THE MINISTRY OF ENERGY AND MINERAL DEVELOPMENT
THE REPUBLIC OF UGANDA

BASIC DESIGN STUDY REPORT
ON
THE RURAL ELECTRIFICATION PROJECT
IN
THE REPUBLIC OF UGANDA

FEBRUARY, 1999

JAPAN INTERNATIONAL COOPERATION AGENCY

YACHIYO ENGINEERING CO., LTD.

THE MINISTRY OF ENERGY AND MINERAL DEVELOPMENT
THE REPUBLIC OF UGANDA

BASIC DESIGN STUDY REPORT
ON
THE RURAL ELECTRIFICATION PROJECT
IN
THE REPUBLIC OF UGANDA

FEBRUARY, 1999

JAPAN INTERNATIONAL COOPERATION AGENCY
YACHIYO ENGINEERING CO., LTD.

PREFACE

In response to a request from the Government of the Republic of Uganda, the Government of Japan decided to conduct a basic design study on the Rural Electrification Project and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Uganda a study team from August 31 to October 21, 1998.

The team held discussions with the officials concerned of the Government of Uganda, 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 Uganda 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 Republic of Uganda for their close cooperation extended to the teams.

February, 1999

Kimio Fujita
President
Japan International Cooperation Agency

LETTER OF TRANSMITTAL

February, 1999

We are pleased to submit to you the basic design study report on the Rural Electrification Project in the Republic of Uganda.

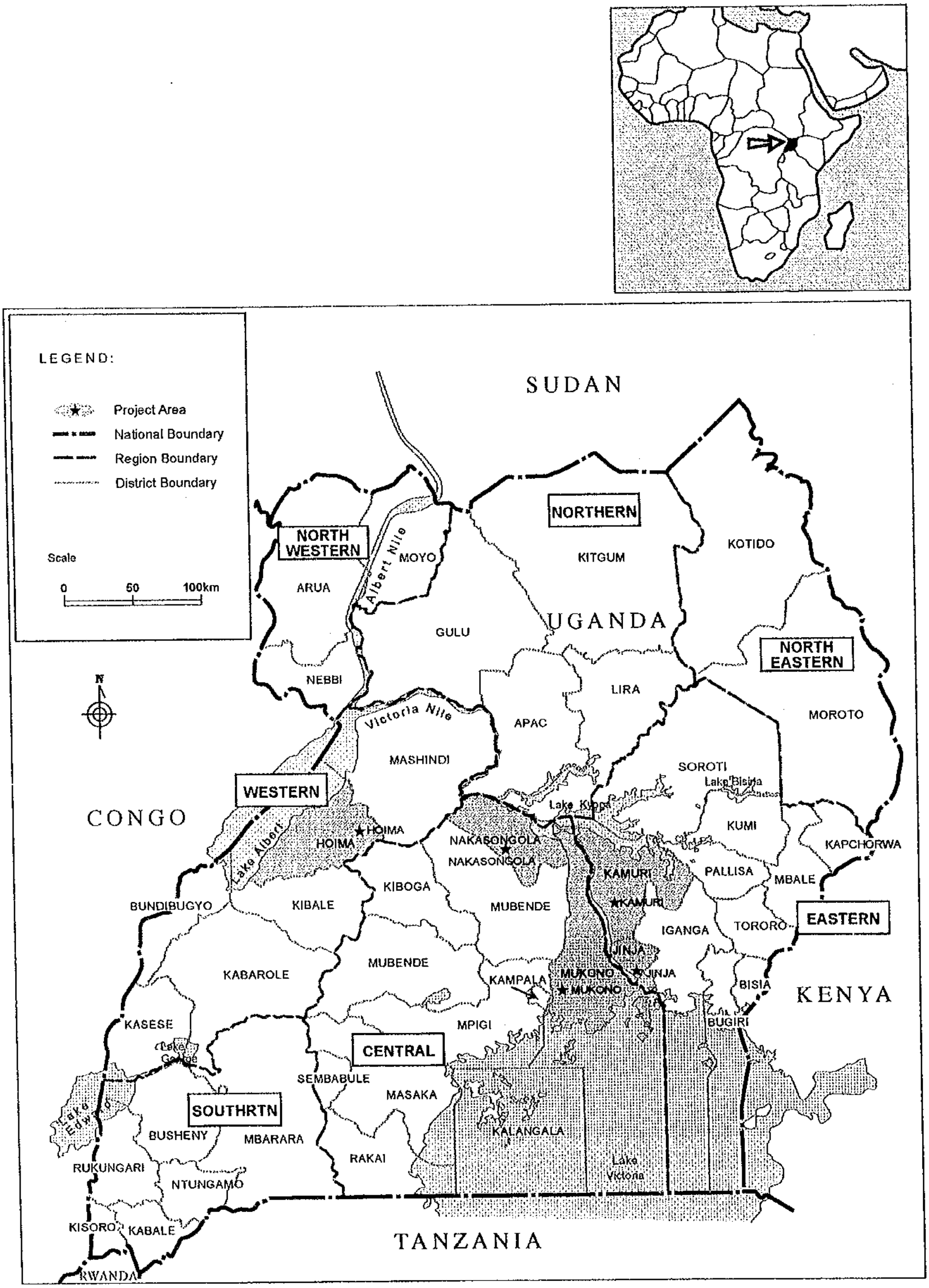
This study was conducted by Yachiyo Engineering Co., Ltd., under a contract to JICA, during the period from August 21, 1998 to February 16, 1999. In conducting the study, we have examined the feasibility and rationale of the project with due consideration to the present situation of Uganda and formulated 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.

