THE UNITED REPUBLIC OF TANZANIA

FEASIBILITY REPORT ON TRANSMISSION AND DISTRIBUTION NETWORK IN KILIMANJARO REGION

November 1979

JAPAN INTERNATIONAL COOPERATION AGENCY

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PREFACE

The Government of Japan, in response to the request of the United Republic of Tanzania, has agreed to conduct a feasibility study on the power transmission and distribution network project in Kilimanjaro Region and entrusted the Japan International Cooperation Agency (JICA) to carry out the study.

JICA, in view of the social and economic importance of this Project, dispatched a team headed by Mr. Masashi Koike (Director, EPDC International LTD.) to Tanzania for a period of 45 days from January 31, 1979.

The team, after returning to Japan, analyzed and studied the results of the survey and the data collected, and has now completed this Report.

I hope this Report will be useful for the electric power development and electrification in the Kilimanjaro region and contribute to the economic and social development of the United Republic of Tanzania as well as to the promotion of friendly and cooperative relations between our two countries.

I wish to express my sincere thanks to all the parties concerned of the United Republic of Tanzania for their close cooperation extended to our Study Team.

November, 1979

Shinsaku Hogen
President
Japan International
Cooperation Agency

LETTER OF TRANSMITTAL

Mr. Shinsaku Hogen
President
Japan International Cooperation Agency

Dear Sir:

It is a great pleasure to herewith submit a Feasibility Study Report on the "Transmission and Distribution Network Project for Kilimanjaro Region" which will be the basis of the comprehensive development plan for Kilimanjaro Region of the United Republic of Tanzania.

In December 1978, at the request of the Japan International Cooperation Agency, a survey team was organized of eight specialists from the Japan International Cooperation Agency and EPDC International Ltd.

The Survey Team visited Tanzania for a period of 46 days from January 31, 1979 to March 17, 1979, and engaged in collection of data, discussions with agencies concerned, and field reconnaissances.

Upon returning to Japan, the Survey Team, based on the results of field investigations and the data collected, proceeded with studies and work regarding power demand, power transmission and distribution project design, approximate construction cost, and economic analysis, and have now prepared this Report.

Briefly described, the work contemplated for this Project is the following. The major facilities are 308 km of high-voltage transmission and distribution lines, 90 km of low-voltage distribution lines, 107 pole mounted transformers of a total capacity of 6,325 kVA, 1,650 low-voltage service lines, 5 distribution substations for total capacity of 7,500 kVA, and the total construction cost converted to Japanese currency is 1,851 million yen.

It is strongly hoped that through submittal of this Report the power transmission and distribution network project will be realized at an early date and that the comprehensive development and economic progress of Kilimanjaro Region will be greatly facilitated.

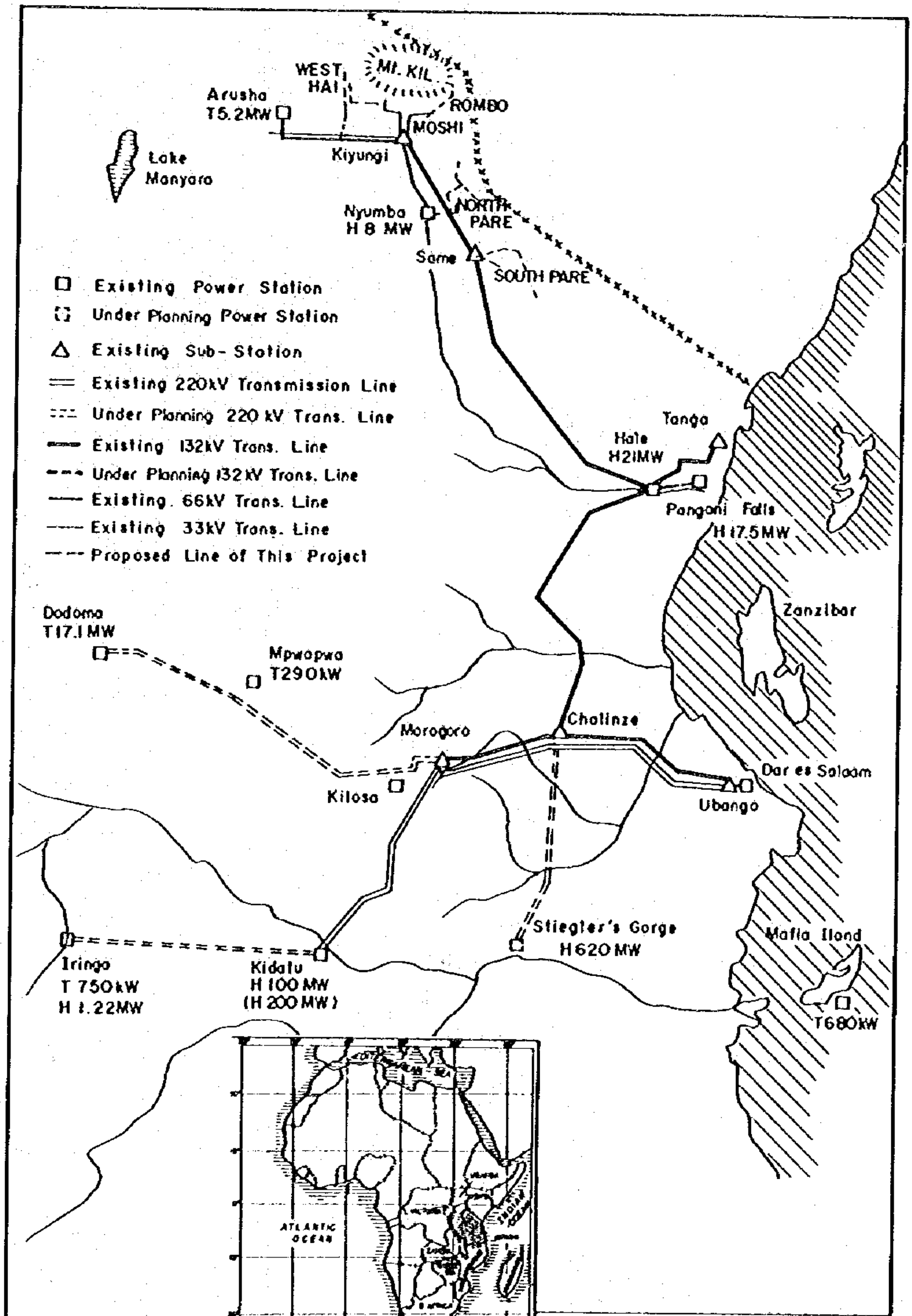
It is wished to express the deepest gratitude to the government agencies concerned of the United Republic of Tanzania, the agencies concerned of the Kilimanjaro Region Government, the Tanzania Electric Supply Company and the Japanese Embassy in Tanzania for their cooperation and assistance in field investigations and data collection for preparation of this Report, and those persons concerned at the Ministry of Foreign Affairs, the Ministry of International Trade and Industry and the Japan International Cooperation Agency in Japan for their cooperation in carrying out the investigations.

November, 1979

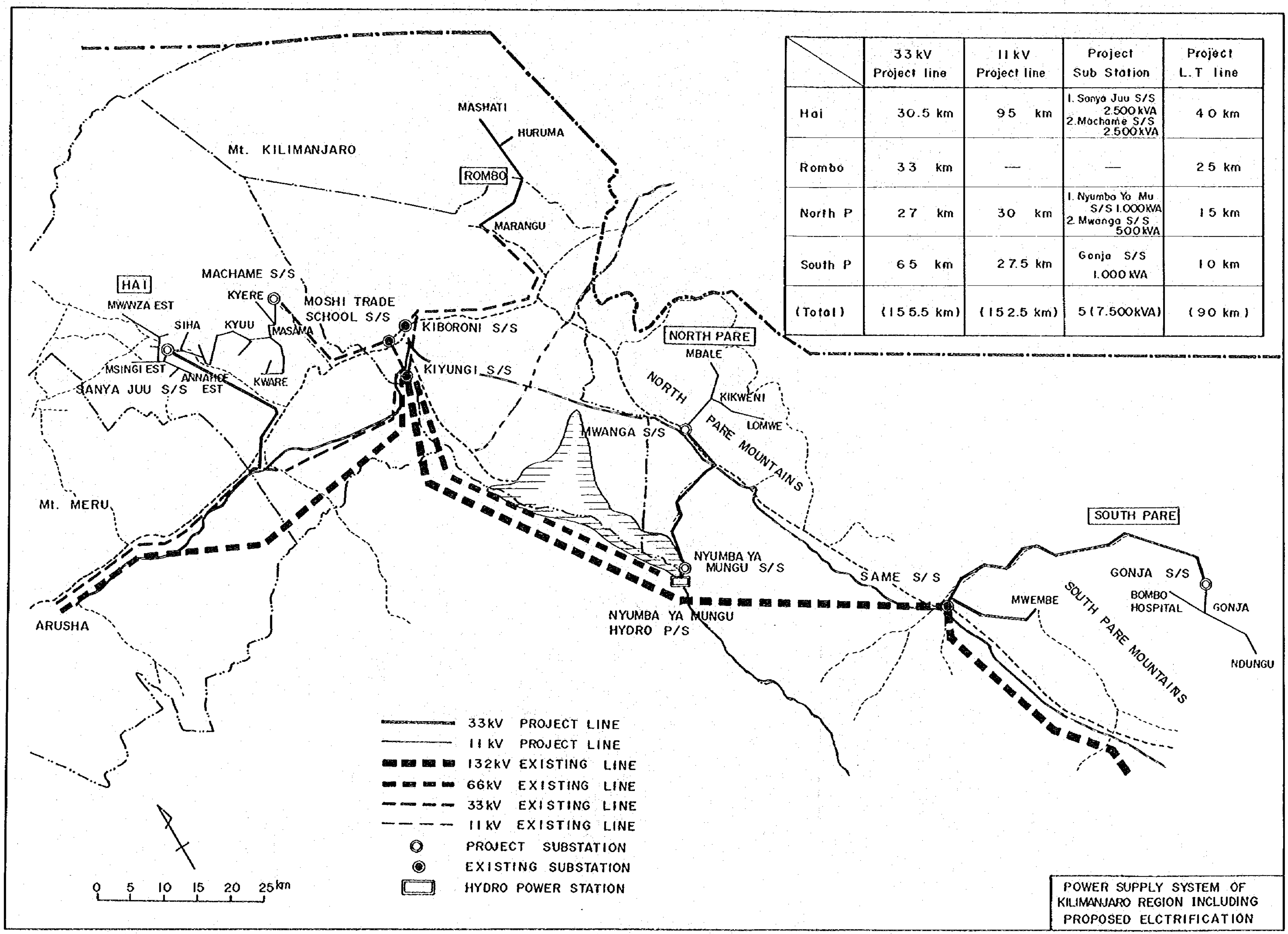
Yours respectfully

M. Koike

Masashi Koike
Team Leader of Japanese Survey
Team for Transmission and
Distribution Network Project
for Kilimanjaro Region



POWER SUPPLY SYSTEM OF TANZANIA INCLUDING PROPOSED ELECTRIFICATION



	33 kV Project line	11 kV Project line	Project Sub Station	Project L.T line
Hai	30.5 km	95 km	1. Sanya Juu S/S 2.500 kVA 2. Machame S/S 2.500 kVA	40 km
Rombo	33 km	—	—	25 km
North P	27 km	30 km	1. Nyumbo Ya Mu S/S 1.000 kVA 2. Mwanga S/S 500 kVA	15 km
South P	65 km	27.5 km	Gonja S/S 1.000 kVA	10 km
(Total)	(155.5 km)	(152.5 km)	5 (7.500 kVA)	(90 km)

POWER SUPPLY SYSTEM OF KILIMANJARO REGION INCLUDING PROPOSED ELCTRIFICATION

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PART I

CONCLUSIONS AND RECOMMENDATIONS

CHAPTER 1

CONCLUSIONS

CHAPTER 1 CONCLUSIONS

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1.1 PRESENT STATE OF SOCIETY AND ECONOMY IN KILIMANJARO REGION

Kilimanjaro Region is situated at the northeast part of Tanzania with an area of 13,200 Km^2 and population of 891,000, and is one of the relatively more advanced regions of the country (Against national GDP of 1,120 T.shs/capita, the GRP of Kilimanjaro Region was 1, 318 T.shs/capita in 1975 estimates). The industry which has supported the high income level of this region has been agriculture which had prospered from the past (67% of total GRP), and espeically, in 1977, production of coffee which made up 42% of the exports of the country was the greatest foreign currency earning industry of Tanzania. The coffeee of Kilimanjaro Region makes up 51% of the total coffee production of the country, and the weight of this product in the national economy is high. Coffee is produced on the mountainside of Mt. Kilimanjaro and the highland of the Pare mountanous area, and the population is also concentrated in this highland. (The area of the highland is 16.3% of the entire Region whereas the population makes up 64.3%. The population density of the entire region is $67/km^2$, second in the country to Dar es Salaam.)

1.2 KILIMANJARO REGION INTEGRATED DEVELOPMENT PLAN AND NEEDS FOR ELECTRIFICATION

The Tanzanian Government, in formulating the Third Five-Year Plan, further promoted the policy of increased regional autonomy whereby development of one's own region would be the responsibility of the region. As a consequence, the various regions of the country have set up development plans for their respective regions with cooperation from developed countries.

Kilimanjaro Region, with the cooperation of the Japanese Government, set up an integrated development plan (hereafter called KIDP) for the region in 1977. In this KIDP, the period of the Third Five-Year Plan (1976–1981) is to be a preparatory period for future industrialization, and it is aimed for the infrastructure to be built up, agricultural productivity to be improved, efforts made for farmland development, and promotion of small-scale industries centered on agro-industry to be made.

The essential points are as listed below.

- Improvement and expansion of highlands which are the existing high-density agricultural lands.
- Development of agricultural land at lowlands of high probabilities of water resources development.
- A population absorption plan to increase the tolerable number of the highlands as much as possible, but also to absorb population in the upper lowlands of Mt. Kilimanjaro and the footlands of the Pare Mountains.

Threfore, it is thought that the needs of this electrification project will be born in the desire of improvement of infrastructure for agro-industrialization of the farmland area of the highlands and farmland development of areas such as the upper lowlands.

Meanwhile, as stated in the Third-Year Plan, in modern times when the aspect of social development is one of the objectives of rural electrification, electricity is a fundamental necessity, and electrification is one of the requisites of the social minimum. From this aspect, it is considered that electrification of public facilities such as government agencies, hospitals and schools in the area should first be done in this Electrification Project, and this constitutes the needs of highest priority.

1.3 PRINCIPLES OF PLAN FORMULATION

(1) Scope of Electrification

In accordance with the needs described in the preceding section, the scope of electrification under this Project was determined based on the principles below for the four districts of Hai, Rombo, North Pare and South Pare in Kilimanjaro Region where electrification is most urgently needed.

a) Electrification of administrative centers (district office, police station, court, etc.)
b) Electrification of public facilities (school, hospital, training center, church, etc.)
c) Supply to existing large-scale power demand establishments such as factories and estate farms.
d) Leading in of distribution lines to village centers of especially high population densities.
e) Supply to areas of high potential for industrial develment.
f) Electrification of villages to be passed by distribution lines for power distribution to the above.
g) Those corresponding to a) – e) above but extremely remote with no particular objectives for electrification route were omitted from the present scope in consideration of economy.

The social conditions of the four districts are given in Table III-2-15.

(2) Method of Electrification

Since an existing power transmission and distribution system is abailable comparatively nearby and there is ample power supply, electrification is to be done by leading in transmission and distribution lines. Regarding South Pare, which among the four districts would require the longest transmission line, an alternative plan for electrification by diesel generators was studied, but the transmission line plan was found to be overwhelmingly more advantageous economically.

1.4 LOAD FORECAST

(1) Method of Forecasting

For the intial demand and the growth during the 10-year period after electrification, forecasting was done by the analytical method based on various data from investigations of regional conditions, while for a long-range forecast, estimations were made for the period after the 10th year through the 25th year by the macroscopic method which forecasts growth in power demand from economic indices on a national scale.

(2) Number of Consumers

The number of customers was forecast as described below. With regard to the number of consumers to be electrified in Tariff Group 1 of general domestic demand, based on investigations of the actual conditions in part of the region, it was forecast that 8% of the present number of households would surface as actual demand in a short period of time. Consumers in the public facilities and commercial categories under Tariff Group 2 and light industrial under Tariff Group 3 would all become actual in a short period of time according to DDD and

TANESCO data. Industrial demand under Tariff Group 4 was studied grasping the actual situations at estates, and all of these facilities would become load immediately after electrification. The number of public lighting under Tariff Group 5 was considered as being 10% of general consumers.

(3) Forecast of Initial State Maximum Demand

Maximum demand was calculated grasping the existing actual facilities with regard to industrial demand, while for other groups the demand levels by type of consumer obtained from TANESCO data and the number of consumers of the preceding subsection were used. Table II-2-3 shows the number of consumers and maximum demand by district and by tariff rate group.

Other than the above, a total of 300 kW (230 KW in terms of synthesized maximum demand) was calculated as the demand of the urban development plans (UDP) of the three administrative centers of Boma La Ngombe, Mkuu and Mwanga.

