING SCHEDULE (仕上表)

	FLOOR		EXT. WALL 外壁	INT. WALL 内壁	CEILING 天井		ROOF 屋根
ROOM 部屋	VINYL TILE WITH BASE MORTAR モルタル下地ビニールタイル貼	ACID PROOF PAINT ON BASE MORTAR モルタル下地耐酸ペイント	MORTAR t=30B ON BRICK WALL t=200 ブリック壁の上モルタル塗 厚さ30mm(両面)	MORTAR t=30B ON BRICK WALL t=200 ブリック壁の上モルタル塗 厚さ30mm(両面)	CONCRETE SLAB コンクリートスラブ打放し		THREE PLY BUTUMINOUS FELT WITH MORTAR t=30 モルタル下地の上 アスファルト防水3層
① SWGR ROOM スイッチギヤールーム	●		●	●	●		●
② BATTERY ROOM バッテリールーム	●	●	●	●	●		●

DOORS AND WINDOWS SCHEDULE 1:50
扉、窓リスト

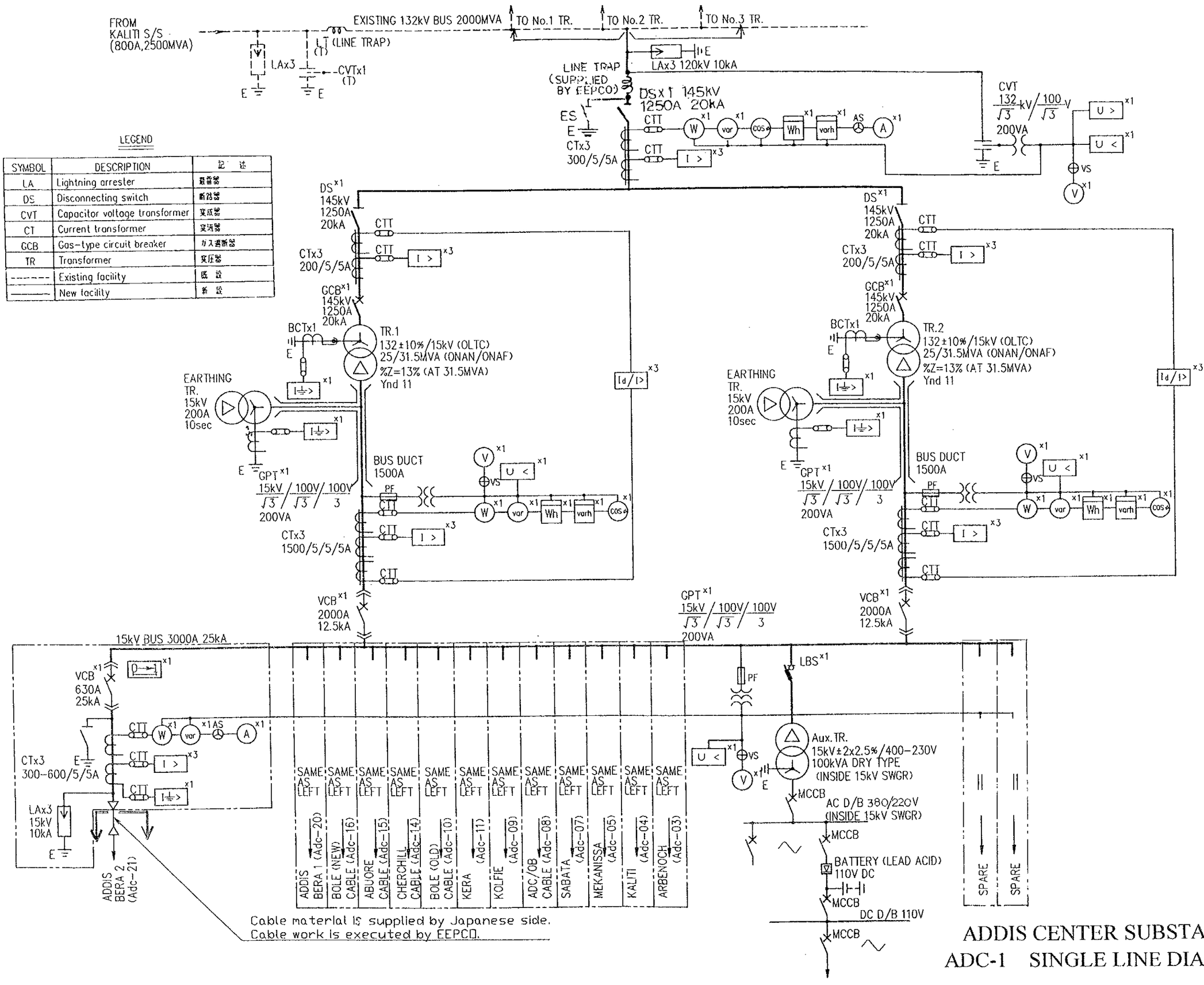
(FRAME:GALVANIZED TUBOLAR STEEL AND PAINT)
(枠:鉄製、亜鉛メッキ)