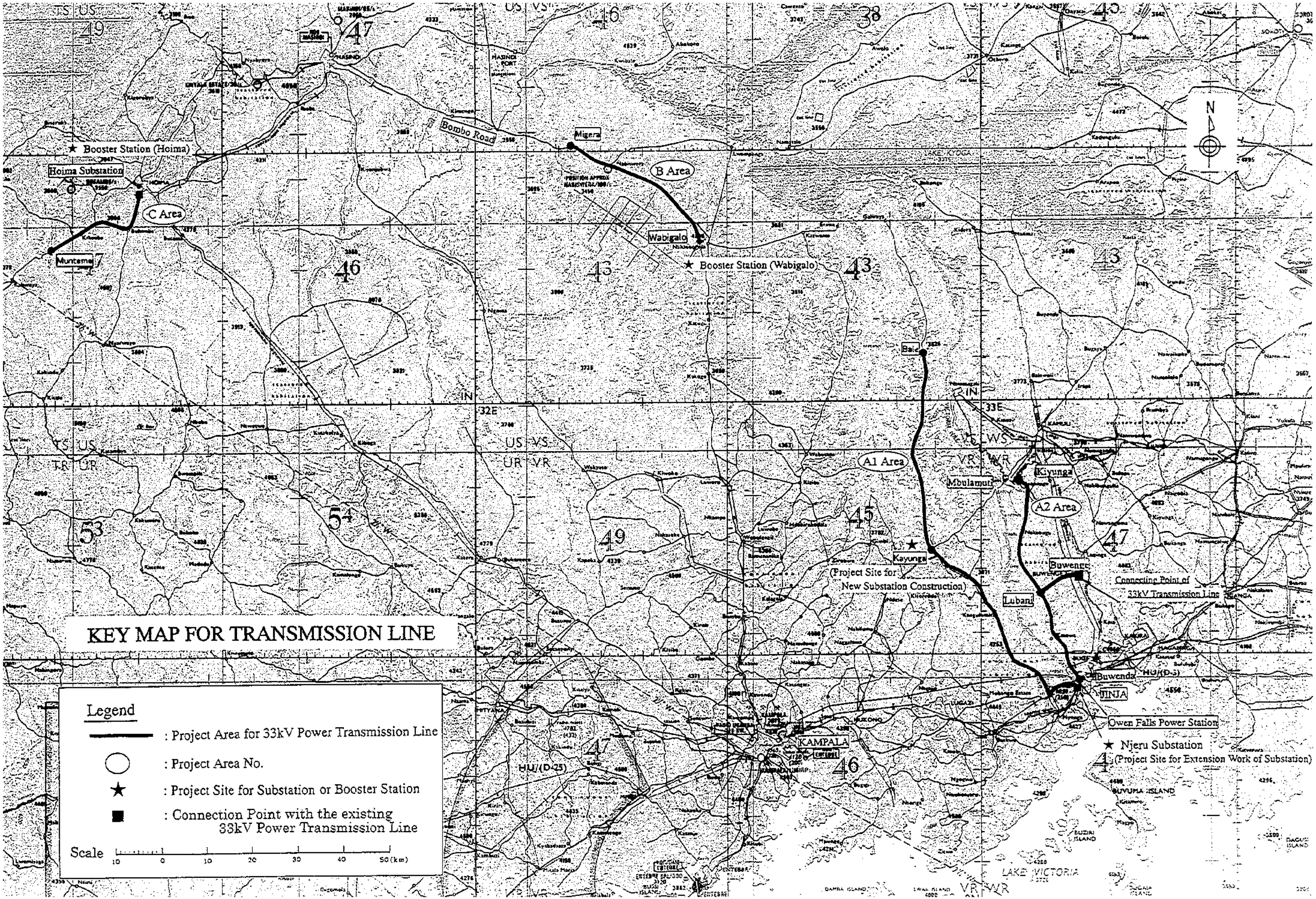
Very truly yours,

M. Komiya

Masatsugu Komiya
Project Manager,
Basic design study team on
the Rural Electrification Project
Yachiyo Engineering Co., Ltd.



Map of Uganda


KEY MAP FOR TRANSMISSION LINE
Legend
: Project Area for 33kV Power Transmission Line
: Project Area No.
: Project Site for Substation or Booster Station
: Connection Point with the existing 33kV Power Transmission Line
Scale
10 0 10 20 30 40 50 (km)
Booster Station (Hoima)
Hoima Substation
C Area
Munteme
Bombo Road
Migera
B Area
Wabigalo
Booster Station (Wabigalo)
Bale
A1 Area
Kayunga
(Project Site for New Substation Construction)
Mbulamuti
Kiyunga
A2 Area
Buwenge
Lubani
Connecting Point of 33kV Transmission Line
Buwenda
JINJA
Owen Falls Power Station
Njeru Substation
(Project Site for Extension Work of Substation)
KAMPALA
LAKE VICTORIA
LAKE KYOGA
N