It was assumed that the above demand would be realized within a short period of time after completion of electrification (1983) and the rate of realization by tariff group was taken to be the following:

	T_3, T_4	T_1, T_2, T_5	UDP
1983	85%	50%	25%
1984	93%	75%	50%
1985	100%	100%	75%
1989			100%

(4) Synthesized Maximum Demand and Annual Energy Consumption

Regarding the synthesized maximum demands of the distribution networks, since the above-mentioned loads will not be at maximum simultaneously, they were obtained with diversity factor as 1.3. The results are the following:

Hai Distribution Network	1,822 kW
Rombo Distribution Network	483 kW
North Pare Distribution Network	435 kW
South Pare Distribution Network	572 kW

With respect to annual energy consumption, the annual load factor was calculated to gradually increase from 25% in 1983 to 35% in 2007 based on the records of rural areas in Tanzania which have already been electrified.

(5) Forecast of Demand Growth Rate

Using data of TANESCO on energy sold in the past, omitting urban types and extracting only rural township districts, the growth rate in energy demand was studied by tariff group and these growth rates were applied to this region. For all tariffs combined there will be a gradual increase with time from 6.3% to 6.55%.

(6) Long-Range Forecast of Demand

Regarding the long-range forecast beyond 10 years after electrification, an empirical method by which the degree of growth in power demand is predicted from economic indices of the country, namely, GNP, GNP/capita, growth rate of GNP/capita was used. The growth rate and trend were estimated for the period after the 10th year to the 25th year (2007 A.D.) by this method and were made to be in conformity with the results of the short-term forecast. As a result, there will be a gradual decrease with time from 6.6% to 6.2%.

(7) Results of Load Forecast

The overall power demands and annual energy consumptions of the entire area of this Project are forecast to be as shown in Table II-2-15 and Fig. II-2-4.

1.5 PARTICULARS OF PROJECT

(1) Major Facilities in Hai District

Roughly the entire high-density agricultural area spread out on the southern slope of Mt. Kilimanjaro is to be electrified through an 11 kV distribution line running along the mountainside. For this purpose, substations are to be provided at two locations, east and west, up to where 33 kV transmission lines are to be led in from the existing system. For the urban development load of Boma La Ngombe, direct distribution is to be done from this transmission line.

Substation

Name	Capacity	Voltage
Sanya Juu	2,500 kVA	33/11 kV
Machame	,,	,,

Transmission Line

Name (Provisional)	Sector	Voltage	Distance
Sanya Juu	Existing 33 kV Air-port Line No. 177 Pole – Sanya Juu S.S	33 kV	30.5 km

Note: Leading in of 33 kV to Machame Substation has already been done from the Moshi area (presently operating at 11 kV) and new construction of a 33 kV transmission line is unnecessary.

Distribution Line (11 kV)

Sector	Distance	Principal Load Supplied
Sanya Juu S.S – Gararagua Estate area	22 km	10 estates
Sanya Juu S.S – Machame S.S	55 km	General load including Kibongoto Hospital
Masama – Kibo Estate area	18 km	General load including Kibo Estate

Pole Mounted Transformer

Quantity	Total Capacity
54	2,350 kVA

(2) Major Facilities in Rombo District

Electrification is to be done by a 33 kV distribution line as far as the densely populated community of Mashati in the agricultural area of high population spread out in a band along the eastern slope of Mt. Kilimanjaro. For power supply, a direct connection is to be made to a new 33 kV transmission line constructed by TANESCO from Kiyungi Substation to this area.

Distribution Line

Sector	Distance	Principal Loads Supplied
Marangu – Mashati	33 km	General demand including urban development load of Huruma

Pole Mounted Transformer

Quantity	Total Capacity
23	1,075 kVA

(3) Major Facilities in North Pare District

The agricultural area in the northern part of the Pare Mountains and Mwanga, considered as the site of a new DDD office, are to be electrified by a 11 kV distribution line. For this purpose, a substation is to be provided at Mwanga with a 33 kV transmission line led in to this substation. The power supply is to come from the existing Nyumba Ya Mungu Hydro Power Station. The sisal estate of Kisangara on the way is to be directly supplied from the 33 kV line.

Substation

Name	Capacity	Voltage
Nyumba Ya Mungu	1,000 kVA	11/33 kV (step up)
Mwanga	500 kVA	33/11 kV

Transmission Line

Name	Sector	Voltage	Distance
Kisangara	Nyumba Ya Mungu – Mwanga	33 kV	27 km

Distribution Line

Sector	Distance	Principal Loads Supplied
Mwanga – Ugweno, Usangi area	30 km	Incudes Mwanga urban development load, Usangi Training School

Pole Mounted Transformer

Quantity	Total Capacity
16	875 kVA

(4) Major Facilities in South Pare District

In order to electrify Bombo in the Pare Mountains and the irrigable area northest of the mountain range where irrigation is possible, a substation is to be provided at Gonja up to where a 33 kV transmission line is to be led in from the existing Same Substation. Along the way, direct supply from 33 kV is to be made to Kisiwani Estate, while for Mwenbe, the center of the Pare Mountains, a branch line is to be led out part way along the above-mentioned transmission line for distribution at 33 kV.

Substation

Name	Capacity	Voltage
Gonja	1,000 kVA	33/11 kV

Transmission Line

Name	Sector	Voltage	Distance
Gonja	Same S.S – Gonja S.S	33 kV	49 km
Mwembe	Branching point – Mwembe	"	16 km

Distribution Line (11 kV)

Sector	Distance	Principal Loads Supplied
Gonja S.S – Ndungu area	19 km	General demand including Gonja Estate
Branching point – Bombo area	8.5 km	General demand including Bombo Hospital

Pole Mounted Transformer

Quantity	Total Capacity
14	1,125 kVA

(5) Summarization of Facilities

In addition to the major facilities described above, facilities such as low-voltage distribution lines, service lines, watt hour meter, street lights, and vehicles required for construction and maintenance are to be included in the Project. A summarization of all facilities is given in Table II-5-2.

1.6 DESIGN OF FACILITIES

The items considered in design of facilities are as described below.

(1) Harmony with Existing Facilities

The facilities planned for this Project will all be on extensions of the existing system, and particularly in designing the standards of the existing facilities were followed as much as possible in consideration of future maintenance.

In effect, design conditions such as voltage classes, insulation system, grounding system, distribution system, wind pressure, temperature, clearances, etc., were all made identical to those of existing facilities.

(2) Determination of Transformer Capacity

a) Regarding main transformers of substations, the most economical capacities were determined considering expansion costs and maintenance costs for the next 25 years.
b) Regarding pole transformers, the capacity for each installation location was selected from standard transformer capacities with the aim that replacement would be unnecessary for about a 10 year period.

(3) Determination of Conductor Size and Standard Span

Regarding conductor sizes for 11 kV and 33 kV, studies were made of the two varieties of ACSR 95 mm^2 and 120 mm^2 in consideration of existing conductor sizes, and as a result 95 mm^2 has proved to be advantageous.

Regarding spacing between supports, sag calculations were made, and taking into consideration that the lines would run over mountainland, 100 m was taken as the standard span for 11 m poles.

(4) Voltage Drop Countermeasures

Current voltage calculations were made and it was determined that voltage drop would be within specified limits until 15 years later, and no special phase modifying equipment will be immediately needed. However, regarding the transformers of the two substations in Hai District, they are to be equipped with Load Ratio Control Transformers (LRT) in consideration of loads being larger than in other districts and of voltage fluctuation of the power supply system.

(5) Reclosing System

Circuit breakers at the outlets of substations are to have reclosing devices capable of 1 to 2 times after breaking due to faults in aiming to improve supply reliability.

(6) Protective Devices

Disconnecting switches are to be provided as necessary at branching points of 33 kV transmission lines for the convenience of disconnecting lines in maintenance, while at important locations of 11 kV distribution lines, oil-immersed switches are to be provided to make possible switching as necessary even during current impression, thereby aiming for convenience of operation.

Oil-immersed circuit breakers are to be provided at primary sides of all main transformers of substations for protection, while pole transformers are to be protected by cut-out switches provided at their primary sides. Further, low-voltage lines are to be protected by fuses. All locations where pole transformers are installed are to have lightning arresters.

(7) Principal Design Items of Facilities

(a) Transmission and Distribution Lines

	33 kV Transmission and Distribution Lines	11 kV Distribution Line	Low-Voltage Line
Wiring	3-phase, 3-wire	3-phase, 3-wire	3-phase, 4-wire 1-phase, 2-wire
Structure	Wood pole (standard 11 m height)	Wood pole (standard 11 m height)	Wood pole (standard 9 m height)
Conductor arrangement	Horizontal	Horizontal	Vertical
Standard span	100 m	100 m	50 m
Conductor	ACSR 95 mm²	ACSR 95 mm²	HAl 55, 30, 22 mm²
Insulator			
[Non-terminal]	Solid LP insulator (LP-30)	Special height pin insulator	Low-voltage terminal insulator
[Terminal]	250 mm suspension insulator, 3 discs per string	250 mm suspension insulator, single	
Switchgear	34.5 kV disconnecting switch	12 kV oil-immersed switch	Switch with fuse

(b) Pole Mounted Transformer

	For 33 kV	For 11 kV
Rated capacity (kVA)	25, 50, 100, 200, 300	25, 50, 100, 200, 300, 500
Number of phases	3	3
Rated frequency (Hz)	50	50
Rated voltage	33 kV/400, 230 V	11 kV/400, 230 V
Tap	±2.5%, ±5.0%	±2.5%, ±5.0%
Connection	Δ – Y	Δ – Y

(c) Substation

i) Transformer

Capacity, kVA	2,500 kVA	1,000 kVA		500 kVA
Number of phases	3	3		3
Rated frequency (Hz)	50	50		50
Cooling system	Oil-immersed, self-cooled	Oil-immersed, self-cooled		Oil-immersed, self-cooled
Rated voltage	33/11 kV	33/11 kV	11/33 kV	33/11 kV
Tap	±10%, 17 tap	±5.0%, 5 tap	±5.0%, 5 tap	±5.0%, 5 tap
Insulation class	30 A/10 B	30 A/10 B	10 B/30 A	30 A/10 B
Connection	Y – Y – Δ	Δ – Y	Δ – Y	Δ – Y
Neutral point	Direct ground	Direct ground		Direct ground
Tap change	On load	No load		No load
Number of units	2	1	1	1

ii) Circuit Breaker

Rated Voltage	36 kV	12 kV
Insulation class (No.)	30 A	10 B
Rated current	600 A	600 A
Breaking current	12.5 kA	25 kA
Condition of use	Outdoor	Accommodated in cubicle

1.7 CONSTRUCTION WORK AND CONSTRUCTION COST

(1) Construction Schedule

It is strongly desired not only of course by TANESCO, but also by the administrative authorities and all residents of the region for construction of this Electrification Project to be started at an early date, and since it is desired for completion to be in March 1983, it is considered the start of work will be at the beginning of 1981. The details of construction schedules according to the four districts are as shown in Table II-5-3.

(2) Construction Setup

It was considered that the construction of this Project would be executed directly under TANESCO with the assistance of the Consultant and in facilitating the work. The Consultant is to cooperate with TANESCO in a series of work such as promotion of officaial procedures, preparation of Specifications, tenderr business and evaluation, inspections during and on completion of manufacture of materials and equipment, coordination of delivery times, adjustment of construction schedules, and supervision of construction.

(3) Construction Cost

The construction cost is as shown in Table II-5-4, calculated to consist of a foreign currency portion of 1,358 million yen, and a domestic currency portion of $19,714 \times 10^3$ T.shs (Corresponding to 493 million yen), a total of 1,851 million converted into yen.

The preconditions for estimation are the following:

Materials and Equipment Costs

A commodity price escalation of 13%/yr was taken into consideration and the costs were calculated for 1980 considered to be the time of contract award. The costs were calculated on the basis of CIF Dar es Salaam, and the costs of insurance and freight occupies 12% of the total costs. Import duties are not included.

Labor Costs

Based on the prevailing standard estimation costs of TANESCO, the unit labor cost was set up taking into account escalation rate of 15% annually until the construction period, and compiling the required labor costs by type of work, the total was estimated.

Domestic Transportation Costs

The domestic transportation and insurance cost from unloading at Dar es Salaam Port to the site was calculated as 6% of CIF cost.

Contingency Cost

The contingency cost was calculated as 10% for both of foreign currency portion and domestic currency portion.

Engineering Fee

The engineering fee was calculated as 10% of total construction costs plus expenses of stay in Tanzania

Administrative Cost

Approximately 10% of the domestic currency portion of the direct construction cost was calculated.

Conversion Rate ..... 1 T.sh = 25 Yen

1.8 FINANCIAL ANALYSIS

In evaluation of this Project, it is first necessary to analyze whether there will be profitability of the Project from the financial standpoint of TANESCO. The period of analysis for this Project was taken to be 25 years considering the service lives of facilities, comparing the electricity charge revenue to be obtained according to the load forecast made previously and disbursements such as the initial construction cost, the subsequent additional construction costs, administrative, maintenance and repair costs, and power receiving costs to obtain the internal rate of return. The electricity charges were varied according to growths in the number of consumers and energy consumption following the prevailing electricity charge system and the initial demands by type of demand (Tariff Groups No. 1–5). Of the costs, the intial construction cost is as described previously, and regarding the additional construction cost, the costs of adding pole transformers, low-voltage distribution lines, service lines and substations in accordance with growth in demand were calculated, while administrative costs and maintenance and repair costs were varied in accordance with the scales of the facilities. The electric energy cost at the receiving end was taken to be 23 T.cents per kWh, the standard cost used by TANESCO for economic analyses. On determining the internal rate of return from the revenues and disbursements calculated in this manner (Table II-6-3), it will be IRR = 3.3%. This cannot be said to be very favorable compared with an interest rate prevalent in Tanzania. Seemingly, this calculation shows low profitability, but if a loan with a low interest rate is provided, it is considered that this Project will be well in the range of feasibility.

Further, a sensitivity analysis was made for the case of variations in revenues and disbursements, and the results obtained of variations in internal rate of return are shown in Table II-6-6. According to this table, if it were to be assumed that revenues would be increased by 30% because of tariff revisions to be implemented soon, it is expected that IRR will become 7.4%.

The fund requirements are computated to be 1,851 million yen including domestic currency portion of 493 million yen as a total construction cost. In the event that the above costs to be required for construction at the initial stage should be funded under a long-term loan in the form of foreign assistance, taking account into later expenses for additional facilities and operation balance of revenue and expenditure in future of this Project are as shown in the following table and Table II-9-21 ~ Table II-9-29.

Interest Rate	Repayment Period	Maximum Accumulated Deficit	Year of Turning to Surplus
1.5%	30 (10)	38.5 Million yen (in 1983)	1985
3.0%	30 (10)	129.9 Million yen (in 1984)	1987
5.0%	30 (10)	480.9 Million yen (in 1996)	—

The grace period is indicated in parenthesis.

The maximum amount of accumulated deficits and the year in which surplus will take place will depend upon the terms and conditions of a loan.

For example, in case an interest rate of 1.5% and a loan period of 30 years with a grace period of 10 years are taken into consideration, the amount of maximum accumulated deficit will be read 38.5 million yen in 1983 and the year in which the balance of income and expenditures will turn to surplus will be 1985.

The amount of maximum accumulated deficits is to be paid from TANESCO's own capital and subsided from the budget of the country.

However, in view of the present situation of TANESCO in procurement of funds, especially the tight situation of foreign currency, it is believed essential that a "soft" loan with a long term repayment period and low interest rate should be procured for the Project.

1.9 ECONOMIC ANALYSIS

(1) Economic Evaluation against Alternative Plan

Aside from a financial analysis, it is necessary for an analysis of the Project to be made from the viewpoint of the national economy. Firstly, the consideration would be of an alternative cost evaluation where installation of diesel generators would be conmplated as the next best alternative in case transmission and distribution line construction is not carried out as a means of rural electrification of this region, the cost being considered as benefit of this Project.

It is planned for electric power for this Project to be supplied from the Coastal Grid System, but in the case particularly of the South Pare District, where the existing power transmission system and the load area are distant from each other, and where consumers comprise a number of groups, the possibility of autogenerators would be an objective of study.

For the South Pare District, planning was done for the case of providing diesel generators of 100, 275, 300, 275 and 125 kVA at Mwembe, Kisiwani, Gonja, Ndungu and Bombo, respectively, and the construction and operation costs were calculated.

In making the comparison between the transmission and distribution scheme and the diesel generator scheme, shadow prices are employed instead of normal market prices. In effect, costs were calculated using shadow rate as 1.43 for the foreign currency portion, 0 for unskilled labor wages, and 1.2 for domestic transportation costs.

The comparison of costs for a 25 year period is as shown below with the transmission and distribution scheme being overwhelmongly more advantageous compared with the diesel scheme, and a large profit will be produced.

Unit: 10^6 yen

		10%	20%
C :	Transmission and distribution line scheme cost	581.2	485.5
B_1 :	Diesel generator scheme cost (with reserve capacity)	1,752.7	1,133.8
B_2 :	Diesel generator scheme cost (no reserve capacity)	1,402.2	874.8
	$B_1 - C$	1,171.5	648.3
	$B_2 - C$	821.0	389.3
	B_1/C	3.02	2.34
	B_2/C	2.42	1.80

Since the Project will provide such a large benefit even in South Pare, a district where it may be thought a diesel generator scheme would be of great advantage, even larger benefits can be obtained in other districts.