MARK 符号	SD-1	SD-2	SW-1
DIMENSION (サイズ)			

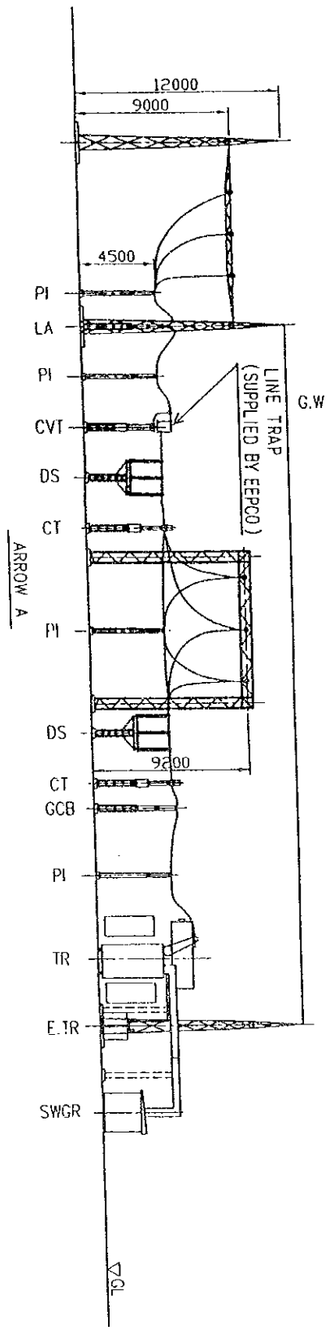
AKAKI SUBSTATION AKA-3 CONTROL BUILDING PLAN・SECTION