CONTENTS

ABBREVIATIONS

EEC	European Economic Committee
E/N	Exchange of Notes
GDP	Gross Domestic Product
GNP	Gross National Product
IDA	International Development Association
IEC	International Electrotechnical Commission
IMF	International Monetary Fund
JEAC	Japan Electric Association
JEC	Japanese Electrotechnical Committee
JEM	Standards of Japan Electrical Manufacturer's Association
JICA	Japan International Cooperation Agency
JIS	Japanese Industrial Standards
IPP	Independent Power Producer
O & M	Operation and Maintenance
OECF	Overseas Economic Cooperation Fund
OJT	On-the-Job Training
OLTC	On-Load Tap Changer
SCADA	Supervisory Control and Data Acquisition
UEB	Uganda Electricity Board
NEPS	National Rural Electrification Programme

LIST OF TABLE AND FIGURES

CHAPTER 1

BACKGROUND OF THE PROJECT

CHAPTER 1 BACKGROUND OF THE PROJECT

The economy of the Republic of Uganda (hereinafter referred to as Uganda) continued to be sluggish in the 1970's and early 1980's because of the adverse impacts of civil war but began to show signs of recovery in the second half of the 1980's due to the introduction of an economic rehabilitation Programme and other measures. In the last 10 years, the economy has grown at an average annual rate of 6.5%. The GDP shares by sector in 1997 were 42% for agriculture, 9.1% for manufacturing, 14.5% for commerce, 15.3% for services and 18.7% for others, illustrating the importance of agriculture as the key industry for the country's economic rehabilitation. Nevertheless, the development of living infrastructure in rural areas is inadequate and the resulting urban-rural gap is the cause of a continuous population migration from rural areas to urban areas.

In the period of the National Development Strategy for 1996 - 1998, the Government of Uganda formulated the Poverty Eradication Action Plan, in which improvement of the infrastructure in rural areas was a key component to rectify the urban-rural gap in terms of the standard of living. The Poverty Eradication Action Plan Paper compiled in 1997 adopted the provision of social and public services for the poor as a major policy, calling for the urgent improvement of the urban-rural gap.

Under these circumstances, the Uganda Electricity Board (UEB) in charge of the electricity sector conducted the Nationwide Rural Electrification Plan Study in 1992 with the assistance of the IDA and formulated a master plan for rural electrification. While genuine efforts have been made to implement this master plan using domestic funds, it has been difficult to secure the necessary loans for rural electrification projects. As a result, the progress of the electrification plan has been slow and the electrification rate as of 1998 is still as low as some 5%.

To facilitate the electrification plan in four areas, the priority of which is indicated by the master plan, the Government of Uganda has requested the Government of Japan's provision of grant aid for the Rural Electrification Project (hereinafter referred to as the Project) which is the development of 33 kV transmission lines, because the Japanese Government has provided Grant Aid on two occasions in the past (the Project for the Reinforcement of Electric Power Distribution Network in Kampala in 1991 and the Project the for Reinforcement of Electric Power Distribution Network in Kampala Suburban Area in 1993).

In the original request by Ugandan side, the fifth project Area (called as Area D) for Lugolole - Mayuge (approx. 18km) at Iganga District was included. However, during the discussion for draft final report consultation, Ugandan side requested to withdraw the Area D from the project areas, because the electrification of this area will be done by a local NGO.

[Contents of the Request]

(1) Procurement of 33 kV Transmission Line Equipment and Materials

1) Subject Areas (Total: approximately 200 km)

A-1 : Mukono District, Central Province
Njeru - Kayunga - Bale (approximately 92 km)

A-2 : Kamuli District and Jinja District, Eastern Province
Jinja - Budondo - Mbulamati (approximately 44 km)

B : Nakasongola District, Central Province
Migera - Wabigalo (approximately 31 km)

C : Hoima District, Western Province
Hoima - Munteme (approximately 33 km)

2) Equipment and Materials for Procurement

- Conductors, cables, insulators, pole-mounted transformers, air-break switches, arresters and other equipment and materials of 33 kV transmission lines
- Two tracks with crane
- One set of spare parts (two year's supply) and repair tools
- One set of installation and maintenance manuals

(2) Substation Construction Work

1) Kayunga Substation (New) Construction Work

- Procurement and installation of 33 kV outdoor switchgears, 11 kV outdoor switchgears, 33/11 kV transformer (2.5 MVA) and accessories
- Foundation work and construction of auxiliary facilities, including de-oiler, cable pits,etc.

2) Njeru Substation Extension Work

- Procurement and installation of one 33 kV outdoor switchgear for transmission to the Kayunga Substation

3) Procurement and Installation of Booster Stations

- One set of 3 MVA 33 kV step voltage regulator for B area (to be installed at the branch point of the existing transmission line in the B area
- One set of 5 MVA 33 kV step voltage regulator for C area (to be installed at the existing Hoima Substation)

4) Procurement of spare parts (two years' supply) and maintenance tools for the above

5) Procurement of maintenance manuals for the above

CHAPTER 2

CONTENTS OF THE PROJECT

CHAPTER 2 CONTENTS OF THE PROJECT

2.1 Objectives of the Project

The Government of Uganda has adopted the promotion of economic growth and the equal distribution of the benefits of economic growth among the public as the two main targets of its National Development Strategy and considers the eradication of poverty to be an urgent task to rectify the urban-rural gap in the standard of living in order to meet these targets.