(2) Economic Analysis by Comparison with Tariff Revenue

Social and economic benefits due to rural electrification, as described in 8.3 to follow, may be considered as diverse benefits derived in complex form, but since most are intangible, it is difficult to indicate them numerically in comparisons with economic costs. Since the total sum of the various benefits due to electrification is thought to be greater than the total sum of the willingness to pay of consumers, while further, the willingness to pay of consumers is thought to be greater than the revenue from sales of electric power, to simplistically compare sales revenue and the economic costs of the Project would mean considerably underevaluating the economic profitability of the Project. In any event, computing here the internal rate of return, it is 4.8%. This figure at least is larger than the financial profitability, and as mentioned above, since the intrinsic social and economic benefits are much larger than sales revenue, the intrinsic internal rate of return of the Project may be looked upon as being considerably higher than the above figure, and it may be judged that economic profitability of the Project is sufficiently high.

(3) Effects of Development on Regional Society and Economy

The effects of development of the Project on the society and economy of this region may be considered to be of manifold kinds in diverse sectors. The principal ones in summary will be as cited below.

(a) Impact on Agriculture

As an effect of electrification on agricultural development which is one of the principal objects of development of Kilimanjaro Region, the development of water resources for agriculture through utilization of electricity for motive power may be considered, while further, improvement in productivity through rationalization of processing of cash crops represented by coffee, and processing of food crops such as maize and rice may be considered.

(b) Impact on Industry

Supply of electric power in the sense of securing a cheap and stable motive power source is thought will have a great effect in development of small industries, the other important object of development of Kilimanjaro Region. On analysis of survey data of the state of industry in areas which are presently already electrified, the costs of motive power supplied by TANESCO are cheaper than motive power costs from other sources, and the ratio of electric power utilization is high. Through the coming expansion of the electrified area, approximately 80% of the business establishments of Kilimanjaro Region and roughly 100% of the gross production will have been brought into the electrified area.

(c) Impact on Domestic Finances

Kerosene is the most common as the energy source of households in unelectrified areas. About 20 T.shs out of the monthly kerosene bill is paid for lighting and this amount is higher than the electricity charge of 13 T.shs for 10 kWh and under. When the intensity of illumination, ease of use, and sanitary condition of electric lights are considered, conversion from kerosene lamps to electric lighting is more than reasonable seen from the domestic economy, and this is also a reason that electrification is being eagerly awaited by the residents.

(d) improvement in Welfare of Residents

Through regional electrification, public facilities such as government offices, police stations, post offices, hospitals, medical clinics and schools will be electrified, and whereas only inadequate public services can be rendered at present using diesel engines and auto generators, through introduction of modern machines, the possibility of providing night-time service, etc., many social benefits will be brought to the regional residents. Electrification of water supply facilities and installation of street lighting are also planned, and many effects such as improvement in the living standards of the residents and building up of communities may be considered.

(e) Comprehensive Effect

Such individual effects of development such as described above when seen from the standpoint of rural development means that through the introduction of electricity a mechanism of industrialization is cumulatively introduced in the rural economy, and effects such as increased employment opportunities in rural areas, expansion of the economy through increase in income, and prevention of excessive migration of the population to urban areas through correction in differences between rural and urban societies may be considered. Further, the conversion from oil as the motive power to hydroelectric power sources will lead to conservation of foreign currency, and together with earning of foreign currency through promotion of industries, there will be a great effect on the national economy also.

CHAPTER 2

RECOMMENDATIONS

CHAPTER 2 RECOMMENDATIONS

CHAPTER 2 RECOMMENDATIONS

2.1 NECESSITY FOR EARLY IMPLEMENTATION OF PROJECT

The purpose of this Project is aiming at the electrification of rural areas which have been left behind without electricity. In this respect, the Project holds significance as securing a social minimum in terms of an obligation to the nation, and it does not have a nature to be discussed only on the basis of economical aspects.

Nevertheless, as it was proved that the region taken up as the survey area could be electrified with relatively short distribution lines and the power demand and supply balance of the Coastal Grid System would be surplus hydro-electric supply capability for the time being, the results of this feasibility study showed that a comparatively good economic effect could be secured for a Project of this type.

Meanwhile, in order to increase the agricultural productivity of the subject area and to meet the high rate of population growth, it is considered to be necessary that both agro-industrialization of the rural area and development of cultivation field by irrigation would be realized as soon as possible. The Tanzanial Government, Kilimanjara Regional Government and TANESCO consider this Project as the most important infrastructure to support the above developments and also being of urgent priority.

Consequently, the JICA survey team considers that this Project has not only an economic development impact, but also tangible and intangible social development effects, and it is desirable to be implemented at an earliest date.

2.2 PREPARATIONS FOR EXPEDITING IMPLEMENTATION

(1) Establishment of Organization in the Government to Handle Project

The schedule of this Project is extremely tight and it will be necessary to decide immediately the government organ to be responsible for the project, the established organization to handle it, and to expedite the implementation of this Project.

(2) Procedures for Loan

In order to prepare the necessary foreign currency and any domestic currency required for the Project, it is necessary that the procedures to secure loans should be taken. The first step in this regard would be to prepare and submit an implementation program.

(3) Selection of Consultant

It will be necessary to immediately select a consultant to advise not only on matters regarding a request for a loan, but also on purchases of equipment and materials, evaluation, and execution of work, thereby expediting implementation of the Project.

2.3 PREPARATIONS FOR EXECUTING WORK

(1) Establishment of Construction Organization and Securing of Personnel

The Project is to be implemented directly by TANESCO so that establishment of a construction organization for this Project in TANESCO and securing of construction personnel should be studied and prepared.

(2) Surveying of Transmission and Distribution Line Routes

The proposed transmission and distribution line routes should be surveyed in detail and route maps prepared.

(3) Preparations for Right-of-Way Acquisition, Tree Clearing Compensation

Preparations are necessary for acquisition of rights-of-way and land for transmission and distribution lines and substations, and to make compensations for trees cleared.

2.4 EQUIPPING OF TELECOMMUNICATIONS NETWORK FOR LOAD DISPATCHING AND MAINTENANCE

Telecommunications facilities are indispensable for maintenance and operation of the power transmission-transformation-distribution system of this Project.

At the outset, public telephone channels would probably be utilized in this region, but in the future it will be necessary for the electric power company to have its exclusive telecommunications network for load dispatching and maintenance, and an installation plan should be studied.

(Although a telecommunication facilities plan is not included in the present Project, a necessity for telecommunications will arise even at the stage of construction for the Project and portable wireless talkie has been included under the item of vehicles and tools for construction.)

PART II

FEASIBILITY STUDY

CHAPTER 1

OBJECTIVES AND SCOPE OF THE PROJECT

CHAPTER 1 OBJECTIVES AND SCOPE OF THE PROJECT

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1.1 MEANING AND OBJECTIVES OF RURAL ELECTRIFICATION

The Third Five-Year Plan, of which the correct title is "Third Five-Year Plan for Economic and Social Development" aims at simultaneous development of economic and social development.

Needless to say, when viewed as a shole without economic development, there can be no social development and conversely, without social development there can be no economic development. The relationship between economic development and social development is mutually interdependent and accumulatively developed. It is natural that on the whole the "Third Five-Year Plan for Economic and Social Development" has two-fold objectives.

Thus although being different in dimension, each individual microscopic plan of the Third Five-Year Plan nevertheless has both aspects of economic and social development as its objective. However, implementation of the objectives of economic and social development on a microscopic level from a viewpoint of economic effectiveness implies a kind of "trade-off" relationship in a short term. Consequently, selection of the project necessarily involves the national policy of Tanzania and requires assessment from a policy-holder's standpoint. The stronger the aspect of social development becomes, the lower the social rate of discount must be set. Though rural electrification as an individual microscopic plan has literally as its aim availability of electricity in the rural community from a point of view of development, it may be said to be a comparatively well-balanced plan in economic and social aspects. The primary objective of the program of rural electrification is to further promote economic development of the rural area, and to let the national economy "take-off" so to speak, using rural electrification as a leverage.

In the kind of society where agriculture is the major industry and most people live in rural areas, increase of productivity of the agricultural sector (including agro-industry) is a prerequisite of industrialization. Only when products are produced in surplus in the agricultural sector does industrialization become feasible. When products of the industrial sector are put into the agricultural sector, productivity of the agricultural sector further increases and, in turn, accelerates industrialization. This is a process of industrialization in its embryo based on the agricultural sector.

That is to say, when inter-relations between agriculture and industry in the rural area develops into inter-relations between small scale industries in the rural area and modernized industry of the urban area, such process of underdeveloped industrialization enters into a new stage of development.

The economy of Tanzania stands upon a early phase of such new stage of development. This is because modernized industry of the urban area exists in a widely-dispered, independent manner and the organic relationship with small scale industries of the rural area still remains to be quite sparse.

In order to develop organic relationship between small-scale industries of the rural area and modernized industry of the urban area, it is necessary to have industrialization in early stage, related analogy, increased productivity of small-scale industries of the rural area, in short, increased productivity of the agricultural sector as prerequisites. Source of national savings and expansion of the domestic market must be sought in the development of the agricultural sector. One ought to learn a lesson from the example of a complete failute in the government's attempt to implement an industrialization policy at a time when productivity of the agricultural sector was still very low.

Stemming from the primary objective, the secondary objective of rural electrification is to correct economic gap between the urban community and the rural community. Tanzania is a socialist country whose national policy comprises the correction of economic gap between the urban and rural communities, among other things. Tanzania impeaches the economic policy of apartheied of the urban area toward the rural area in many of the African nations, and in fact stands in a position of impeach such a policy. The content of the five-year development plan from the First to the Third stands as testimony to this. The correction of economic gap between the urban nd rural communities means increased employment opportunities in the rural area, which moderates a "Push the rural community" type of drastic urbanization. The rural electrification program is a measure for correcting economic gap between the urban and rural communities and at the same time has a social policy coloring.

The third objective of the rural electrification program is social development.

In the present age electricity is becoming a basic, necessary social service. Availability of electricity is one of the factors of a social minimum. Hence, rural electrification can be given a meaning as a means of correcting social gap between the urban and rural communities as well.

As mentioned before, the rural electrification program proposes to bring about not only economic development but also social development. It is up to the policy-holder's assessment to give priority to one or the other of the two objectives, nevertheless, by reading the quotation which follows, one can detect what great significance the government places on the effectiveness of social development as contained in the rural electrification program.

"..., in trying to achieve the goal of rural electrification, social consideration should be given more weight. Economic considerations should not be the only criteria."

In this context, in making social and economic evaluation of the rural electrification program, social rate of discount can be set on a low level; and in financial analysis, it can become elegible for a subsidizing policy of the government. But, no matter how high the effect of social development may be, there can be no development plan which does not accompany economic cost. Needless to say, the rural electrification program must produce maximum economic and social effects with a minimum cost. Principle of scarcity value should be lived through to the end.

Thus, priority order cannot but be given to the electric supply area for rural electrification. Accordingly, in the electric supply area for rural electrification also, it is to be decided to give priority order, after taking into consideration the anticipated economic and social effects.

1.2 SCOPE OF THE PROJECT

1.2.1 Policy for Determining the Electric Supply Areas

As has been mentioned before, it is necessary to establish a certain potential site under the present conditions of the Kilimanjaro Region as an applicable area for the electrification program to take place.

Behind this Project there is Kilimanjaro Region Integrated Development Plan (KIDP), the gist of which is based upon the electrification program of the sectoral plan of the integrated plan. However, the applicable areas of the Project is established in the light of the nation's policy of rural electrification regional and district development policies and the existing program of TANESCO, etc. and furthermore, derives various information obtained from the actual survey of the site.

It should be pointed out also that, considering that this Project has a pioneering role before the nationwide rural electrification is to take place in the future, special attention has been paid to the social and economic significance of rural electrification.

The policy for establishing the applicable areas for rural electrification consists of the following:

(1) Electrification of the District Centers

This is given the highest priority in the nation's electrification policy. In considering the effect of electrification, this can exert its effect most efficiently. Among the district centers in Kilimanjaro Region, the ones to be electrified are Moshi and Same alone and electrification is to be quickly implemented for the rest of the district center as well.

(2) Electrification of the Division Centers

This is one of the policies of KIDP to provide infrastructure and proposes to focus social infrastructure on the community center on the divesion level. Nevertheless, as the electrification of the entire Division center within the region is despersed area-wise, it is very difficult to implement it all at once. Hence, for the time being, it is to be done step by step and as much as possible in conjunction with the extention of transmission lines.

(3) Electrification of the Area of High Population Density

The population of the Kilimanjaro Region is concentrated much on the Highland of Mt. Kilimanjaro and summit of Mt. Pare. Thus supply of electricity power to this area has important social effect.

(4) Electrification of the Area of High Potential for Industrial Development

The area of high agricultural production has various industries attached to agriculture and is an area with high potential for such development. In addition, development of small scale industries is an earnest wish of the Kilimanjaro Region, without which there can be no development of the Kilimanjaro Region. Supply of electric power as infrastructure in this regard is extremely important and urgent.

(5) Correction of Regional Gaps

In the Kilimanjaro Region, Moshi Town as a Regional capital represents a large share in the industrial economy, furnished with various types of infrastructure. Next come the highlands of Moshi Rural, Hai, Rombo on the mountainside of Mt. Kilimanjaro. The relative position of the Pare District is not same as other districts. Considering the economic efficiency of the electrification, although it can be implemented step by step, the simultaneous electrification of the four areas (Hai, Rombo, North Pare, South Pare) has been decided for implementation for the present electrification program.

(6) Respect of TANESCO's Plan

TANESCO, itself, has a plan for the rural electrification of Kilimanjaro Region and a preinvestment study has been conducted from 1975 to 1978. Such plan may be slightly different from the KIDP electrification program but rather close to it. In the Hai District, electrification is laid between Machame and Sanya Juu and transmission and distribution systems are provided to the south of Sanya Juu and north of Sanya Juu, respectively.

In the Rombo District transmission and distribution of electricity is laid from Marangu along the highway to Mkuu.

In North Pare transmission and distribution systems are laid from Nyunba Ya Mungu to

Usangi Ugweno on the mountaintop, and from Same through Kisiwani, Gonja, to Kifurio.

These plans of TANESCO maps out a scheme on a long-term basis which is beyond the scope of KIDP (up to 1985); adustment was made after frequent discussions with TANESCO.

1.2.2 Establishment of each Electric Supply Area

The following describes the establishment of areas for electrification into four areas:

(1) Hai District

Hai District, from its regional characteristic, may be divided into: Highland on the southern inclination of Mt. Kilimanjaro, Lowland which is south of the Moshi-Arusha Road and an extensive lowland on the west side of Mt. Kilimanjaro. Sanya Juu occupies the central part of Hai District and its electrification should necessarily be implemented in the first instance. Also, the area between Machame and Sanya Juu is called Highland generally reffered to as the coffee and banana zone, embracing huge population many villages and public services, supported by high agricultural productivity. Hence, it is highly urgent that the electrification between these areas is implemented.

Furthermore, Boma La Ngombe along Moshi-Arusha Road is to become the center of the district in the coming age, and already construction of a new town is underway in order to transfer the functions of the center gradually to the new town. Therefore it is necessary to supply electricity to this new town as well.

On the other hand, in the area north of Sanya Juu, an Upper Lowland, there is mostly wheat industry cultivation and livestock. Population is very scarce in this area. Therefore, to the area north of Sanya Juu, electric power is to be supplied only as far as the extent of some coffee estates in the vicinity, and the extention system is decided to take place in the next stage of the plan.

(2) Rombo District

At present, there are transmission lines up to Marangu in Moshi Rural District. But from Marangu onward, through a part of Moshi Rural, there are many villages of Rombo District such as Mengwe, Mkuu, Mashati, Usseri, Tarakia, all of which are located on the eastern side of the highland of Mt. Kilimanjaro, with various public services and shops along the trunk road, forming a rich belt of coffee/banana zone on both sides of the road. Population also concentreates on this area and there is a strong demand for the electrification of this area. In the center of Rombo District, there is Mkuu which embraces many public services and where, at present, a new town is constructed centering aroud the D.D.D. office. Hence, electrification up to Mkuu is highly urgent, and furthermore, transmission and distribution lines should be extended to Mashati where there is the division center of the neighboring district with high agricultural productivity, population density and active commercial operations.

Also, despite the fact that Usseri and Tarakia are not included in the scope of electrification program under the present scheme, since the electrification of these districts also is considered to have high priority in the next phase, transmission and distribution lines were planned with sufficient capacity for additional extention.

(3) North Pare District

Most of the population of North Pare District is concentrated on the Highland near the mountaintop of the Pare mountains, where coffee, banana, maize and other products are being produced. These centers of the Highland consists of the two division centers of Usangi and Ugweno, with schools, hospitals and other public services and also shops.

On the other hand, it was determined that the present Pare District will be separated into North Pare and South Pare. The new North Pare District Center is to be located in Mwanga along the highway of the lowland. In this Mwanga also, there is a plan for a new town, and construction of various functions such as administrative and commercial organs are scheduled for implementation and therefore supply of electric power to Mwanga is first to be needed.

Next, it is necessary to extend transmission lines to Usangi and Ugweno of the Highland which is actually the center of this district. The scope of this Project was decided to cover as far as Usangi and Ugweno this time.