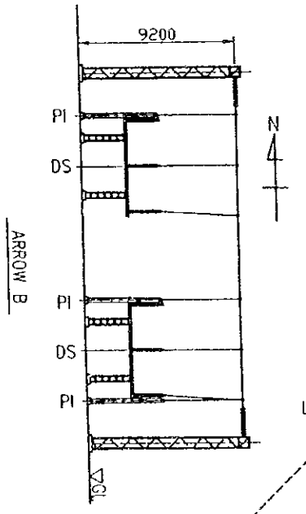
LEGEND

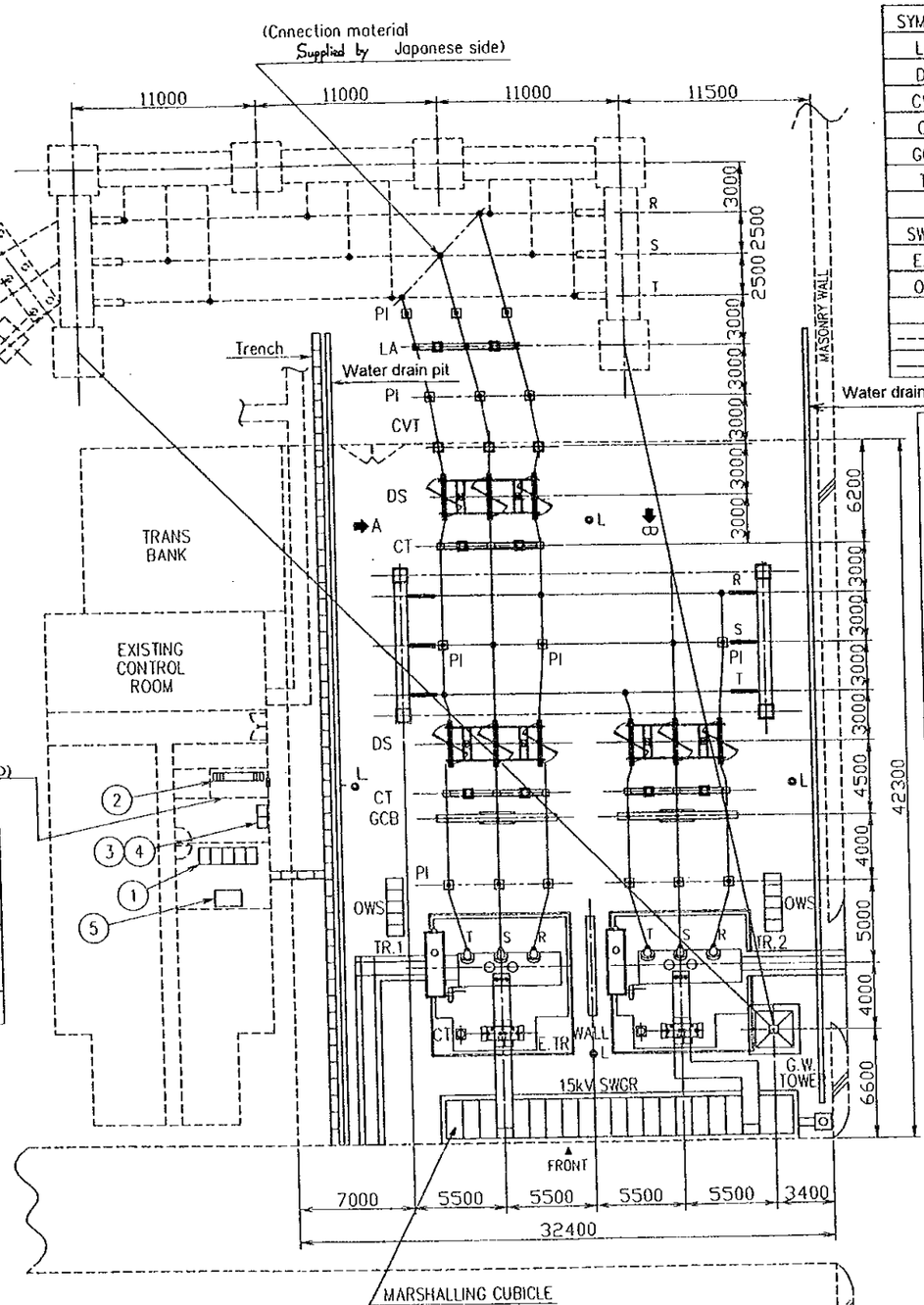
SYMBOL	DESCRIPTION	記 述
LA	Lightning arrester	避雷器
DS	Disconnecting switch	断路器
CVT	Capacitor voltage transformer	変成器
CT	Current transformer	変流器
GCB	Gas-type circuit breaker	ガス遮断器
TR	Transformer	変圧器
-------	Existing facility	既 設
———	New facility	新 設



ADDIS CENTER SUBSTATION
ADC-1 SINGLE LINE DIAGRAM





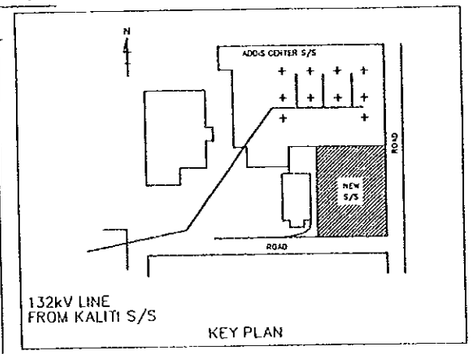


NAME OF EQUIPMENT

NO.	EQUIPMENT
①	132kV CONT. & PROT. PANELS
②	BATTERIES
③	CHARGER
④	DC 110V D/B
⑤	15kV REMOTE SV & CONT. PANEL

LEGEND

SYMBOL	DESCRIPTION	記 述
LA	Lightning arrester	避雷器
DS	Disconnecting switch	断路器
CVT	Capacitor voltage transformer	変成器
CT	Current transformer	変流器
GCB	Gas-type circuit breaker	ガス遮断器
TR	Transformer	変圧器
L	Lighting	照 明
SWGR	Switchgear	スイッチギヤ
E.TR	Earthing transformer	接地変圧器
OWS	Oil water separator	油水分離装置
PI	Post insulator	碍子
-------	Existing facility	既 設
———	New facility	新 設



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ADDIS CENTER SUBSTATION
ADC-2 LAYOUT PLAN • SECTION