The Project forms part of the social infrastructure development project which is essential for improvement of the living standard in rural areas, the stable operation of social and public facilities and the fostering of industries as it facilitates "the provision of basic social and public services for the masses". Its objective is to construct 33 kV transmission lines capable of meeting the estimated power demand upto 2004 in four unelectrified areas despite the fact that all of these areas are important rural agricultural production areas in Uganda.

2.2 Basic Concept of the Project

The economy of Uganda, once impoverished due to the long civil war which commenced in 1970, eventually began to steadily recover with the introduction of the economic rehabilitation Programme and other measures, recording an average annual economic growth rate of 6.5% in the last 10 years. The Government of Uganda is, however, concerned in regard to the fact that the benefits of such economic recovery have been concentrated in urban areas, failing to reach the poor in rural areas where some 86% of the total population live (1995/96 statistics). As a result, the eradication of poverty has become an urgent task for the government. In the electricity sector, promotion of the electrification of rural areas where the national average electrification rate is still as low as some 5%, is urgently required to fulfill this task in view of the rectification of the urban-rural gap in the standard of living.

The UEB has adopted the extension and improvement of the transmission network for rural electrification as a pressing task but the fiscal problems of the country and the low profitability of the relevant projects have made it difficult to implement the electrification work with loans, causing strong concern in regard to the delay of such work.

All of the four subject areas of electrification requested by the Government of Uganda are key areas for agriculture, which is the main industry in Uganda, but are hardly electrified, forcing local people to rely on kerosene lamps and firewood. Even though some areas (for example, Kayunga town) have been electrified, the significant voltage drop of the existing 11 kV distribution lines has negative impacts on the operation of public facilities and daily life, including the malfunction of medical and other electrical equipment.

Based on the above assessment, the basic concept of the Project is the procurement of equipment and materials for the urgently required 33 kV transmission lines together with the construction of 33/11 kV substations to develop the 33 kV transmission lines as important social infrastructure in major local agricultural areas for the purposes of improving the local standard of living and the management of social welfare facilities and vitalizing socioeconomic activities in the subject areas.

2.3 Basic Design

2.3.1 Design Concept

(1) Natural Conditions

1) Altitude

The project sites are located on highland with an approximately altitude of 1,300 m. In general, the dielectric strength of electrical appliances declines by 1% for every 100 m increase of the altitude. This necessitates the careful selection of equipment with a suitable insulation level for high altitudes in order to ensure their safety and durability.

2) Temperature

The temperature at the project sites is fairly constant throughout the year in the range of 16 - 28°C, showing a warm climate. As the planned substation will use outdoor-type enclosed switchgears, careful attention must be paid to its structure so that the temperature inside the panel is kept in the normal working temperature range of the equipment for its continuous operation despite the likely increase of the temperature caused by direct sunshine and higher external temperature.

3) Relative Humidity and Rainfall

The relative humidity ranges from 60 - 90% through the year and is fairly comfortable. The use of a space heater, however, should be considered for the sealed panel to prevent condensation due to temperature fluctuations. Rainfall drainage facilities will be constructed on the substation premises to prevent the disruption of smooth operation and maintenance by standing rainwater.

(2) Social Conditions

In Uganda, while life with some degree of convenience can be expected in the capital, the living conditions in the project areas are greatly inferior because of the delayed development of social infrastructure. In some areas, English is not widely spoken and the absence of appropriate medical facilities also makes it inconvenient for the long-term stay of foreign engineers. The planning of temporary structures for substation construction, etc. must take these local conditions into consideration.

(3) Local Construction Industry

The economic growth in recent years has led to a series of large-scale construction works for office buildings, etc. in Kampala. As a result, several foreign general construction companies have moved into the capital, creating a reliable local construction industry.

At the planned sites for the new substation, etc. under the Project, however, construction work has been limited and the low infrastructure level presents poor conditions for construction work. The planning of construction work under the Project must, therefore, take the transportation method of the construction equipment and materials from the capital, the service facilities for the site office and other aspects into careful consideration.

Meanwhile, as the installation of the substation equipment and step voltage regulators will require special skills of a high technical standard, the dispatch of Japanese engineers will be necessary for technical guidance and process control purposes.

(4) Use of Local Construction Companies, Equipment and Materials

1) Use of Local Construction Companies

General construction companies of foreign capitals are operating in Kampala as mentioned above and it is relatively easy to locally secure workers, transport vehicles and construction equipment/materials. It will, therefore, be possible to subcontract the foundation work to a local company.

In contrast, it will be difficult to entirely rely on a local company for the installation of the substation equipment because of the need for special skills of a high technical standard. The dispatch of Japanese engineers will, therefore, be necessary for technical guidance and process control purposes.

2) Use of Local Equipment and Materials

In the preparation of the work plan, emphasis is placed on the procurement of local equipment and materials where possible. Aggregate, cement and reinforcing bars, etc. for civil engineering and building works are available in Uganda and, therefore, these materials will be locally procured for the Project. In comparison, the equipment and materials for the planned transmission lines and substation under the Project are not domestically produced in Uganda and are imported. Therefore, their procurement in Japan or a third country will be planned.

The existing transmission lines and substations use equipment of various country origins because of the funding sources. Few manufacturers of such equipment have a local agent capable of providing after-services, such as the repair of failed equipment and the supply of spare parts. According to staff of the UEB, the agreed delivery terms are not met in some cases, leading to work suspension. Staffs of the UEB are familiar with the operation and maintenance of the Japanese equipment procured for previous ODA projects and they believe the after-service system of Japanese manufacturers to be reliable.