(4) South Pare District

The population of South Pare District, except for Same and a part of the village, concentrates mainly on the range of Pare mountains. In the Highland, coffee, banana and maize are produced, but compared to the mountainside of Mt. Kilimanjaro, the incline is too steep and also agricultural productivity is low and population dispersed.

Same is the center of Pare District and also scheduled to be the center of the new South Pare District. Same was electrified in 1975 and the town of Same is rapidly being electrified at present. Viewed on the division level, the Center comprises Mwembe, Gonja, Mamba and Makanya. In particular, the vicinity of Gonja although being a Lowland allows utilization of water resources and has high potential for the agricultural development of maize, rice, etc. In addition, there are several estates of sisal and sugar in the vicinity at present. Consequently, a transmission line to Gonja is considered to have the upmost priority. For a course of transmission line up to Gonja, a route via the Highland and another route via the Lowland may be considered. On the route via the Highland, there is much population at present and hence the social significance of electrification is great, it is considered. However, due to the steep configuration of the ground, construction and maintenance of transmission lines is estimated to cost tremendous expense. In particular, the road which leads through the Highland and on to the mountainside is very poor, and causes one to pass judgement that the improvement or the new construction of the road is first to be implemented for the agricultural production and public welfare of the area.

On the other hand, the route along the Lowland is partly in contact with the Mkomazi Game Reserve with very sparse population at present. But it is possible to build transmission lines along the regional road and the cost of construction and the cost of maintenance are inexpensive compared with those of the Highland route. In addition, water resources development of Mkomazi Valley which is the area between Kisiwani and Gonja has become possible by electrification, and it is considered that not only does it contribute to the agricultural development but also to the industrial and commercial promotion of the area as well. As for the region from Gonja alongside Mkomazi Valley, extention as far as Ndungu which is adjacent to the Region was set as an extent of the Project to be covered for the time being.

Furthermore, as a stepping-stone for the electrification of the Highland, Mwembe which is the division center is also included in the plan for electrification. Conditions of the road between Same and Mwembe are comparatively good. In addition, as a stepping-stone for the electrification for the future, the same as with the electrification of the Highland, it has been decided to provide distribution lines from Gonja to Bombo. It has been decided that Bombo also is to be included in the applicable area for electrification, where there are a big hospital and other public services.

CHAPTER 2

LOAD FORECAST

CHAPTER 2 LOAD FORECAST

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CHAPTER 2 LOAD FORECAST

2.1 DATA AND INFORMATION

Up to the present time long-range power demand forecasts have been made for Tanzania by Merg and MacLellan, SOFRELEC, SWECO, Norconsult-Electrowatt, ACRES and Oskar von Miller GMBH, with forecasts also made by TANESCO itself. These studies have all contributed greatly to facilitation of electric power development and electrification of Tanzania.

The areas considered for load forecasting are the urban types of Dar es Salaam, Tanga, Morogoro and Dodoma, and rural townships scattered throughout the country. Among the reports mentioned above, a load forecast has been made for Same in Kilimanjaro Region in "Feasibility Study of the Rural Electrification Project in Tanzania, May 1975," by Oskar von Miller GMBH. In other reports, forecasts have been made for Arusha/Moshi.

A load forecast for Kilimanjaro Region was made as one part of the development plan in "Kilimanjaro Region Integrated Development Plan, October 1977" carried out by the Japan International Cooperation Agency. The load forecasts for rural districts comprising the electrification project area of the Survey Team were carried out by TANESCO separately for Hai, Rombo, North Pare and South Pare.

The Survey Team, in investigating the electrification project area referred to the above-mentioned report adding the results of investigations of the actual conditions described below set forth to grasp a more accurate picture of the potential consumers and the projected demands in the various load areas, based on which forecasts of future loads would be made.

As reference materials for forecasting, the power generation and energy sales records of the various branches of TANESCO from 1975 through 1978, TANESCO Annual Reports, operation records of Kiyungi Substation, the Third Five-Year Plan, and United Nations Statistical Yearbooks were used.

2.2 FIELD INVESTIGATIONS

Generally, in an electric power load forecast, basic data indicating the economic activities in the past of the area being considered and performance records of electric power demand and supply are combined, and incorporating the development project, the forecast is made statistically or by a mathematical method. However, such a method cannot be applied to an area where electrification is still only in the planning stage.

Consequently, in forecasting load in such an area, it is necessary to find through on-site investigation of the area potential consumers who would materialize in the form of power demand if electrification were to be implemented. Accordingly, the Survey Team, in addition to carefully examining the before-mentioned reference material, carried out the site investigations listed below.

a. Investigation of presently owned facilities and collection of information on present situations through interviews regarding estate farms (Kibo, Kisangara, Kisiwani, Gonja, Mdungu, etc.) in Hai, North Pare and South Pare districts thought to be probable large-scale consumers.
b. Investigations of electrical facilities of Kibongoto, Bombo and Furuma hospitals.
c. Visits with Regional Development Director (RDD) and District Development Directors (DDD) to inquire about degree of cooperation of residents of districts with electrification, and observation through interviews with potential consumers of present state of lighting and degree of desire for electrification.

d. Obtaining figures on potential load in each district from planning officer of the district.
e. Investigations of actual situation with regard to connections between districts (roads, communication facilities, etc.).
f. Investigation of urban development plan visiting Ministry of Lands, Housing and Urban Development, Moshi.
g. Visits to existing electric power facilities (Kiyungi Substation, Same Substation, Nyumba Ya Mungu Hydroelectric Power Station, etc.) to obtain data on state of installations, operating records, etc.

2.3 METHOD OF LOAD FORECAST AND PERIOD COVERED

The subject area of load forecasting is as set forth at the beginning of Chapter 1. Accordingly, there are 104 rural townships with a total population of approximately 255,000 and 24 estate farms to be considered in load forecasting. A breakdown of the above is given in an appendix. As stated in the preceding section, it is not possible to discuss the load forecast for the area based on fundamental data of that area. Therefore, the principle regarding the method of forecasting is to take into account population, number of households, types and compositions of demand in the subject area during the 10-year period from electrification and using as references the power demand and supply trends of other areas judged to have similar characteristics as those of this area to predict future demand. Namely, the traditional so-called "analytical method" was applied.

From a long-range viewpoint, trends in electric power demand will of course change considerably. In this regard, since electric power is used in almost every aspect of economic activities of production and consumption, from a long-range viewpoint, it may be considered to have an extremely good correlation with GNP. In this connection, there is a "macroscopic method" whereby global trends are found in correlations between per capita GNP and per capita electric power consumption based on which the long-range trend in electric power demand of a certain country is estimated.

The scale of electric power demand derived by this prediction method would be for the whole of the country and it would be a difficult matter to deduce the power demand of a single area from this demand on a nationwide scale.

However, a certain degree of approximation is required in load forecasting in any case. Consequently, for the load forecast for the 10-year period immediately after electrification, it was decided that the scale and growth rate of demand by the analytical method would be taken, while after the 10-year period, a switch to a growth rate on a nationwide scale obtained by the macroscopic method would be made.

The period of load forecast was taken as 25 years after electrification, although this has no special meaning in making the forecast.

2.4 LOAD FORECAST BY "ANALYTICAL METHOD"

Demands were predicted according to the sequence below.

2.4.1 Uncovering and Classification of Potential Demand

Firstly, potential consumers who will emerge in the form of electric power load and lighting load accompanying electrification must be uncovered.

Table II-2-1 List of Potential Consumers and Estimated Maximum Demand in kW

Tariff	Potential Consumers	M.D (KW)	Anticipated Electric Commodities
T-1	Domestic Consumers		
	Large houses	0.784	Light, Radio, Ceiling fan, Iron, etc.
	Medium houses	0.328	Light, Radio, Iron, etc.
	Small houses	0.180	Light, Radio, etc.
T-2	Commercial Consumers		
	Government offices	1.0	Light, Radio, Ceiling fan, Copy machine, etc.
	Police stations	1.0	ditto
	Post offices	0.5	ditto
	Courts	0.5	Light
	Primary schools	0.4	ditto
	Secondary schools	1.0	ditto
	Training schools	1.0	Light, Lathe, Drill, Grinder, etc.
	Missions	1.0	Light, Ceiling fan, Radio, etc.
	Mosques	0.5	ditto
	Banks	1.0	Light, Ceiling fan, Radio, etc.
	Hospitals	10–40	Light, Medical appliances, etc.
	Dispensaries	0.5	ditto
	Health centres	0.5	ditto
	Hotels	1.0--	Light, Ceiling fan, Cooker, etc.
	Bars	0.5	Light, Radio, Refrigerator, etc.
	Shops	0.2	Light, Radio, etc.
	Carpentries	0.5	Light, Radio, Saw, etc.
	Garage/workshops	1.0	Light, Radio, Grinder, Welder, etc.
	Petrol station	1.0	Light, Oil pump, etc.
	Markets	0.5	Light
	Veterinary offices	0.5	Light, Ceiling fan, Radio, etc.
T-3	Light Industrial Consumers		
	Maize mills	*	Motors for maize mills
	Coffee pulpings	*	Motors for coffee pulpings
	Estate farms	*	Light, motors for water pumps, maize mills, coffee pulpings, etc.
	Hospitals	*	Light, medical appliances, etc.
T-5	Public Lighting	0.1	

Note *: Maximum demands of tariff T-3 and T-4 are electrical out-puts of motors, prime movers, diesel engines, etc., and refer to appendix tables.

For this purpose, the Survey Team sorted out potential consumers referring to the reports mentioned at the beginning of this chapter, and these potential consumers were classified in accordance with the tariff system of TANESCO as shown in Table II-2-1. Based on this, data on the number and scale or maximum power demand of the potential consumers were collected by site investigations and from related agencies and DDD offices.

2.4.2 Number of Potential Consumers

The number of domestic consumers that can be electrified at the initial stage was estimated as follows based on investigation data of TANESCO. According to the surveys by TANESCO the number of potential domestic consumers in the following:

(1) Hai Distribution Network (Sept. 1975)

(a) Sanya Juu

Domestic Consumer	Number	Composition (%)	Number of Households 1978
Large houses	10	12.5	
Medium houses	20	25.0	536
Small houses	50	62.5	
Total	80	100.0	536

(b) Nrong Area

Domestic Consumer	Number	Composition (%)	Number of Households 1978
Large houses	12	11.8	
Medium houses	30	29.4	1,330
Small houses	60	58.8	
Total	102	100.0	1,330

(2) Rombo Distribution Network (June 1978)

Domestic Consumer	Number	Composition (%)	Number of Households 1978
Large house	20	4.0	
Medium houses	80	16.0	6,303
Small houses	400	80.0	
Total	500	100.0	6,303

(3) North Pare Distribution Network (May 1975)

Domestic Consumer	Number	Composition (%)	Number of Households 1978
Large houses	20	4.3	
Medium houses	100	21.3	5,877
Small houses	350	74.4	
Total	470	100.0	5,877

(4) South Pare Distribution Network (May 1975)

Domestic Consumer	Number	Composition (%)	Number of Households 1978
Large houses	43	7.3	
Medium houses	142	24.3	5,556
Small houses	400	68.4	
Total	585	100.0	5,556

The proportion of the number of domestic consumers that can be electrified at the initial stage in the various electrification districts, excepting Sanya Juu and South Pare, is roughly 8%. Sanya Juu is the county seat of the Hai District and differs from rural townships of other districts. As for South Pare, from the observations of the Survey Team in site investigations, it cannot be thought to differ particularly from other districts. Therefore, it may be estimated at 8% from an average standpoint.

Meanwhile, the number of domestic consumers was investigated by TANESCO from May 1975 to 1978, and it is fully conceivable that the number has been increasing yearly. Although it may be considered that the rate of increase of this has correlations with income and population growth, there was no available data indicating the income trends of the pertinent areas, and therefore, the target of 5.1% for the agricultural sector in the Third Five-Year Plan was adopted. At this growth rate, 10% of the number of households in 1978 would be the number of domestic consumers that can be electrified in the initial stage in the year electrification work is started. However, when considering the territorial spread, it is unthinkable that 100% of the above can be electrified and the Survey Team estimated that 80% would be the proportion of domestic consumers electrified in the initial stage. That is, 8% of the number of households in 1978 was assumed to be the number of domestic consumers.

The numbers of commercial consumers, light industrial consumers and industrial consumers were obtained from DDD offices and TANESCO data. Details are given in an appendix.

As the number for public lighting, 10% of the number of domestic consumers was taken. The number is that adopted by TANESCO, and this was followed.

The numbers of potential consumers according to tariff groups obtained from the foregoing are as shown in Table II-2-2.

Table II-2-2 Number of Potential Consumers by Tariff Group

Distribution Network	Tariff T-1	Tariff T-2	Tariff T-3	Tariff T-4	Tariff T-5	Total
Hai	1,158	318	126	5	117	1,724
Rombo	1,646	400	42	-	164	2,252
North Pare	469	303	21	1	48	842
South Pare	444	300	12	4	46	806
Total:	3,717	1,321	201	10	375	5,624

Note: As for breakdown, refer to the appendix

2.4.3 Maximum Power Demand of Consumers

Normally, the maximum power demand of consumers is decided by the size of installed load facilities, but the total of load facilities does not constitute maximum power. Consequently, the general procedure used is to compute maximum power introducing a coefficient called "demand factor." The demand factor for an ordinary household consumer, taking Japan as an example, is approximately 24%.

Demand factor may be defined as the following:

$$\text{Demand Factor} = \frac{\text{Maximum Power (kW)}}{\text{Total Load Facilities of Consumers (kW)}} \times 100\ (\%)$$

The survey area of the present study is a projected electrification area, and the actual situation is that there are hardly any load facilities of consumers existing. Consequently, it is impossible to calculate the aggregate of load facilities. However, from the viewpoint of load forecasting, the types and uses of load facilities, or their scales have only secondary meaning, and what is important, and moreover, necessary, is the maximum power demand of consumers. With regard to this maximum power demand, there is an estimate by TANESCO engineers. With this as the basic data, and adding the results of site investigations, observations and experience of the Survey Team, the maximum power demand of potential consumers was determined to be as shown in Table II-2-1.

The maximum power demands under Tariff 3, Light Industrial and Tariff 4, Industrial Consumers, in this table are outputs of electric motors, prime movers or diesel engines installed by consumers converted into electric power, and the original data are given in an appendix.

For maximum power demand of Tariff 1, Residential Consumers, the maximum power demands according to large, medium and small houses were not used in this load forecast for convenience of calculations, and the wighted averages of individual maximum power demands were used. Since it was surmised that sizes of consumers would differ somewhat according to distribution network, the weighted averages (maximum power demand of one residential consumer) are 207.2 W/one residential consumer for Hai, and 158.8 W/one residential consumer for Rombo, North and South Pare. The calculation process is explained in an appendix. The maximum power demands according to tariff groups are shown in Table II-2-3.

Table II-2-3 Estimated Maximum Demand in kW by tariff Group

Tariff Group	Hai		Rombo		North Pare		South Pare		Total	
	No. of Consumers	Maximum Demand	No. of Consumers	Maximum Demand	No. of Consumers	Maximum Demand	No. of Consumers	Maximum Demand	No. of Consumers	Maximum Demand
T-1 Domestic	1,158	240.0	1,646	261.4	469	74.5	444	70.5	3,717	646.4
T-2 Commercial	318	246.3	400	159.6	303	161.9	300	117.9	1,321	685.7
T-3 L. Industrial	126	1,210.8	42	193.4	21	114.3	12	50.4	201	1,568.9
T-4 Industrial	5	660.0	–	–	1	210.0	4	500.0	10	1,370.0
T-5 Public Lighting	117	11.7	164	16.4	48	4.8	46	4.6	375	37.5
Total:	1,724	2,368.8	2,252	630.8	842	565.5	806	743.4	5,624	4,308.5

Note: As for breakdown of maximum demand, refer to the Table in the attached appendix.

2.4.4 Synthesized Maximum Power

The maximum power demands of individual consumers do not arise simultaneously, but occur with differences in time. Therefore, the maximum power demand when individual loads are aggregated normally is smaller than the aggregate of individual maximum power demands.

This is expressed in the form of the equation below and is called "diversity factor."

$$\text{Diversity Factor} = \frac{\text{Aggregate of Maximum Power of Individual Consumers (kW)}}{\text{Maximum Power when Individual Consumers Synthesized (kW)}} > 1$$

The diversity factor approaches a constant value when the number of consumers becomes large to a certain extent. Normally, at rural areas of Japan, lighting load is said to be 1.15–1.25, motive power load around 1.5, and synthesized lighting and motive power load 1.2–1.3. According to observations by the Survey Team of load facilities in the subject electrification area, the motive power load makes up more than 65% of maximum power demand, and the diversity factor may be considered to be high. Therefore, it was decided to obtain the synthesized maximum power demand assuming a diversity factor of 1.3. In effect, the synthesized maximum power is determined by the following.

$$\text{Synthesized Maximum Power (kW)} = \frac{\text{Aggregate of Maximum Power of Individual Consumers (kW)}}{1.3}$$

Accordingly, the synthesized maximum power by distribution network will be, respectively,

Hai Distribution Network	1,822 kW
Rombo Distribution Network	485 kW
North Pare Distribution Network	435 kW
South Pare Distribution Network	572 kW

and the synthesized maximum power of all potential consumers will be 3,314 kW. However, the urban development demand described under a later item is not included.

2.4.5 Annual Energy Consumption

The annual energy consumption (kWh) is expressed by the equation below.

$$\text{Annual Energy Consumption (kWh)} = \text{Maximum Power of Load (kW)} \times \frac{\text{Annual Load Factor (\%)}}{100} \times 24\ \text{hr} \times 365\ \text{day}$$

Annual load factors in electrified areas of Tanzania according to tariff groups are estimated to be as indicated below. Approximate values for cases in Japan are also given.

Table II-2-4 Annual Load Factor in Tanzanian Rural Areas

Tariff Group	Annual Load Factor (%)	Load Factor x 24 hr	Japan*
Domestic Consumer	12.5 – 16.5	3 – 3.96	approx. 35.0
Commercial Consumer	16.5 – 20.0	3.96 – 4.8	approx. 45.0
Light Industrial Consumer	20.0 – 25.0	4.8 – 6	approx. 45.0 – 60.0
Public Lighting	approx. 50	12	–

*Estimated values since tariff classifications not the same.

It may be seen that the load factors are fairly low.

According to the Finance Manager's Report for 1978 (excluding December), the annual load factor was 45.8% for all TANESCO systems, 46% for the Coastal Grid System including Dar es Salaam, Morogoro and Tanga, and 57.5% for Dar es Salaam. At Songea Branch and Mafia Branch electrified in 1970 and 1972, the annual load factors were 32% and 37% respectively. The above indicates that annual load factor is low at the initial stage of electrification, but is high at an industrial center of urban type.

Therefore, in the forecast of energy consumption at the initial stage of electrification, the annual load factors adopted were the intermediate value of 14.5% (3.5 hr/day) for residential consumers, the minimum value of 16.5% (4 hr/day) for commercial consumers, the minimum value of 20% (5 hr/day) for light industrial and industrial consumers, and 50% (12 hr/day) for public lighting, while in calculations the equivalent hours per day, that is, the figures in parentheses, were used. As a result, the synthesized load factors for the initial stages of electrification of the various distribution networks will be as indicated in Table III-2-14 in an appendix, 24.7% at the initial stage of electrification.

2.4.6 Development Plan

In load forecasting, it is needless to say that future development plans should be investigated, and the development sites, scales, natures, types, and details of plans electrically analyzed for incorporation in the load forecast. Therefore, the Survey Team investigated the development plans in the projected electrification area at RDD and DDD offices but other than for urban development plans, data of the extent that would contribute to load forecasting were not available. Meanwhile, as a development plan for Kilimanjaro Region, there is the "Kilimanjaro Integrated Development Plan, October 1977" produced by the Japan International Cooperation Agency. It is more than conceivable that these projects will carry considerable weight as electric power demand if they were to be realized, but at the present time it is difficult to develop demand in terms of time series. And to incorporate these demands based on a certain hypothesis is to introduce an optimistic view into the feasibility study of a transmission and distribution project, and cannot be considered as the principal aim of load forecasting. Accordingly, the above-mentioned projects were not considered in the load forecast.

Urban development plans consist of urbanization projects presently in progress and administrative central city plans accompanying separation of administrative divisions. The Boma La Ngombe and Rombo (Mkuu) urban development plans belong to the former and the Mwanga urban development plan to the latter. The scales of these urban development plans are shown in Drawing III-2-1 through Drawing III-2-3 in an appendix.

The urban development plans are being expedited by the Ministry of Lands, Housing and

Urban Development, Moshi, but data for indicating construction targets by year were not available. Therefore, the maximum power demands at the initial stage of electrification were estimated as described below.

(a) Boma La Ngombe Development Plan: Drawing III-2-1

This project is planned at a savannah spreading out centered at Boma La Ngombe located approximately 23 km west of Moshi. Boma La Ngombe is at a hub of transportation routes leading from Moshi to Arusha or Kilimanjaro International Airport, and is also a branching point of the road leading to Sanya Juu where the DDD office is presently located. The urban development area is as much as approximately 1,300,000 m² (130 hectares) and many public facilities, social welfare facilities and educational facilities are included. At present, construction of a new DDD office is under way aiming for completion at the end of 1979.

New DDD office	20 kW
Employee housing	10 kW
Drinking water pumps	30 kW
Public lighting, others	10 kW
	70 kW

(b) Rombo Urban Development Plan: Drawing III-2-2

A project similar to that at Boma La Ngombe is being expedited in an area of approximately 2,000,000 m² (200 hectares) centered at the Rombo District. At present, there are a DDD office, National Bank of Commerce, and an SIDO office, while expansion of Furuma Hospital is planned. At present, coffee pulping and maize milling for the Rombo District are being done at Moshi, but it is surmised that these will be done within this urban development area in the future.

DDD office	10 kW
National Bank of Commerce	20 kW
SIDO office	10 kW
Furuma Hospital	40 kW
Employee housing	10 kW
Light industry	80 kW
Public lighting, others	10 kW
	180 kW

(c) Mwanga Urban Development Plan: Drawing III-2-3

It has been decided that North Pare is to be separated from the Pare District to become a new independent district, and it is scheduled for Mwanga to become the center of the district. Mwanga is located approximately 55 km east of Moshi and is the branching point of the road leading to Usangi and Ugweno from the highway between Moshi and Same.

DDD office	20 kW
Employee housing	20 kW
Public lighting	10 kW
	50 kW

2.4.7 Load Forecast

It has already been stated that there is no way a load forecast at the initial stage of electrification can be made based on past performance. Therefore, the energy sales from 1970 through 1978 of rural townships where electrification has been carried out were investigated, excluding industrial city types such as Dar es Salaam, Arusha and Tanga, and the growth rate of these was taken as the growth rate of the projected electrification area.

The energy sales of 19 rural townships by tariff group from 1970 through 1978 are as indicated in Table II-2-5, the basic data of which are given in Table III-2-20 of an appendix.

From this table, the annual growth rates for the periods of 1970/1974, 1974/1978 and 1970/1978 as seen by tariff group will be as indicated below.

Tariff Group	1970/1974 (%)	1974/1978 (%)	1970/1978 (%)
T-1 Domestic	7.40	13.60	10.45
T-2 Commercial	Δ1.15	4.72	1.74
T-3 Light industrial	5.86	6.83	6.34
T-4 Industrial	12.72	0.56	6.47
T-5 Public lighting	7.00	1.03	3.97
Total	7.74	4.21	5.96

Table II-2-5 Summary of Energy Sold in GWh by Tariff Group (1970–1978)

Year	T-1	T-2	T-3	T-4	T-5	Total
1970	11.32	20.77	6.61	33.73	1.64	74.07
1971	12.15	23.29	7.96	31.93	1.87	77.20
1972	12.72	23.08	7.82	37.75	1.91	83.28
1973	13.54	25.03	8.24	43.79	1.97	92.57
1974	15.06	19.83	8.30	54.46	2.15	99.80
1975	17.21	20.71	8.94	58.42	2.14	107.42
1976	17.32	21.29	9.57	57.04	2.24	107.46
1977	19.65	22.02	9.23	58.37	2.06	111.33
1978	25.08	23.85	10.81	55.70	2.24	117.68

Source: Finance Manager's Report

The average annual growth rates by tariff group divided into maximu, medium and minimum will be as indicated below.

Tariff Group	Maximum (%)	Medium (%)	Minimum (%)
T-1 Domestic	13.60	10.40	7.40
T-2 Commercial	4.72	1.74	Δ1.15
T-3 Light industrial	6.83	6.34	5.86
T-4 Industrial	12.72	6.47	0.56
T-5 Public lighting	7.00	3.97	1.03
Total	7.74	5.96	4.21

As the annual growth rates of tariff groups the medium growth rates of 19 rural townships from 1970 through 1978 were adopted. In effect,

T-1	Domestic Consumers	10.5%
T-2	Commercial consumers	1.8%
T-3	Light industrial consumers	6.4%
T-4	Industrial consumers	6.5%
T-5	Public lighting	4.0%

It was considered that potential demand would become actual 85% for T-3 and T-4 and 50% for T-1, T-2 and T-5 at completion of electrification, with all tariff groups reaching 100% in succession after 2 years. Following this, the growth rates by the tariff groups above would be indicated.

It was forecast that demand according to urban development would materialize 25% at completion of electrification, 50% during the following year, 75% after 2 years, and 100% after 3 years. Subsequent increases in demand would be determined by public facilities and housing which would be built in succession, but as mentioned previously, concrete indices could not be obtained. Therefore, the forecast population growth rate of 8% for Moshi Town indicated in the Third Five-Year Plan, and the forecast population growth rate (1980–1990) of 8% centered at the district indicated in the previously-mentioned "Kilimanjaro Integrated Development Plan, 1977" were focused on, and with the elasticity ratio as 1, the growth rates for Boma La Ngombe and Mwanga were both taken to be 8%, and that of Rombo 6%. Since the weight of light industry at Rombo is large, the rate was considered to be lower than at the others.

Based on the processes of the above potential demands surfacing and the forecast of growth rates, the results of load forecasts from 1983 through 1993 are as shown in Table II-2-6 through Table II-2-10 and Fig. II-2-1.

Table II-2-6 Forecast of Energy Consumption by Tariff Group
(All Distribution Networks)

Year	T-1 (MWh)	T-2 (MWh)	T-3 (MWh)	T-4 (MWh)	T-5 (MWh)	U.D.P. (MWh)	Total (MWh)	Increase Rate (%)
1983	424.0	500.6	2,433.7	2,125.2	83.9	126.4	5,693.8	18.1
1984	635.9	750.9	2,648.6	2,312.9	126.2	252.6	6,727.1	15.3
1985	847.8	1,001.1	2,863.3	2,500.3	167.7	379.0	7,759.2	7.5
1986	936.6	1,019.2	3,046.6	2,662.8	174.4	505.2	8,344.8	6.3
1987	1,034.7	1,037.6	3,241.6	2,835.9	181.4	539.5	8,870.7	6.3
1988	1,143.3	1,056.2	3,449.0	3,020.3	188.6	576.3	9,433.7	6.4
1989	1,262.6	1,074.5	3,669.7	3,216.5	196.2	615.6	10,035.1	6.4
1990	1,395.4	1,094.6	3,904.7	3,425.7	204.1	657.6	10,682.1	6.5
1991	1,541.5	1,114.1	4,154.5	3,648.3	212.1	702.6	11,373.1	6.5
1992	1,703.1	1,134.2	4,420.3	3,885.4	221.6	750.7	12,115.3	6.55
1993	1,881.5	1,154.7	4,703.2	4,138.0	229.5	802.1	12,909.0	

Note: U.D.P. is an abbreviation of Urban Development Plan

Table II-2-7 Forecast of Energy Consumption by Tariff Group
(Hai Distribution Network)

Year	T-1 (MWh)	T-2 (MWh)	T-3 (MWh)	T-4 (MWh)	T-5 (MWh)	U.D.P. (MWh)	Total (MWh)	Increase Rate (%)
1983	164.3	179.8	1,878.2	1,023.8	27.4	29.5	3,303.0	14.3
1984	246.5	269.7	2,044.0	1,114.2	41.4	59.0	3,774.8	12.5
1985	328.6	359.6	2,209.7	1,204.5	54.8	88.5	4,425.7	6.9
1986	363.1	366.1	2,351.1	1,282.8	57.0	118.0	4,538.1	6.4
1987	401.2	372.7	2,501.6	1,366.2	59.3	127.4	4,828.4	6.4
1988	443.4	379.4	2,661.7	1,455.0	61.6	137.6	5,138.7	6.5
1989	489.9	386.2	2,832.0	1,549.5	64.1	148.6	5,470.3	6.5
1990	541.4	393.2	3,013.3	1,650.3	66.7	160.5	5,825.4	6.5
1991	598.2	400.2	3,206.1	1,757.5	69.3	173.4	6,204.7	6.5
1992	661.0	407.4	3,411.3	1,871.8	72.1	187.3	6,610.9	6.57
1993	730.4	414.8	3,629.7	1,993.4	75.0	202.2	7,045.5	

Note: U.D.P. is an abbreviation of Urban Development Plan

Table II-2-8 Forecast of Energy Consumption by Tariff Group
(Rombo Distribution Network)

Year	T-1 (MWh)	T-2 (MWh)	T-3 (MWh)	T-4 (MWh)	T-5 (MWh)	U.D.P. (MWh)	Total (MWh)	Increase Rate (%)
1983	167.0	116.5	300.0	–	35.9	75.8	695.2	37.7
1984	250.4	174.8	326.5	–	53.9	151.5	957.1	27.4
1985	333.9	233.0	353.0	–	71.8	227.3	1,219.0	11.5
1986	368.9	237.2	375.6	–	74.7	303.0	1,359.4	6.5
1987	407.7	241.5	399.6	–	77.7	321.2	1,447.7	6.6
1988	450.6	245.8	425.2	–	80.8	340.5	1,542.9	6.6
1989	497.8	250.2	452.4	–	84.0	360.9	1,645.3	6.7
1990	550.1	254.7	481.4	–	87.4	382.5	1,756.1	6.8
1991	607.8	259.3	512.2	–	90.8	405.5	1,875.6	6.9
1992	671.7	264.0	545.0	–	95.4	429.8	2,005.9	6.91
1993	742.2	268.7	579.8	–	98.3	455.6	2,144.6	

Note: U.D.P. is an abbreviation of Urban Development Plan

Table II-2-9 Forecast of Energy Consumption by Tariff Group
(North Pare Distribution Network)

Year	T-1 (MWh)	T-2 (MWh)	T-3 (MWh)	T-4 (MWh)	T-5 (MWh)	U.D.P. (MWh)	Total (MWh)	Increase Rate (%)
1983	47.6	118.2	177.3	325.8	10.5	21.1	700.5	21.9
1984	71.4	177.3	193.0	354.6	15.8	42.1	854.2	18.0
1985	95.2	236.4	208.6	383.3	21.0	63.2	1,007.7	7.4
1986	105.1	240.7	222.0	408.2	21.8	84.2	1,082.0	5.9
1987	116.0	245.0	236.2	434.7	22.7	90.9	1,145.5	5.9
1988	128.1	249.4	251.3	463.0	23.6	98.2	1,213.6	6.0
1989	141.4	253.9	267.4	493.1	24.6	106.1	1,286.5	6.1
1990	156.1	258.5	284.5	525.2	25.5	114.6	1,364.4	6.1
1991	172.4	263.1	302.7	559.3	26.6	123.7	1,447.8	6.2
1992	190.3	267.8	322.0	595.6	27.6	133.6	1,536.9	6.24
1993	210.1	272.7	342.6	634.4	28.7	144.3	1,632.8	

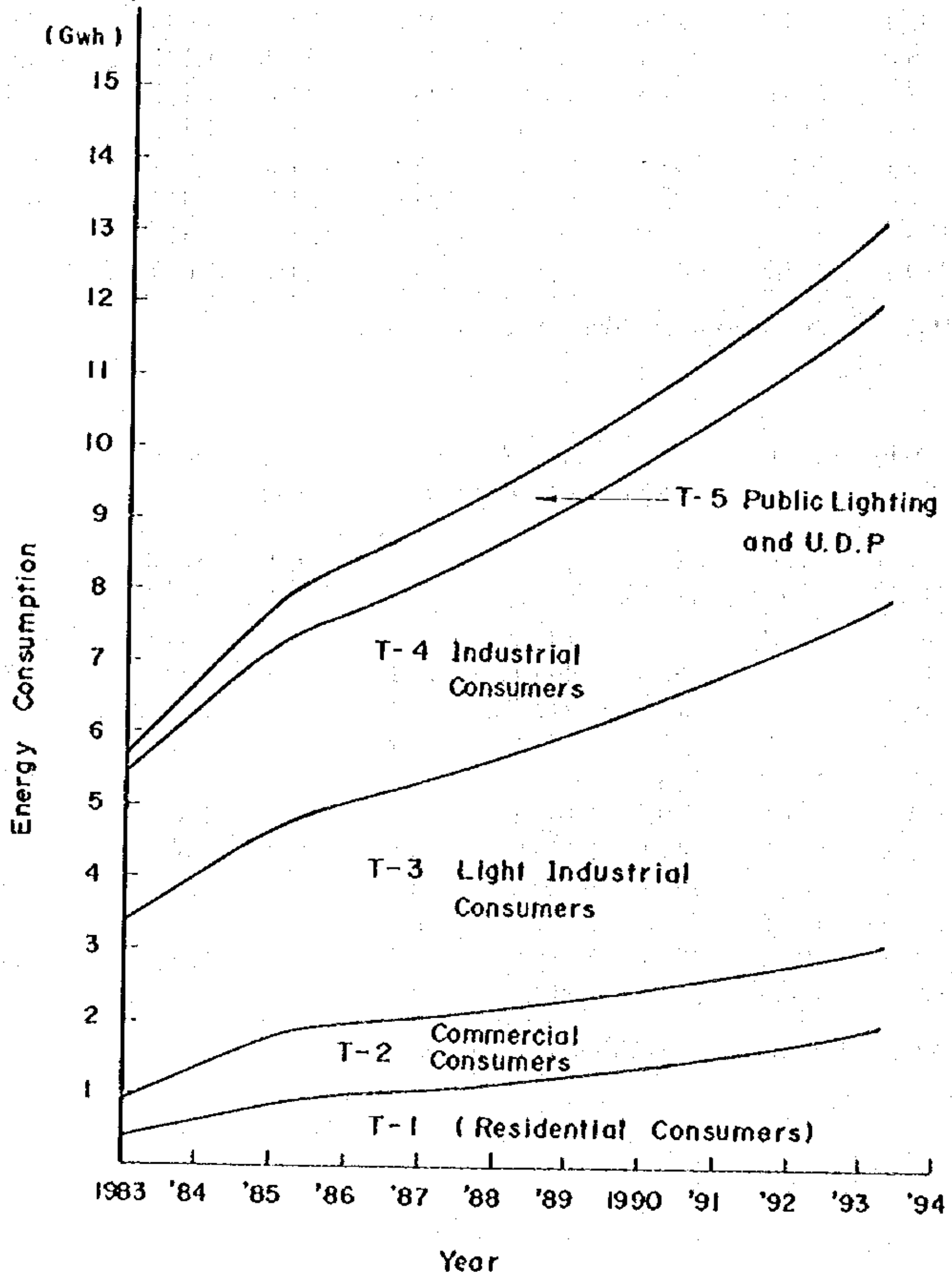
Note: U.D.P. is an abbreviation of Urban Development Plan