In short, it will be necessary for the selection of the supplier(s) of the planned transmission and substation equipment for the Project to take into consideration the ease of equipment operation and maintenance for Ugandan engineers and the availability of an after-service system to deal with equipment breakdowns and to supply spare parts.

(5) Maintenance and Management Capability of Project Implementation Body

The UEB has been directly operating and maintaining the nationwide transmission and distribution networks, including the 132 kV transmission lines. The subject substations of previous Japanese ODA projects which are similar to the substation planned under the present Project have been adequately operated and maintained by the UEB.

Given such maintenance conditions of the existing facilities, UEB operators are judged to be conversant with the maintenance of general transformation and distribution equipment. However, it is still possible that their skills in regard to the planned latest equipment under the Project may fall short of perfection. Japanese engineers will therefore, provide OJT on the operation and maintenance of substation equipment during the work period in order to ensure the effective as well as efficient operation of the new facilities constructed under the Project.

(6) Scope and Grade of Facilities and Equipment, etc.

The scope of procurement and installation 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, etc.

The configuration as well as the specifications of the equipment must be decided in regard to the procurement of the 33 kV transmission line equipment and materials to ensure safe and stable electricity distribution to residents and to such social and public facilities as hospitals and schools along trunk national roads in important rural areas in Uganda.

2) Grade

Special care must be taken in regard to the 33 kV transmission equipment to be procured under the Project so that the equipment grades are not beyond the technical capability of the UEB which will be responsible for the operation and maintenance of the equipment following the completion of the construction work. Further consideration should be given to the selection of equipment and materials, which are appropriate in view of the level of construction technologies in Uganda as the UEB will be responsible for the construction/installation of transmission lines and pole mounted transformers.

2.3.2 Basic Design

(1) Planning Conditions

1) Power Demand Forecast of the Project Areas

(a) The power demand forecast was made in the following manner.

① Estimation of Present Power Demand

A population census has been conducted in Uganda every 10 years and the latest data is for 1991. However, this data does not show the population of individual villages (trade centers) in each province. In view of this shortcoming, the potential users in each village in the Project Areas, confirmed by the field survey, were classified as ordinary households, shops, schools, hospitals/clinics and factories, i.e. small household industries, in order to establish the number of users subject to electrification under the Project.

In regard to the unit power demand, it has been decided that the value applied by the UEB for the present rural electrification Programme will be used for the Project. Accordingly, the prospective users are classified into the following three groups. The unit power demand for each group is shown in Table 2-4-4.

- Low income group (monthly income of less than 100,000 Ush)
- Middle income group (monthly income of 100,000 Ush or more but less than 400,000 Ush)
- High income group (monthly income of 400,000 Ush or more)

The unit power demand in the table is determined based on the power demand forecast of the hydropower development master plan commissioned by the UEB and prepared by a UK consultant in 1996 which has been reviewed based on the actual power demand since 1996 for the purposes of the present Project.

Table 2-3-1 Unit Power Demand as Basis for Power Demand Estimation

User Type	Unit Power Demand per User	Demand Factor
Ordinary Households	172 W	0.7
Shops and Clinics	1,060 W	0.7
Others (Schools, Hospitals and Factories, etc.)	3,500 W	1.0

Note: Demand factor: demand reduction rate based on the assumption that all users in one category do not use electricity at the same time.
Source: UEB

② Estimation of Power Demand in Target Year

The target year of the Project is set at 2004, five years after the completion of the basic design study (1999) and the annual growth rate of the power demand is set at 4% which is the actual results of the rural electrification Programme of the UEB in the past as in the case of above. This growth rate of 4% is judged to be appropriate in view of the Uganda's average GDP growth rate of 6.5% for the last 10 years, the estimated national average power demand growth rate of 5.5% adopted by the above-mentioned hydropower generation development master plan and the likelihood that the power demand growth rate in the Project Areas will be slightly lower than that of urban areas due to the predominance of small scale users in rural areas.

③ Result of the Estimation

The maximum power demand forecast in each Project Area made in the above manner, is listed in Table 2-3-2 below. See Appendix 4 for a more detailed description of the estimated power demand in the Project Areas.

Table 2-3-2 Demand Forecast in each Project Area

(Unit: kW)

Area	Estimated Maximum Power Demand										
	1988	1999	2000	2001	2002	2003	2004 Target Year	2006	2008	2010	2012
A-1	1,208	1,256	1,307	1,359	1,413	1,470	1,528	1,653	1,788	1,934	2,092
A-2	1,046	1,088	1,131	1,176	1,223	1,272	1,323	1,431	1,548	1,674	1,811
B	459	477	496	516	536	558	581	628	679	735	795
C	439	456	475	494	513	534	555	601	650	703	760

2) Measures to be Introduced Under the Project to Reduce Voltage Drop

(a) Voltage Drop in Project Areas

The analysis results of the voltage drop in each Project Area are given in Appendix 6. The estimated voltage drop at the 33 kV transmission ends in the target year in each Project Area is listed below.

Area	Voltage Drop Rate at System End
Area A-1	7.9%
Area A-2	3.5%
Area B	16.4%
Area C	23.0%

(b) Voltage Drop Reduction Measures

The analysis results referred to in (a) above indicate that the estimated voltage drop rate in Areas A-1 and A-2 is less than the allowable limit (±10%) and that adequate system operation will be maintained in these areas. In Areas B and C, the voltage fluctuation rate (here, drop rate) significantly exceeds the 10%, necessitating the introduction of voltage drop reduction measures.