Table II-2-10 Forecast of Energy Consumption by Tariff Group
(South Pare Distribution Network)

Year	T-1 (MWh)	T-2 (MWh)	T-3 (MWh)	T-4 (MWh)	T-5 (MWh)	U.D.P. (MWh)	Total (MWh)	Increase Rate (%)
1983	45.1	86.1	78.2	775.6	10.1	--	995.1	14.7
1984	67.6	129.1	85.1	844.1	15.1	--	1,141.0	12.8
1985	90.1	172.1	92.0	912.5	20.1	–	1,286.8	6.1
1986	99.5	175.2	97.9	971.8	20.9	--	1,365.3	6.1
1987	109.8	178.4	104.2	1,035.0	21.7	–	1,449.1	6.2
1988	121.2	181.6	110.8	1,102.3	22.6	–	1,538.5	6.2
1989	133.8	184.8	117.9	1,173.9	23.5	–	1,633.9	6.3
1990	147.8	188.2	125.5	1,250.2	24.5	–	1,736.2	6.3
1991	163.1	191.5	133.5	1,331.5	25.4	–	1,845.0	6.3
1992	180.1	195.0	142.0	1,418.0	26.5	–	1,961.6	6.35
1993	198.8	198.5	151.1	1,510.2	27.5	--	2,086.1	

Note: U.D.P. is an abbreviation of Urban Development Plan

Figure II-2-1 Forecast of Energy Consumption by Analystical Method (10 years of 1973/1983)



Note; UDP is an abbreviation of Urban Development Plan

2.5 NATIONAL LOAD FORECAST BY MACROSCOPIC METHOD

2.5.1. Forecasting Method

The macroscopic method of forecasting electric power demand is that of estimating electric power demand of a country as a whole for an extra-long period based on the correlation between per capita GNP, GNP/capita, and per capita energy consumption, kWh/capita.

This correlation is separately determined in each country according to economic scale and individual income level, and therefore, differs considerably from country to country. However, according to the statistical investigations by country carried out by EPDC, there are general trend curves which exist for electric power consumption scales according to a number of income levels. The parameters required for this long-range forecast method are the following:

a. Degree of growth rate at present stage of national economy estimated from past records.

b. Present scale of GNP/capita.

c. Present scale of kWh/capita.

d. Degree of variation in GNP growth rate for variation in scale of GNP/capita.

e. Degree of variation in kWh/capita for variation in scale of GNP/capita.

The above parameters and the future scale of the nationwide power demand estimated based upon it are the following:

(1) Present GNP/capita, Average Growth Rate kWh/capita

From the standpoint of international comparisons in long-range forecasts, the necessary economic indices, namely, population, GNP, nationwide total energy production, etc., were considered using United Nations statistical data, and the economic indices for 1970--1976 were used as the bases for examinations. As indicated in Table II-2-11, GNP/capita, kWh/capita, and the average growth rate in GNP/capita are as indicated below.

a. Average-Type Growth Rate
- Talking the annual average growth rate for the 3 years during which growth rates were high ································ 2.0% (H)
- Annual average growth rate for 1970–1976 ························ 1.6% (M)
- Talking the annual average growth rate for the 3 years during which growth rates wer low ································ 1.2% (L)

b. GNP/capita for most recent year, 1976 ···························· US$102.0

c. kWh/capita for most recent year, 1976 ···························· 37.3 kWh

Further, with regard to GNP, it is expressed in terms of U.S. dollars on the basis of the year 1968. The above per capita GNP and energy consumption in 1976, and the above average growth rate of GNP/ capita expressed by (H), (M) and (L) constitute the starting point for long-range forecasting.

(2) Correlation between GNP/capita and GNP Growth Rate

A correlation may be seen between the scale of the above-mentioned GNP/capita and the GNP growth rate according to statistical investigations. In effect, until GNP/capita reaches US$500–1,000 in terms of 1968 prices, the growth rate will gradually rise, but subsequently, it will gradually decline. However, the GNP growth rates will differ among countries even though the scales of GNP/capita may be the same. Classifying the countries into groups of high, medium and low growth rates to find trends, they are as shown in Fig. II-2-2. Plotting three kinds of average growth rates, 2.0% (H), 1.6% (M), and 1.2% (L) for the 1976 GNP/capita of Tanzania of US$102.00 in this figure, they are as shown in that figure.

According to the 3 trend curves of Tanzania drawn in Fig. II-2-2, with US$102.00/capita in 1976 as the starting point and gradually increasing to US$120, and US$140, the GNP growth rates will be as shown in Table II-2-12.

(3) Correlation between GNP/capita and kWh/capita

A correlation may also be seen between GNP/capita and kWh/capita, again in statistical studies. This correlation, as with the correlation between GNP/capita and GNP growth rate, is not the same in all countries, but classification can be made into a number of groups indicating the same trends as shown in Fig. II-2-3. Plotting the GNP/capita and kWh/capita of Tanzania for 1970, 1973 and 1976 on the graph to obtain trend curves, it may be seen that they are roughly the same as the average curves for the world.

The variations in scale of future GNP/capita and the corresponding kWh/capita obtained from the trend curves of Tanzania drawn on Fig. II-2-3 are as indicated in the middle column of Table II-2-13.

2.5.2 Forecast Results

The population growth rate of Tanzania from 1970 through 1976 indicated in statistical data of the United Nations was 2.7%. In 1978, a census was taken in Tanzania and although the results have not yet been published, in the First Five-Year Plan, economic development plans were formulated with the projected population increase as 2.7%. Consequently, as a condition of the long-range forecast in this report, the population growth rate up to 1980 was considered to be 2.7% with a gradual decrease of 0.5% every five years assumed and the demand forecast for the future was made based on this.

The period of long-range forecast was taken to be 25 years after completion of electrification work, until the year 2007 (work completion 1982). In making the forecast, the average growth rates of the starting point GNP/capita were assumed at the three levels of 2.0% (H), 1.6% (M) and 1.2% (L). The trends in demand corresponding to these three average growth rates are as shown in Table II-2-13.

Looking at the power demand and the average growth rates in Table II-2-13, they are the following:

Power Demand (GWh)	1976		1980		1985		1990		1995		2000		2007
Case (H)	582		850		1,285		1,877		2,632		3,651		5,684
Case (M)	582		824		1,186		1,631		2,223		2,999		4,509
Case (L)	582		798		1,097		1,450		1,891		2,449		3,445
Demand Growth Rate (%)													
Case (H)		9.93		8.62		7.87		7.00		6.76		6.52	
Case (M)		9.08		7.56		6.71		6.26		6.17		6.00	
Case (L)		8.21		6.57		5.74		5.45		5.31		5.00	

The above long-range load forecast is predicated on the assumption that there will be no sudden change in the economic structure of Tanzania, and with the present tempo of growth as the starting point, a gradual development will continue into the future.

Predicting the scale of electric power demand of Tanzania based on this predication, it is forecast that it will increase to between 2,600 GWh and 3,600 GWh around the year 2000, most probably 3,000 GWh, with the growth rate changing from the approximately 9% at present to about 6% around 2000. Incidentally, the growth rate in energy sales of TANESCO for 1976–1978 was the following:

	1976		1977		1978*
Energy Sales (GWh)	490		516		581
Growth Rate (%)		5.3		12.6	
1976–1978 Growth Rate (%)			8.9		

*Estimated from sales records up to November
Source: Annual Report 1977, TANESCO

Table II-2-11 Basic Data for Long-Range Load Forecast

Year	Population (10^5)	GNP (10^6 T.shs)	GNP/capita (T.shs/capita)	GNP/capita at price in 1968 (T.shs/capita)	GNP/capita at price in 1968 (US$/capita)	Energy Consumption (Gwh)	KWh/capita (KWh/capita)
1970	13.3	9,173	690	661	92.5	407	30.6
1971	13.6	9,814	722	669	93.7	433	31.8
1972	14.0	11,172	798	695	97.3	473	33.7
1973	14.4	13,103	910	702	98.3	511	35.4
1974	14.8	15,994	1,081	702	98.3	532	36.0
1975	15.2	18,905	1,244	708	99.1	555	36.6
1976	15.6	22,507	1,443	728	102.0	582	37.3

Average Growth Rate of GNP/capita

(a) Annual average of higher 3 years 2.0%

(b) Annual growth rate from 1970 to 1976 .... 1.6%

(c) Annual average of lower 3 years 1.2%

SOURCE: Statistic Yearbook 1977

Figure II-2-2 Estimated Growth Rate of GNP / capita

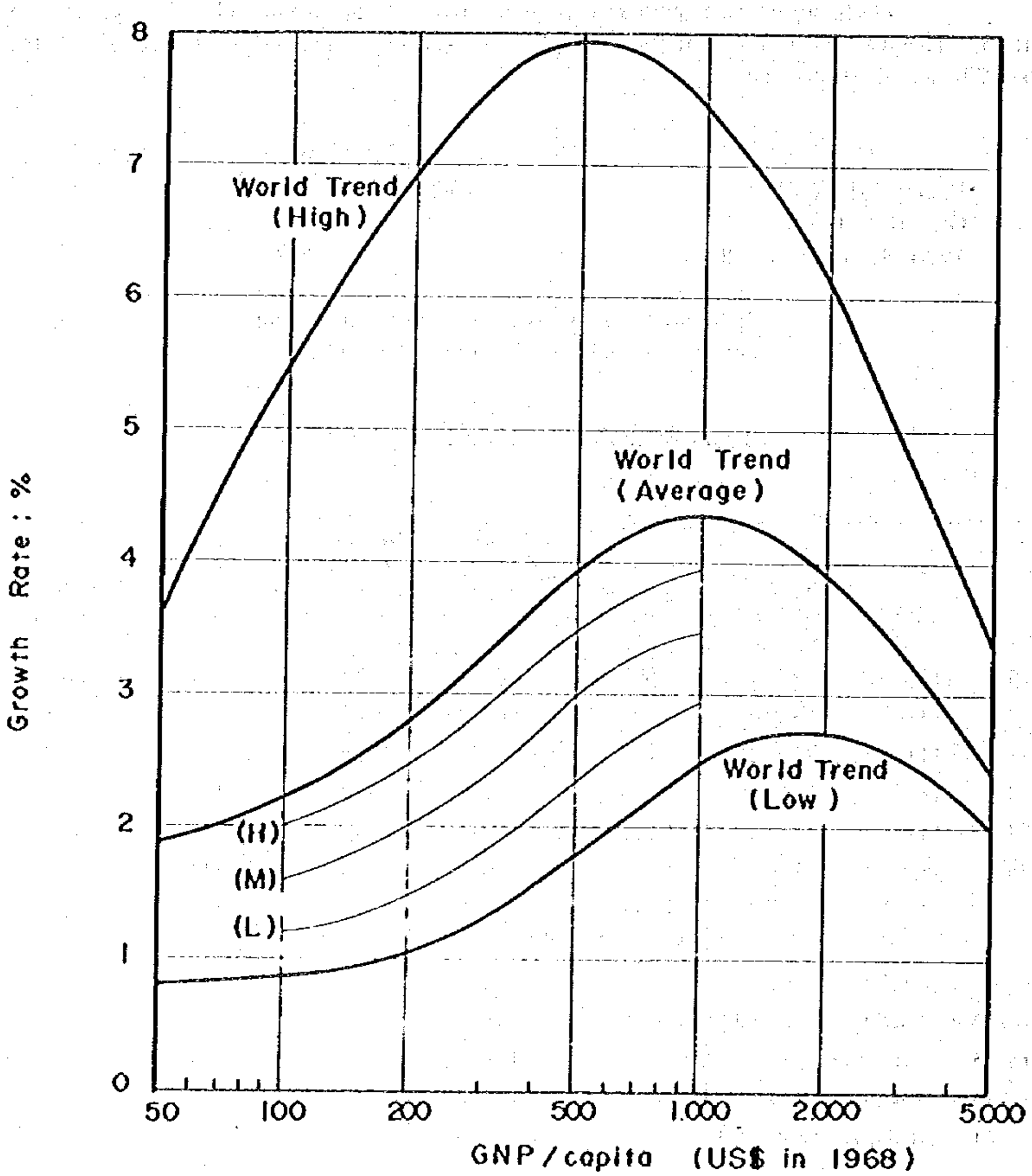


Figure II-2-3 Energy Consumption path chart

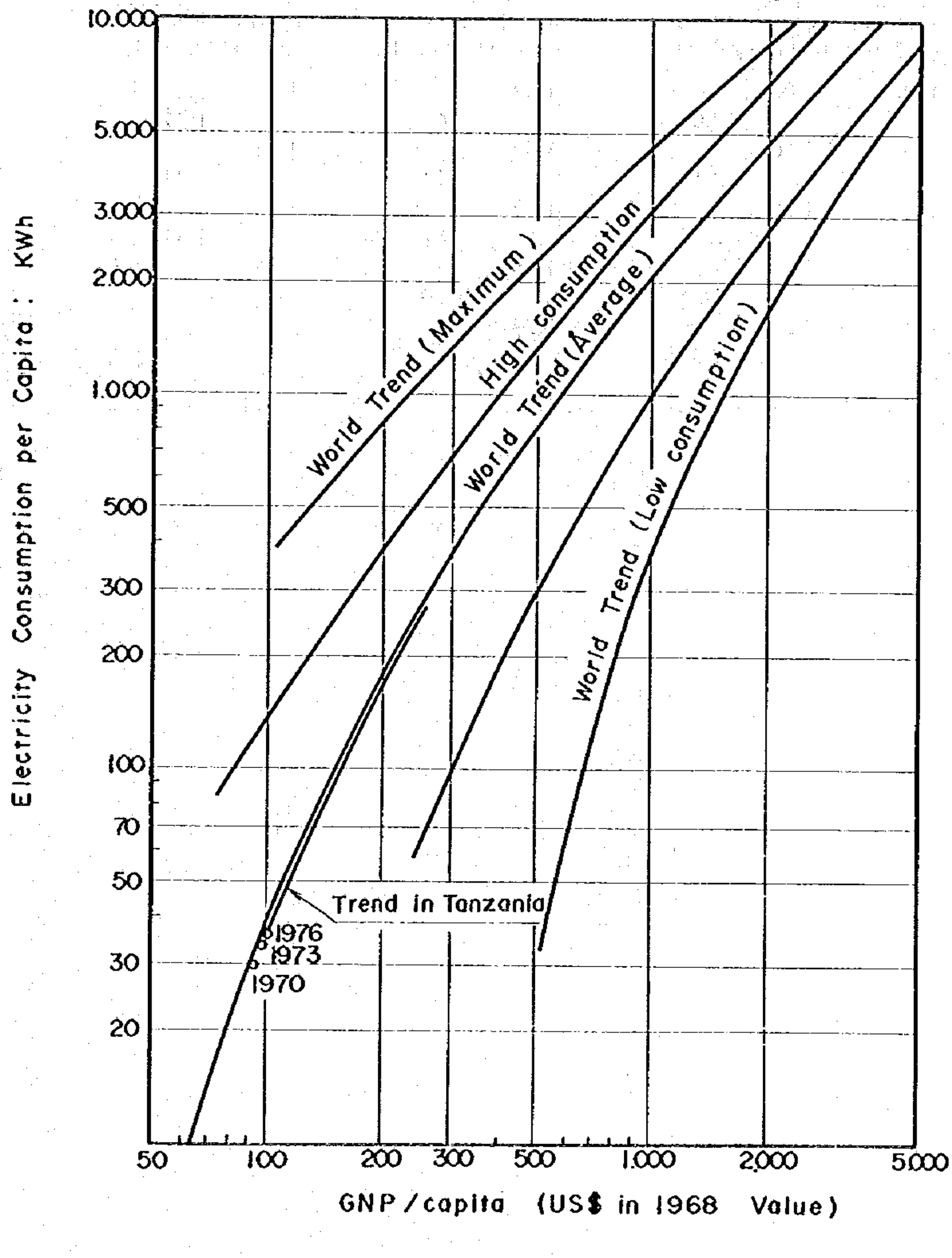


Table II-2-12 Forecasted Growth Rate of GNP/capita

	Growth rate starting from 2.0% base		Growth rate starting from 1.6% base		Growth rate starting from 1.2% base	
GNP/capita (US$ in 1968)	Growth rate (%)	Mean value (%)	Growth rate (%)	Mean value (%)	Growth rate (%)	Mean value (%)
100	2.03		1.62		1.22	
		2.07		1.66		1.24
120	2.10		1.69		1.25	
		2.14		1.73		1.28
140	2.18		1.77		1.30	
		2.23		1.81		1.33
160	2.27		1.85		1.35	
		2.31		1.90		
180	2.35		1.94			
		2.39				
200	2.43					

Table II-2-13 Long-Range Energy Consumption Forecast

Year	Growth rate of GNP/capita (%)			GNP/capita (US$ in 1968)			Energy Consumption (KWh/capita)			Population	Energy Consumption (GWh)			Growth rate of Energy Consumption (%)		
	H	M	L	H	M	L	H	M	L	(10^6)	H	M	L	H	M	L
1976	2.03	1.62	1.22	102.0	102.0	102.0	37.3	37.3	37.3	15.60	582	582	582			
1977	2.07	1.66	1.24	104.1	103.7	103.3										
1978	2.07	1.66	1.24	106.3	105.4	104.5								9.93	9.08	8.21
1979	2.07	1.66	1.24	108.5	107.2	105.8										
1980	2.07	1.66	1.24	110.7	108.9	107.2	49.0	47.5	46.0	17.35	850	824	798			
1981	2.07	1.66	1.24	113.0	110.8	108.5										
1982	2.07	1.66	1.24	115.3	112.6	109.8								8.62	7.56	6.57
1983	2.07	1.66	1.24	117.7	114.5	111.2										
1984	2.07	1.66	1.24	120.2	116.4	112.6										
1985	2.14	1.66	1.24	122.8	118.3	114.0	65.0	60.0	55.5	19.77	1,285	1,186	1,097			
1986	2.14	1.66	1.24	125.4	120.3	115.4										
1987	2.14	1.73	1.24	128.1	122.4	116.8								7.87	6.71	5.74
1988	2.14	1.73	1.24	130.8	124.5	118.3										
1989	2.14	1.73	1.24	133.6	126.7	119.7										
1990	2.14	1.73	1.28	136.5	128.8	121.2	83.5	73.0	64.5	22.48	1,877	1,631	1,450			
1991	2.14	1.73	1.28	139.4	131.1	122.8										
1992	2.23	1.73	1.28	142.5	133.3	124.4										
1993	2.23	1.73	1.28	145.7	135.6	125.9								7.00	6.26	5.45
1994	2.23	1.73	1.28	148.9	138.0	127.6										
1995	2.23	1.73	1.28	152.3	140.4	129.2	103.0	87.0	74.0	25.55	2,632	2,223	1,891			
1996	2.23	1.81	1.28	155.7	142.9	130.8										
1997	2.23	1.81	1.28	159.1	145.5	132.5										
1998	2.31	1.81	1.28	162.8	148.2	134.2								6.76	6.17	5.31
1999	2.31	1.81	1.28	166.5	150.8	135.9										
2000	2.31	1.81	1.28	170.4	153.6	137.7	126.0	103.5	84.5	28.98	3,651	2,999	2,449			
2001	2.31	1.81	1.28	174.3	156.4	139.4										
2002	2.31	1.81	1.33	178.3	159.2	141.3										
2003	2.39	1.90	1.33	182.5	162.1	143.1								6.52	6.00	5.00
2004	2.39	1.90	1.33	186.9	165.2	145.0										
2005	2.39	1.90	1.33	191.3	168.3	146.9										
2006	2.39	1.90	1.33	196.0	171.5	148.9										
2007	2.39	1.90	1.33	200.6	174.8	150.9	165.0	130.9	100.0	34.45	5,684	4,509	3,445			

2.6 CONCLUSIONS

As described in 2.4, for the 10-year period from electrification, the growth in demand is obtained by the "analytical method," subsequent to which the growth rate is obtained by the "macroscopic method." It was estimated that the growth rates from 1990 to 2007, as indicated in Table II-2-13, would be the following:

Growth Rate of Energy Consumption

Increase Case	1990/1995 (%)	1995/2000 (%)	2000/2007 (%)
High case	7.00	6.76	6.52
Medium case	6.26	6.17	6.00
Low case	5.45	5.31	5.00

As for the growth rates in demand of the various distribution networks in 1992/1993 obtained by the "analytical method," from Tables II-2-7 through II-2-10, they are 6.57% for Hai, 6.91% for Rombo, 6.24% for North Pare, and 6.35% for South Pare. It was found that these growth rates are slightly higher than the medium case growth rate for the whole of Tanzania. From 1993, the growth rates of the various distribution networks will become that for Tanzania as a whole and will be the following:

Distribution Network	1993/1995 (%)	1995/2000 (%)	2000/2007 (%)
Hai	6.57	6.42	6.20
Rombo	6.91	6.69	6.46
North Pare	6.24	6.10	5.98
South Pare	6.35	6.24	6.06

The load forecasts up to 1993 obtained by the analytical method and the energy demand up to 2007 from the above demand growth rates are as shown in Table II-2-14, II-2-15 and Fig. II-2-4.

It was forecast that maximum power demand would be 24.7% in terms of load factor in 1983 when potential demand is actualized and 35% in the year 2007.

On looking at the results of load forecast per capita of electrification area, it is estimated that it will be 25 kWh/capita in 1985 when potential demand is 100% actualized. This is a forecast lower than the national average of Tanzania in 1976 of 38 kWh/capita. The national average includes manufacturing and industry of high energy-consumption types which raises the average value, and it is natural that the per capita energy demand of so-called small-demand type areas such as the subject area of the present study is low.

On the other hand, this load forecast does not include planned development type demand described in 2.4.6 and is a conservative figure from this aspect also. In the future, if there is prominent development of small manufacturing industries in the subject area a fair amount of increase in demand can be expected. Accordingly, the per capita energy consumption will also approach the average level of the entire country. Incidentally, the kWh/capita figures for regions of the world taken from 1977 statistics are as indicated below.

According to United Nations statistics these figures are the following (as of 1976):

Region	kWh/capita	1967/1976 Growth Rate (%)
Africa	310	8.5
Asia	410	9.4
North America	6,130	5.7
South America	715	9.1
Europe	3,480	6.1
World	1,570	6.7
Tanzania	38	8.3

According to the table above the demand of Tanzania in 1976 was 12.3% of the average for Africa, indicating how large the potential demand is. The growth rate was roughly the same as the average for Africa and it may be predicted that there will be a rapid growth in demand if positive investments were to be made hereafter in the power transmission and distribution sector.

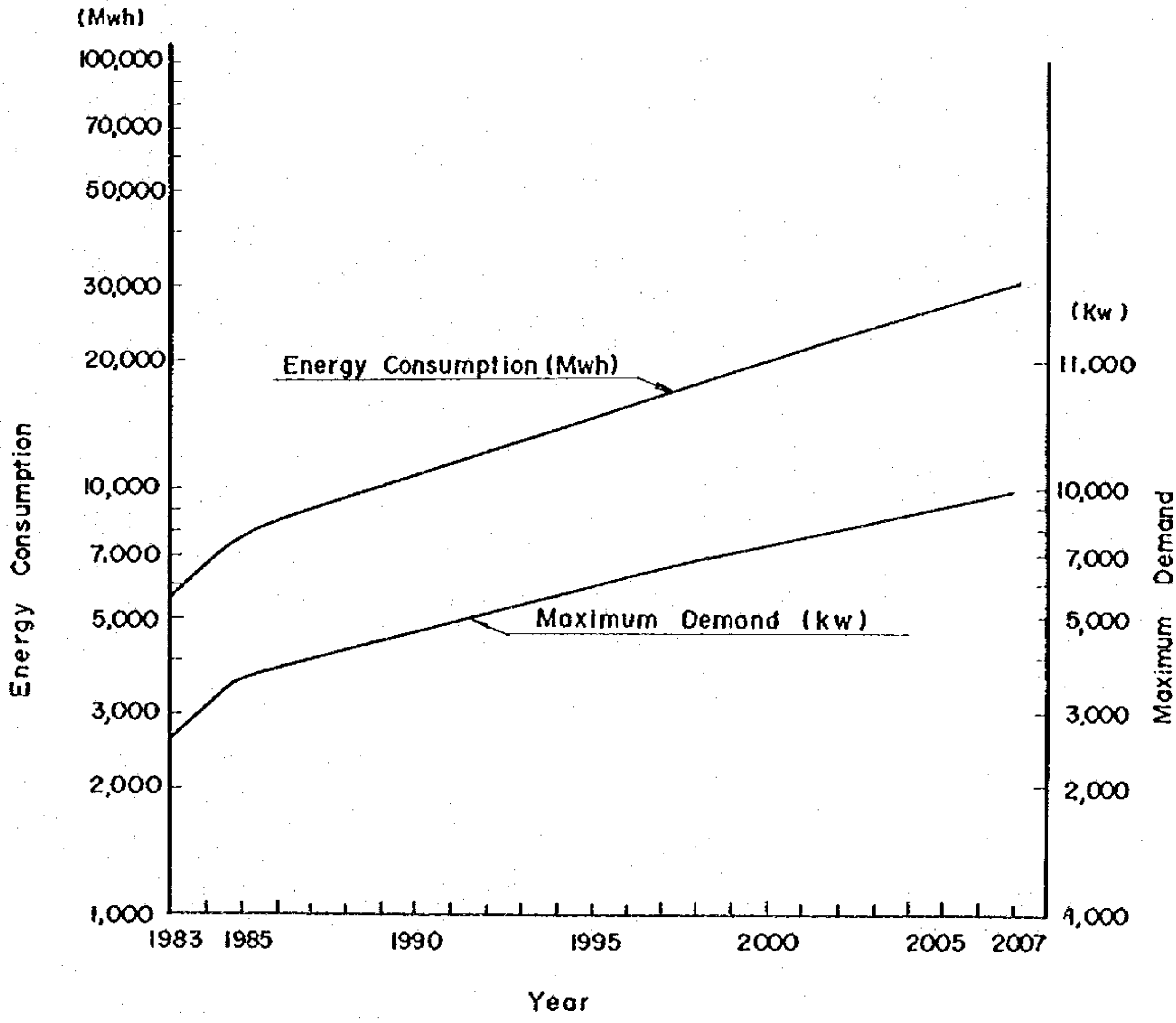
Table II-2-14 Summary of Load Forecast (1)

Year	Hai (MWh)	Rombo (MWh)	North Pare (MWh)	South Pare (MWh)	Total (MWh)	Load Factor (%)	Maximum Demand (%)
1983	3,303.0	695.2	700.5	995.1	5,698.3	24.7	2,633
1984	3,774.8	957.1	854.2	1,141.0	6,727.1	24.7	3,122
1985	4,245.7	1,219.0	1,007.7	1,286.8	7,759.2	24.7	3,590
1986	4,538.1	1,359.4	1,082.0	1,365.3	8,344.8	24.7	3,857
1987	4,828.4	1,447.7	1,145.5	1,449.1	8,870.7	25.1	4,034
1988	5,138.7	1,542.9	1,213.6	1,538.5	9,433.7	25.5	4,223
1989	5,470.3	1,645.3	1,286.5	1,633.9	10,035.1	26.0	4,406
1990	5,825.4	1,756.1	1,364.4	1,736.2	10,682.1	26.4	4,619
1991	6,204.7	1,875.6	1,447.8	1,845.0	11,373.1	26.8	4,844
1992	6,610.9	2,005.9	1,536.9	1,961.6	12,115.3	27.3	5,066
1993	7,045.5	2,144.6	1,632.8	2,086.1	12,909.0	27.7	5,320
1994	7,508.4	2,292.8	1,734.7	2,218.6	13,754.5	28.2	5,568
1995	8,001.7	2,451.2	1,842.9	2,359.4	14,655.2	28.7	5,829
1996	8,515.4	2,615.2	1,955.3	2,506.6	15,592.5	29.2	6,096
1997	9,062.1	2,790.1	2,074.6	2,663.0	16,589.8	29.6	6,398
1998	9,643.9	2,976.8	2,201.1	2,829.2	17,651.0	30.1	6,694
1999	10,263.0	3,175.9	2,335.4	3,005.8	18,780.1	30.6	7,006
2000	10,921.9	3,388.4	2,477.9	3,193.3	19,981.5	31.2	7,311
2001	11,599.0	3,607.3	2,626.1	3,386.8	21,219.2	31.7	7,641
2002	12,318.2	3,846.3	2,783.1	3,592.1	22,539.7	32.2	7,990
2003	13,081.9	4,088.4	2,949.5	3,809.7	23,929.5	32.8	8,328
2004	13,893.0	4,352.5	3,125.9	4,040.6	25,412.0	33.3	8,711
2005	14,754.4	4,633.7	3,312.9	4,285.5	26,986.5	33.9	9,087
2006	15,669.1	4,933.0	3,511.0	4,545.2	28,658.3	34.4	9,510
2007	16,640.6	5,251.7	3,720.9	4,820.6	30,433.8	35.0	9,926

Table II-2-15 Summary of Load Forecast (2)

Year	Demand Annual Energy			Maximum Demand kW	Remarks
	MWh	Increase Rate (%)	Load Factor (%)		
1983	5,693		24.7	2,633	By Analytical Method
84	6,727	18.1	24.7	3,122	
85	7,759	15.3	24.7	3,590	
86	8,344	7.5	24.7	3,857	
87	8,870	6.3	25.1	4,034	
88	9,433	6.3	25.5	4,223	
89	10,035	6.4	26.0	4,406	
90	10,682	6.4	26.4	4,619	
91	11,373	6.5	26.8	4,844	By Macroscopic Method
92	12,115	6.5	27.3	5,066	
93	12,909	6.55	27.7	5,320	
—	--	6.45			
97	16,589		29.6	6,398	
—	—	6.3			
2002	22,539		32.2	7,990	
—	--	6.2			
07	30,433		35.0	9,926	

Figure II-2-4 Forecast of Energy Consumption and Demand



CHAPTER 3

ELECTRIFICATION PLAN

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CHAPTER 3 ELECTRIFICATION PLAN

3.1 POLICY OF PROJECT PLANNING

3.1.1 Selection of Electrification Method

(1) Power Supply by Diesel Generator

In Kilimanjaro Region, there is an exsisting 132 kV transmission line of 275 km between Hale power station and Kiyungi substation, and also the exsisting Same substation is located half-way of the line. The electrification in this area is to be done by setting the said substations and the Nyumba Ya Mungu hydro power station as base points. Therefore, the electrification by method of diesel generators is no longer economical in the areas alongside this transmission line.

The economic comparison between the diesel engine plan and the distribution line plan for South Pare District is drawn, because this area seems to be the best sample area where we could make such a comparison. The detail of the comparison is as shown in Chapter 7. The conclusion is that the diesel engine plan is not competitive against the distribution line plan with considerable gap in cost. Even this district has no room for the diesel generator plan to be employed, therefore, in other districts with shorter line length, the diesel generator plan is not competitive at all.

Only the examination for the distribution line plan is made here in this Electrification Project from the foregoing reason.

(2) Transmission Voltage and System

(a) Selection of Transmission and Distribution Voltage

Transmission and distribution voltages are employed in accordance with TANESCO's standard.

The distribution voltage of 11 kV is mainly employed in this Project and the distribusion voltage of 33 kV is exceptionally employed for the paticular areas.

Employment of the distribution voltage of 33 kV is restricted except Rombo District and for all other districts the distribusion voltage of 11 kV is employed.

(b) Distribusion System

Distribusion systems are determined in accordance with followings.

a. Standard plan

In our standard plan, 11 kV power supply directly from a power souce is deemed to be difficult to be adopted in this Project, from a point voltage drop, because demands are 30 to 50 km away from a power source. Therefore the plan of installing 33/11 kV substations close to demands is standardized in this Project except for Rombo District.

The transmission voltage is stepped down to the distribusion voltage of 11 kV.

Customers scattering alongside the transmission lines can be supplied with electricity from 33/0.4 kV pole mounted transformers by spot supply method.

b. Study of Distribution System in Rombo District

Rombo District has belt area to be electrified, 4 to 5 km wide, which is located half-way up Mt. Kilimanjaro. Customers are scattered both sides of a road which traverses the center of this district. Electrification in this district will be extended up to Tarakiya which is located near the national border. If the said plan comes true, the total length the distribusion line from Kiyungi to Tarakiya will be 90 km. To prove properness of employing our 33 kV distribusion plan especially for the belt area, 90 km long, following three points must be examine.

* Marangu S.S plan
* Mkuu S.S plan
* 33 kV distribution line plan

– Marangu S.S plan

This is our standard plan for this Project. In this plan, Rombo District is supplied with electricity by a 11 kV distribution line of 33 km from a 33/11 kV 2500 kVA substation, which is to be constructed at the entrance of Rombo District. The voltage drop is not a big problem until a few years after operation. However, in the case demands increase in the future especially power supplied area is extended up to Tarakiya, the 11 kV distribution line plan has will have a disadvantage of larger voltage drop and needs much more investments, because the line length will reach to km as a result of the line extension.

– Mkuu S.S plan

In this plan, a 33/11 kV substation is expected to be constructed in the center of Rombo District, and a 33 kV distribution line covers the area between Marangu and Mkuu, 21 km, and beyong Mkuu a 11 kV distribution line takes a part.

This plan has less disadvantage in the respect of voltage drop but requires much construction cost than Marangu substation plan.