One way of reducting a voltage drop in Area B is the installation of a voltage regulator between the Bombo Substation and Area B in order to maintain an adequate voltage (33 kV).

Based on the field survey results, it is concluded that the desirable site for the installation of a voltage regulator is the branch point (Wabigalo) of the existing 33 kV transmission route to Area B and the Nakasongola Substation in view of the existing system network. Given the estimated voltage drop in the target year of 2004 to 28.3 kV (a 14.1% voltage drop from the rated voltage of 33 kV) at the transmission end to Area B, the voltage regulator to be selected should be capable of regulating a voltage drop of upto 15%.

In the case of Area C, the existing transmission line from the Mutundwe Substation to Area C is as long as some 100 km and the existing 33 kV system already suffers from a voltage drop of some 17%. In fact, the UEB has already installed a voltage regulator at the existing Hoima Substation in 1996. This regulator, however, is a second-hand product made in Bosnia in 1990 and after-service by its manufacturer in terms of the supply of spare parts, etc. is far from ideal. Moreover, as the range of voltage regulation is rather narrow (upto a voltage drop of 12.5%), it cannot sufficiently deal with the current level of voltage drop.

Under these circumstances, it will be necessary to replace the said voltage regulator under the Project by a new voltage regulator, which is capable of dealing with the estimated voltage drop in the target year. Given the estimated 26.8 kV (18.7% voltage drop from the rated voltage of 33 kV) at the transmission end to Area C in the target year, it will be necessary to select a voltage regulator, which is capable of dealing with such a large voltage drop.

(2) General Plan

1) Climatic and Site Conditions

The following design conditions are set after examination of the various conditions described in 2.3.1 regarding the scope and specifications for the Project.

(a) Elevation : approximately 1,200 m

(b) Ambient temperature : 40°C (maximum)
15°C (minimum)
23°C (mean)

(c) Relative humidity : 100% (maximum)

(d) Annual rainfall : approximately 1,580 mm (mean)

(e) Seismic force : 0.1 G (horizontal)

(f) Gust : to be considered (40 m/sec)

(g) Dust : to be considered

(h) Long-term allowable bearing capacity

- Kayunga Substation site : 20 tons/m^2 (boring survey result)
- Hoima voltage regulator site : 10 tons/m^2 (estimate)
- Wabigalo voltage regulator site : 10 tons/m^2 (estimate)

2) Electricity System

(a) Transmission voltage : 33 kV, 3 phase, 3 wire (36 kV max)
11 kV, 3 phase, 3 wire (12 kV max)

(b) Distribution voltage : 415 - 240 V, 3 phase, 4 wire

(c) Frequency : 50 Hz

(d) Grounding system : 33 kV system → direct grounding
11 kV system → direct grounding

(e) Basic insulation level (BIL) : 33 kV system → BIL 170 kV
11 kV system → BIL 75 kV

3) Use of Existing Facilities

The following facilities at the existing substations will be used for the Project.

(a) Njeru Substation (additional installation of one 33 kV switchgear)

- Foundations
- Rainwater drainage system
- Fencing and gate
- Cable trenches and ducts

(b) Hoima Booster Station (in Hoima Substation)

- Gate
- Rainwater drainage system

4) Standards and Units Applied

The following International Standards and Japanese Standards that have been applied to the previous project as Japan's ODA, will be applied for the design of the Project. The unit system to be used will be the international unit system (SI units).

International Standard to be applied for main performance of the equipment.

(a) IEC	: applicable to electrical products in general
(b) ISO	: applicable to industrial products in general

Japanese Standard to be applied in general.

(a) JIS	: applicable to industrial products in general
(b) JEC	: applicable to electrical products in general
(c) JEM	: applicable to electrical products in general
(d) JEAC	: applicable to electrical products in general
(e) JCS	: applicable to electrical wires and cables
(f) Technical standards for electrical	: applicable to electrical installation work in general equipment

(3) Outline of Basic Design

The basic design for the Project in view of the basic design principles/conditions described in 2.3.1 above is outlined in Table 2-3-3.