– 33 kV distribution plan

The following table shows the comparison between 33 kV distribution line plan and the above two plans.

Comparison of Equipment

Plan	33 kV D/L Length km	33 kV D/L Pole Tr. Nos.	11 kV D/L Length km	11 kV D/L Pole Tr. Nos.	S.S Main Tr. LRT kVA
Marangu S.S.	0	0	33	23	2500
Mkuu S.S.	21	11	12	12	2500
33 kV D/L	33	23	0	0	0

Comparison of Construction Cost (million yen)

	Line	Pole Tr.	Line	Pole Tr.	S.S	Total
Marangu S.S	0	0	87	15	45	147
Mkuu S.S	60	10	32	4	45	151
33 kV D/L	95	30	0	0	0	125

The construction cost for the Marangu substation plan is around 20% highter than that of the 33 kV distribution line plan and has a disadvantage of larger voltage drop. On the other hand, the Mkuu substation plan requires around 50% highter construction cost than the 33 kV distribution line plan. The 33 kV distribution line plan excels other plans from a viewpoint of the distribution capacity.

Therefore, the 33 kV distribution line plan has much more advantages than the Marangu substation plan and the Mkuu substation plan from a longrange view.

3.1.2 Determination of Installed Capacity

(1) Capacity of 11 kV Distribution Line

The most economical maximum current of the 95 mm² ACSR wire which is to be used for the 11 kV distribution line is around 260 A, and the most economical capacity is around 5000 kVA.

The distribution capacity in our standard plan is as the following Table shows, assurming various conditions as stated below;

Average line length;	30 km
Load distribution;	Uniform distribution
Limitation of voltage drop;	10%
Conductor size;	ACSR 95 mm²
Voltage;	11 kV
Firm distribution capacity;	1700 kVA

(2) Capacity of Pole Mounted Transformer

The pole transformer capacity has been determined assurming that the demands would increase around 6% each year, and that the utilization factor would be 100% 10 years later. The initial utilization factor 60% has been employed.

(3) Determination of Main Transformer Capacity

The capacity of main transformers has been selected from the TANESCO's standard transformer capacity series. The economic calculation has been done as shown in Section II-4 – 3-1 from a long-range view.

3.1.3 Power Source and System in Each District

The electrification in Kilimanjaro Region is proceeded by setting the Kiyungi substation, the Same substation and the Nyumba Ya Mungu power station as base points. The method of the connections between these base points and each district is roughly stated as follows;

In addition, system map of Kilimanjaro Region is roughly shown in Fig. II-3-1.

(1) Hai District

The Machame substation and the Sanya Juu substation are to be constructed on the east side and on the west side of Hai District respectively. The power out-put of each substation is 33/11 kV 3-phase 2500 kVA. These substations are planned to cover East Hai and West Hai plus half of Central Hai respectively.

(a) Sanya Juu substation

The power source for Sanya Juu is planned to be taken out from the nearest 33 kV distribution line. That is, a branch feeder of around 30 km to the Sanya Juu substation has been designed to be connected at pole No. 177 to the existing 33 kV distribution line between Kiyungi and Arusha.

(b) Machame substation

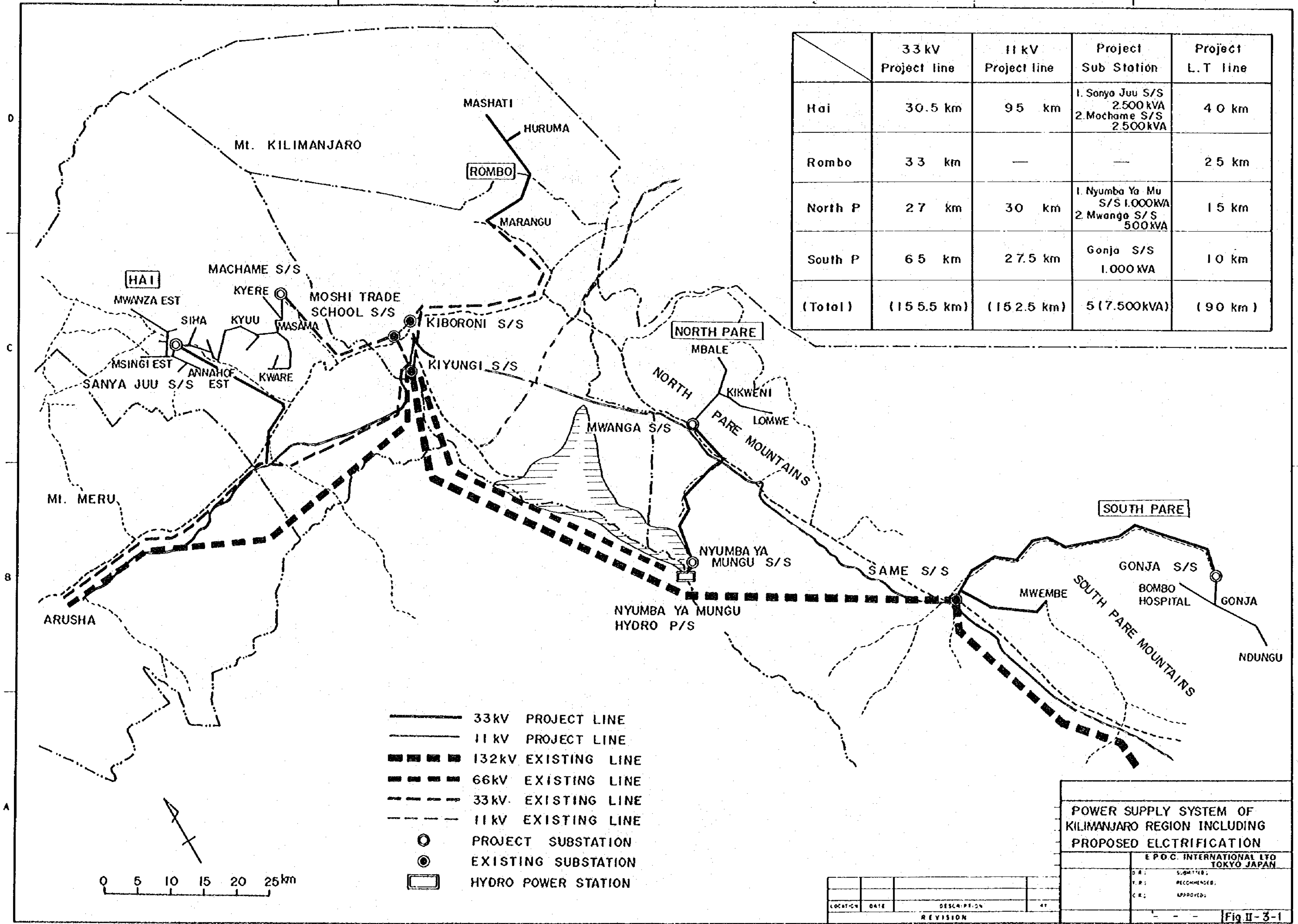
A 11 kV one circuit transmission line from the Kiyungi substation had already reached Machame District. The poles for the transmission line are dressed for use of 33 kV operation at present. The Machame substation has been planned to be constructed at the end of the transmission line and to receive 33 kV power supply. The demands scattering between Machame and Sanya Juu will be supplied with electricity from a 11 kV distribution line which has been planned to be construced. This distribution line runs alongside the road which travases half-way up Mt. Kilimanjaro at right angle between Machame and Sanya Juu, and supplied villages and plantations with electricity. The line length of this distribution line amounts to around 70 km including it's branch lines.

(2) Rombo District

The 33 kV one circuit transmission line of 31 km starting from Marangu up to Mashati is planned to be constructed alongside the road which travases though the foot of Mt. Kilimanjaro up to the national border. Some parts of the 33 kV distribution line had already been constructed in this district. And the Kiboroni substation in West Vunjo supplies electricity to this area. This substation is a simple substation with a 11/33 kV 500 kVA step-up transformer at the end of this substation is to be removed and a 33 kV transmission line of 10 km is to be constructed between the Kiboroni substation and the Kiyungi substation in fiscal 1979. And construction cost for the transmission line had already been included in the fiscal 1979 budget. Therefore, the transmission line had already been included in the fiscal 1979 budget. Therefore, the dependability of the power supply in Rombo District is expected to be improved as a result of a direct connection to a 33 kV bus at the Kiyungi substatation.

(3) North Pare District

The power source for this area designed to be taken out from the Nyumba Ya Mungu power station, 8000 kW, which is at the southern end of North Pare District.



	33 kV Project line	11 kV Project line	Project Sub Station	Project L.T line
Hai	30.5 km	95 km	1. Sanya Juu S/S 2.500 kVA 2. Machame S/S 2.500 kVA	40 km
Rombo	33 km	—	—	25 km
North P	27 km	30 km	1. Nyumba Ya Mu S/S 1.000 kVA 2. Mwanga S/S 500 kVA	15 km
South P	65 km	27.5 km	Gonja S/S 1.000 kVA	10 km
(Total)	(155.5 km)	(152.5 km)	5 (7.500 kVA)	(90 km)

POWER SUPPLY SYSTEM OF KILIMANJARO REGION INCLUDING PROPOSED ELCTRIFICATION

E.P.D.C. INTERNATIONAL LTD TOKYO JAPAN

Fig II-3-1

SHEET NO. OF

For the purpose of voltage step-up, a 11/33 kV 1000 kVA transformer has been designed to be installed adjacent to the Nyumba Ya Mungu hydro power station in order to make 33 kV power supply up to Mwanga, 27 km from the hydro power station. The primary of the transformer is directly connected to a 11 kV bus of the power station. And every possible measures have been taken into consideration to protect generators by providing protective devices, so that the external fault would not affect the generator main circuit.

(4) South Pare District

The power source for this area designed to be taken out from the Same substation which is located in the center of Same area. An lead-out from a 33 kV bus of the station had already installed.

In this Project, a 33 kV transmission line of 49 km to be connected to the Gonja substation and another 33 kV transmission line of around 16 km, T-brached from the above transmission line at a point near the Same substation up to Mwembe, are planned to be constructed.

3.1.4 Reinforcement of Facilities

The scope of power supplied areas and quantity of materials to be invested are as mentioned in the previous statement. However, the scope of power supplied areas is deemed to expand as electrification spreads. A 33 kv transmission line of 70 km to supply electricity for a forest development plan in Londoros, Hai District, and a 33 kV distribution line in Rombo District to be extended up to the national border are now being planned to be constructed by TANESCO. And the scope of demand will possibly increase in other district. It might necessarily require additional investments for the above increasing scope of demand as follows;

(1) 33 kV Transmission Line

This transmission line is the trunk line for this district, and it's transmission capacity has been determined with adequate room by giving adequate investments. Therefore, no additional investments are required against the demand increase, the transmission extension and the expansion of the scope of power supplied areas.

(2) 11 kV Distribution Line

In determining distribution capacity, careful examination has been given to the future demand increase with a longrange view being taken into consideration, so that no replacements of conductors and installations of additional distribution circuits will not take place. Therefore, no additional investments will be required in the future. For the increasing scope of demand, however, the distribution line extension and/or the construction of new distribution lines will be necessarily required.

(3) Main Transformer

In determining the capacity of main transformers. Various cases have been examined to accommodate the demand increase and also to restrict excess investment. Consequently, there will be no necessity of reinforcing facilities against the demand increase and the expanding scope of power supplied areas for some time. In addition, installation of another main transformer of the same capacity will be required to accommodate the demand increase and the expanding scope of power supplied areas.

(4) Circuit Breaker and Disconnecting Switch

Minimum ratings have been employed for the apparatus for use in the transforming facilities. However, they have adequate room to support the expected demand increase.

In this Project, two 11 kV one circuit stand-by cubicles have been designed to be installed, one at Machame substation and another at Sanya Juu substation as a distribution board, because the additional 11 kv distribution circuits are expected to be installed in Hai District.

(5) Pole Mounted Transformer

In determining initial investments, the capacity of pole mounted transformers have been selected to accommodate the demand of ten years later. However, the demand increase in each district varies to a great extent. Therefore, some investments for replacing pole mounted transformers will be required in accordance with the demand increase, seven to eight years after operation.

For plantation demands, the adequate capacity has been employed for pole mounted transformers, so that no investment for replacing pole mounted transformers will not occur for some time. The minimum capacity of pole mounted transformers is 50 kVA.

(6) Power Capacitor

For some time, power capacitors will not be required because of small voltage drop. In the later years, however, voltage drop compensation by power capacitors will be necessarily required for the terminal consumers in Hai District. On this occasion, power factor of large consumers such as plantations should be improved.

(7) Low Tension Line, Service Line and Meters

In the process of actualization of potential consumers, inhabitant's needs for electrification as well as their capability of purchasing power will decide their actual power demand and accordingly there is much fear to make an error in load forecast. Therefore, the length of the service lines and the quantity of the watt-hour meters have been determined by reducing the length and the quantites computed from the load forecast. It is assumed that TANESCO should provide the remainder service lines and watt-hour meters.

3.2 OUTLINE OF PROJECT PLANNING

3.2.1 Outline of Facilities

Under the policy of project planning as stated in Clause 3.1, transmission, distribution, and substation facilities as required for the four districts, Hai, Rombo, North Pare, and South Pare, are planned out and outlined as follows:

33 kV Transmission Line	122.5 km
33 kV Distribution Line	33 km
11 kV Distribution Line	152.5 km
Pole Mounted Transformers	107 (total 6,325 kVA)
Low Tension Line	90 km

Service Line	1,650
Street Lighting	160
33/11 kV 2.5 MVA	2
33/11 kV 0.5 MVA	1
33/11 & 11/33 kV 1 MVA	2

The breakdown of the above figures per district and per kind of facility are shown on the following tables.

Table II-3-1 Transmission and Distribution Lines for Each District

District	Lines	Section	Service Area	Length	Voltage	Wire	Insulator	Supports	Pole Trans.
Hai	Transmission Line	From existing 33 kV Airport line No. 177 pole to Sanya Juu s.s		30.5 km	33 kV	ACSR 95 mm^2	Line Post Insulator (LP-30) 250 mm Disc Insulator x 3	Wooden Pole	54 p.c.s. 3250 kVA
	Distribution Line	From Sanya Juu s.s to Gararagua Estate	Estates in West Hai	95 km	11 kV	ACSR 95 mm^2	Special High Tension Pin Type Insulator 250 mm Disc Insulator x 1	Wooden Pole	
		From Sanya Juu s.s to Machame s.s	Central Hai Area		11 kV	ACSR 95 mm^2		Wooden Pole	
Rombo	Distribution Line	From Marangu to Mashati	Main villages in Mkuu, Mashati	33km	33 kV	ACSR 95 mm^2	Line Post Insulator (LP-30) 250 mm Disc Insulator x 3	Wooden Pole	23 p.c.s. 1075 kVA
North Pare	Transmission Line	From Nyumba Ya Mungu Hydro Power Station to Mwanga s.s.		27 km	33 kV	ACSR 95 mm^2		Wooden Pole	16 p.c.s. 875 kVA
	Distribution Line	From Mwanga s.s to Sido From Mwanga s.s to Ghogho	From Kikweni to Sido area and main villages in Ghogho	30 km	11 kV	ACSR 95 mm^2	Special High Tension Pin Type Insulator 250 mm Disc Insulator x 1	Wooden Pole	
South Pare	Transmission Line	From Same s.s to Gonja s.s		65 km	33 kV	ACSR 95 mm^2	Line Post Insulator (LP-30) 250 mm Disc Insulator x 3	Wooden Pole	14 p.c.s. 1125 kVA
	Distribution Line	From Same s.s to Mwembe s.s	Mwembe area					Wooden Pole	
		From Gonja s.s to Ndungu	Gonja, Mpirani, Bombo area	27.5 km	11 kV	ACSR 95 mm^2	Special High Tension Pin Type Insulator 250 mm Disc Insulator x 1	Wooden Pole	

TABLE II-3-2 OUTLINE OF SUBSTATION FACILITIES

		Machame	Sanya Juu	Nyumba Ya Mungu	Gonja	Mwanga
Main Transformer	Capacity	2,500 kVA	2,500 kVA	1,000 kVA	1,000 kVA	500 kVA
	Phase	3	3	3	3	3
	Frequency	50 Hz	50 Hz	50 Hz	50 Hz	50 Hz
	Rated Voltage	33/11 kV	33/11 kV	11/33 kV	33/11 kV	33/11 kV
	Connection	Y Y Δ	Y Y Δ	Δ Y	Δ Y	Δ Y
	Tap Changer	on-load	on-load	off-load	off-load	off-load
	Number	1	1	1	1	1
36 kV Circuit Breaker	Rated Voltage & Current	36 kV-600A	36kV-600A	36kV-600A	36kV-600A	36kV-600A
	Rated Breaking Current	12.5kA	12.5kA	12.5kA	12.5kA	12.5kA
	Number	1	1	1	1	1
12 kV Circuit Breaker	Rated Voltage & Current	12kV-600A	12kV-600A	12kV-600A	12kV-600A	12kV-600A
	Rated Breaking Current	25kA	25kA	25kA	25kA	25kA
	Number	3	3	1	1	1
Disconnecting Switch	Rated Voltage	36kV	36kV	36kV	36kV	36kV
	Rated Current	400A	400A	400A	400A	400A
	Number	1	1	1	1	1
11 kV Cubicle	Number	7	7	3	4	4