Table 2-3-3 Outline of Basic Design

Category		Contents	
Procurement Plan	Equipment and Materials for 33 kV Transmission Line	(1) Pole mounted distribution transformers	
		1) 25 kVA (single phase)	: 4
		2) 50 kVA (3 phase)	: 11
		3) 100 kVA (3 phase)	: 20
		4) 200 kVA (3 phase)	: 11
		(2) Bare wires for overhead transmission	
		1) All aluminum alloy conductor (95 mm² for 33 kV transmission)	: 691 km
		2) Galvanized steel conductor (55 m² for aerial grounding)	: 5,700 m
		(3) Insulators	
		1) Suspension insulators	: 5,364 pieces
		2) Pin insulators	: 6,270 pieces
		(4) Fused cut-out switches (single phase)	: 138 units
		(5) Load-break switches (3 phase)	: 17 units
		(6) Surge arresters (single phase)	: 189 units
		(7) Pole-fitting materials (for 200 km of 33kV transmission lines)	: one unit
		(8) Trucks with three ton crane	: 2
		(9) Spare parts and tools	ion line
	Accessories, etc. for Substations	(1) 33 kV distribution materials for Njeru Substation	
		1) 33 kV cable with sealing end treatment materials	: 50 m (for one line)
		(2) 33 kV distribution materials for Kayunga Substation	
		1) 33 kV cable with sealing end treatment materials	: 200 m (for 4 lines)
		(3) 33 kV distribution materials for Hoima Booster Station	
		1) 33 kV cable with sealing end treatment materials	: 150 m (for 3 lines)
		(4) 33 kV distribution materials for Wabigalo Booster Station	
		1) 33 kV cable with sealing end treatment materials	: 150 m (for 3 lines)
		(5) Spare parts	: one set
Procurement and Installation Plan	Substation Equipment	(1) Procurement and installation of the following equipment at Njeru Substation	
		1) 33 kV switchgear panel	: 1
		2) 33 kV surge arresters (with support)	: 3 units
		3) Distribution equipment and materials for the above	: one set
		4) Foundation work for surge arresters	: one set
		Note: The existing foundations will be used for the 33 kV circuit breaker panel	
		(2) Procurement and installation of the following equipment at Kayunga Substation	
		1) Main transformer (33/11 kV, 2.5 MVA)	: 1
		2) 33 kV switchgear panels	: 6 units
		3) 11 kV switchgear panels	: 8 units
		4) 33 kV surge arresters (with support)	: 12 units
		5) Distribution materials for the above	: one set
		6) Foundation work	: one set
		(3) Procurement and installation of the following equipment, etc. for Hoima Booster Station	
		1) Step voltage regulator (33/33 kV, 5 MVA)	: 1
		2) 33 kV switchgear panels	: 4 units
		3) 33 kV surge arresters (with support)	: 9 units
		4) Distribution materials for the above	: one set
		5) Foundation work	: one set
		(4) Procurement and installation of the following equipment, etc. for Wabigalo Booster Station	
		1) Step voltage regulator (33/33 kV, 3 MVA)	: 1
		2) 33 kV switchgear panels	: 4 units
		3) 33 kV surge arresters (with support)	: 9 units
		4) Distribution materials for the above	: one set
		5) Foundation work	: one set
	OJT	Implementation of OJT on operation and maintenance techniques for the above equipment/facilities by engineers to be dispatched by the Japanese contractor	

(4) 33 kV Transmission Line Equipment Procurement Plan

Special care should be taken in regard to the following issues when procuring the 33 kV transmission line equipment and materials.

1) Basic Issues

(a) Ease and Safety of Maintenance

The equipment specifications should not exceed the levels of the existing distribution equipment with which UEB engineers are familiar in order to ensure safe and easy maintenance.

(b) Economy

To ensure an economical design, standard equipment specifications confirming to the relevant international standards will be adopted. The variety of equipment will be minimized to maximize the interchangeability of equipment.

(c) Interchangeability with the existing equipment of UEB

The specifications of the equipment and materials to be procured by the Japanese side will meet the specifications of the existing equipment of UEB where possible, considering the interchangeability of the equipment within UEB works.

2) Transmission Line Plan

(a) Route Selection

Using the route map prepared by the UEB based on the field survey results, desk analysis of the transmission routes was conducted. Following field investigation and verification, the final routes have been decided and the transmission line plan are shown on the route map included at the beginning of this Report.

(b) Type of Electric Poles

Of the equipment and materials to be used for the Project, the only materials domestically produced in Uganda are wooden electric poles made of Eucalyptus trees. Logs are treated against pests and rotting. The UEB has anti-pest and anti-rotting processing factories for electric poles at Lugogo in Kampala and Tororo in eastern Uganda. Each factory has a daily production capacity of 40 poles. In addition, there are five privately-run electric pole processing factories in

Uganda and the UEB uses these factories when its own production volume falls short of the demand. This situation suggests that the local procurement of the electric poles required for the Project will be possible and, therefore, locally produced wooden poles will be procured by UEB for the Project in order to foster this industry. The scope of local procurement will include such miscellaneous items related to electric poles as under-bracing, numberplates and warning signs, etc. All of the equipment and materials required for the construction of the 33 kV transmission lines except wooden poles will be procured by the Japanese side.

(c) Type of Bare Conductors for Overhead Transmission Lines

The type and size of the bare conductors for the overhead transmission lines will be all aluminum alloy conductor (AAAC) of 95 mm^2 to ensure conformity with the standard UEB specifications and to avoid increased maintenance complexity due to the introduction of a new type of cable.

(d) Installation of Pole-Mounted Transformers

Pole-mounted transformers will be installed to step down the voltage from 33 kV to 415 - 240 V for distribution to users. The capacity of the pole-mounted transformers will be sufficient to meet the maximum power demand in the target year of 2004 (see Appendix 5) and the types of transformers are selected based on the standard transformer capacity stipulated by the UEB, i.e. 25 kVA, 50 kVA, 100 kVA, 200 kVA, 315 kVA, 500 kVA and 630 kVA. The number of the transformers to be procured has been decided according to the shape of distribution area and necessary amount of load to be covered.

(e) Installation of Load-Break Switches

In accordance with the UEB regulations, load-break switches will be installed at each branching point and at intervals of some eight miles (13 km) for inspection and maintenance of the transmission line.

(f) Installation of Fused Cut-Out Switches

A fused cutout switch will be installed at the primary side (33 kV side) of each pole-mounted transformer to open a circuit for transformer protection and maintenance purposes.

(g) Protection of Pole-Mounted Transformers and Load-Break Switches

33 kV surge arresters will be procured to protect the pole-mounted transformers and load-break switches from lightning.

3) Required Quantities of Equipment and Materials for the Project

(a) Bare Wire for Overhead Transmission Lines

The required quantity of bare wire for the overhead transmission lines, including the cable length between T-off branches to the pole mounted transformers, was calculated by multiplying the flat distance of the transmission lines by 1.15 to allow a safety margin. This safety margin of 15% is commonly used in Japan and consists of 3% for sagging of the bare wire, 4% for work wastage and 8% as a supplement. Accordingly, the procurement quantity of bare conductor for the overhead transmission lines is as follows.

- Procurement quantity of bare conductor : 691,000 m
  (flat distance x 3 phase x 1.15)

(b) Pole-Mounted Transformers

Following the selection process described earlier [2.3.2-(4)-2]-(d)], the total number of pole mounted transformers is 46, consisting of the following capacities.

Capacity	Quantity
25 kVA 1 Φ	4
50 kVA 3 Φ	11
100 kVA 3 Φ	20
200 kVA 3 Φ	11

(c) Load-Break Switches

As described earlier [2.3.2-(4)-2)-(e)], load-break switches will, in principle, be installed at the branching points and at intervals of some eight miles (13 km). As each installation site has a different condition because of the topographical conditions or electric pole type (angle pole or branching pole, etc.), it was necessary to conduct deskwork to determine their positions using the site survey map prepared by the Basic Design Study. Based on such work, it has been decided to procure 17 load-break switches.

(d) Fused Cut-Out Switches

A fused cutout switch will be installed on the primary side (high voltage side) of each pole-mounted transformer. The quantity to be procured is 138 .

(e) Surge Arresters

A surge arrester will be installed to protect the pole-mounted transformers and load-break switches. Accordingly, a surge arrester will be installed at 63 positions (46 transformers and 17 load-break switches). The total quantity to be procured is 189.

(f) Overhead Grounding Conductors

An overhead grounding conductor will be laid between each 33 kV transmission line branching point and the pole-mounted transformers (average distance of 50 m for each site). Two conductors will be laid at a distance of 50 m. A length of 124 m is adopted for each site to include the cross-sectional portion and 15% supplement. The total quantity to be procured is 5,700 m.

(g) Insulators and Pole-Fitting Materials

In addition to those items listed above, insulators and pole-fitting materials will be required for the completion of the work. According to UEB's standard practice, electric poles will, in principle, be installed at interval of some 100 meters. However as the installation sites require specification because of the topographical conditions or electric pole shape (angle pole or branching pole, etc.), it was necessary to conduct deskwork to determine their positions using the survey map prepared by the UEB. Based on such work, actual number of poles with insulators and pole fitting materials has been determined. The details of these materials are given in Basic Design Drawings No. T-1 through T-10 for each type of electric pole to be selected based on the site conditions. The type and quantity of electric poles are shown in Table 2-3-4.
10% or 1 unit minimum supplement is added to the design quantity of insulators and pole-fitting materials, etc. in view of possible damage during the work.

The insulator procurement quantity (including reserves) is shown below.

- Suspension insulators : 5,364 pieces
- Pin insulators : 6,270 pieces

Table 2-3-4 Purpose of Use and Quantity of Different Types of Electric Poles

Type of Pole	Drawing Number	Purpose of Use	Procurement Quantity with each area (sets)				Quantity
			A-1	A-2	B	C	
A	T-1	For horizontal array transmission line (straight line)	863 (785)	368 (335)	250 (228)	308 (280)	1,789 (1,628)
UEB-1	T-2	Angle pole (5° - 30°)	26 (24)	25 (23)	4 (3)	28 (26)	83 (76)
UEB-2	T-3	Angle pole (30° - 50°)	23 (21)	7 (6)	3 (2)	5 (4)	38 (31)
UEB-3	T-4	Angle pole (50° - 90°)	23 (21)	5 (4)	2 (1)	5 (4)	35 (30)
UEB-5	T-5	For triangular array transmission line (straight line)	3 (2)	0 (0)	2 (1)	6 (5)	11 (8)
UEB-6	T-6	For branched line	22 (20)	20 (18)	7 (6)	6 (5)	55 (49)
E	T-7	For vertical array transmission line (straight line)	25 (23)	5 (4)	12 (11)	6 (5)	46 (43)
G	T-8	For installation of load-break switches	10 (9)	6 (5)	2 (1)	3 (2)	21 (17)
F	T-9	Anchor pole	6 (5)	3 (2)	2 (1)	2 (1)	13 (9)
H	T-10	For installation of pole-mounted transformer	20 (18)	19 (17)	7 (6)	6 (5)	52 (46)
Connecting materials (same as pole type F above except wooden pole) to existing pole			1 (1)	1 (1)	1 (1)	1 (1)	4 (4)
Total							2,147 (1,941)

Remarks: In the above table, the value in lower line with ( ) means design quantity and the value in upper line means procurement quantity (including spares).

(h) Vehicles

In addition to the above equipment and materials, two trucks equipped with a crane is procured to assist the construction of the 33 kV transmission lines and the maintenance/inspection of the transmission equipment and materials. Details are shown in Table 2-3-5.

4) Basic Specifications of 33 kV Transmission Equipment and Materials

The transmission lines are planned based on the details shown in Table 2-3-5.