

No. 2

**BASIC DESIGN STUDY REPORT
ON
THE PROJECT FOR RURAL ELECTRIFICATION
IN
WESTERN SAMOA**

FEBRUARY 1990

JAPAN INTERNATIONAL COOPERATION AGENCY

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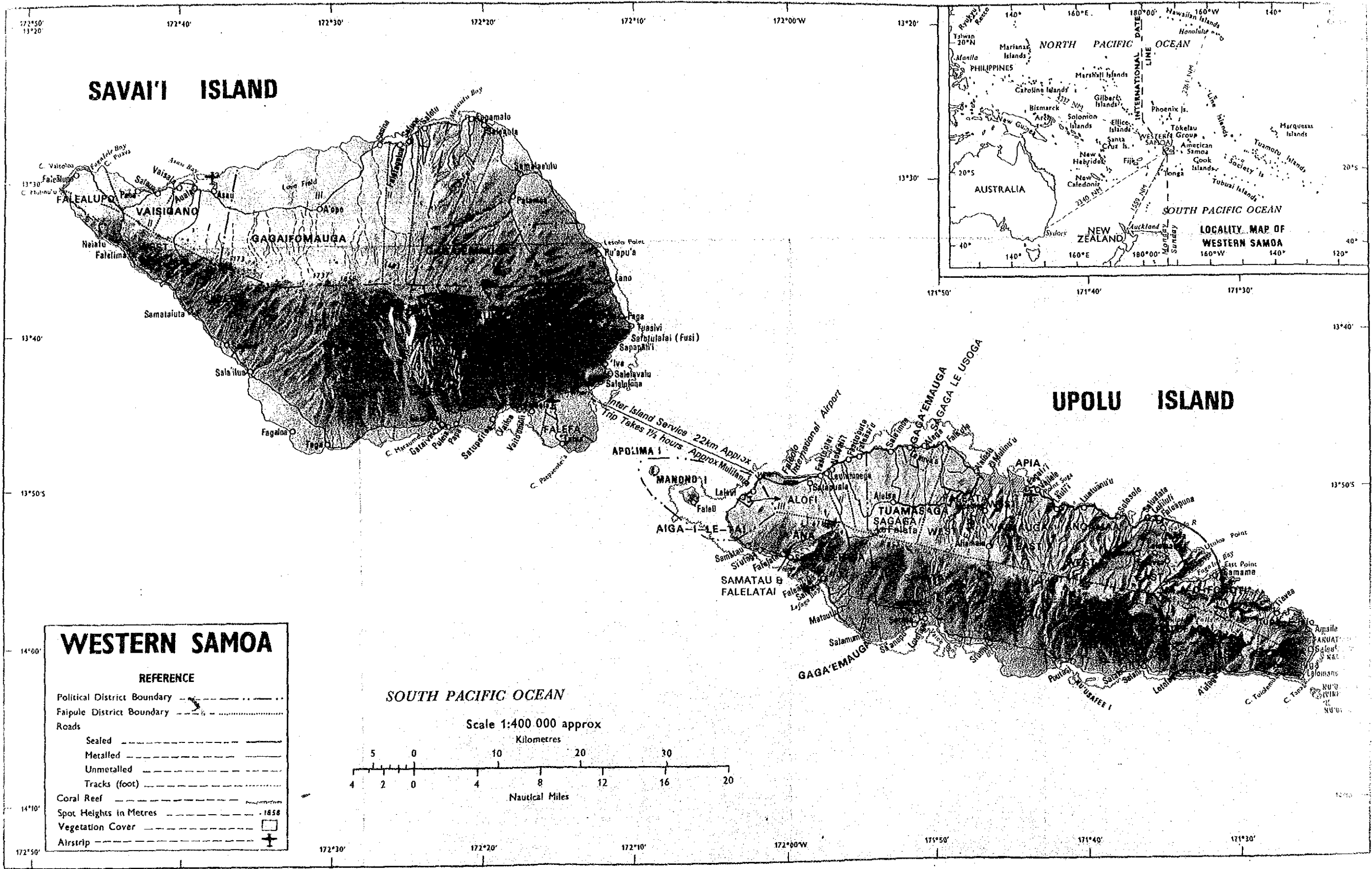
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PREFACE

In response to a request from the Government of Western Samoa, the Government of Japan decided to conduct a Basic Design Study on the Project for Rural Electrification in Western Samoa and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Western Samoa a study team headed by Mr. Munekazu URANO, Electric Power Technology Division, Agency of Natural Resources and Energy, the Ministry of International Trade and Industry from October 9 to November 11, 1989.

The team exchanged views on the Project with the officials concerned of the Government of Western Samoa and conducted a field survey. After the team returned to Japan, further studies were made and the present report was prepared.

I hope that this report will serve for the development of the Project and contribute to the promotion of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of Western Samoa for their close cooperation extended to the team.

February, 1990



Kensuke Yanagiya
President

Japan International Cooperation Agency

S U M M A R Y

SUMMARY

Western Samoa, located in Polynesia in the South Pacific is an island nation comprising two main islands, Upolu and Savaii. It was the first South Pacific nation to achieve independence. Total area of the country is approximately 2,900 km² and the said two islands account for 95 percent of this. According to the census taken in 1986, the population is about 157,500. The country has been electrified well in comparison with other developing countries with an electrification ratio of about 70 percent according to the census.

In order to achieve economic independence and improve public welfare, the Government of Western Samoa decided, in the Sixth Development Plan (1988 ~ 1990), to develop hydroelectric energy to save foreign exchange, to obtain a reliable energy supply for developing medium to small scale industries and to improve public welfare and rural industries (forestry, tourism, etc.) by developing rural electrification to prevent concentration of the population in the capital of Apia.

The Electric Power Cooperation (EPC) of Western Samoa is already proceeding with construction of a hydroelectric power station (output 4.2MW) in the Afulilo valley in the western part of Upolu island with financial assistance from ADB, IDA and EEC, to development a source of electric energy, to satisfy future increments in power demand and to change the source of electric energy from imported oil to hydroelectric energy. At the same time EPC is proceeding with rural electrification to improve rural industries as a principal objective of the said development plan. However, because of financial problems and the difficulties of construction on the lava beds, the Government of Western Samoa requested grant assistance from the Government of Japan.

In response to the official request, the Government of Japan decided to conduct a basic design study on the Project for rural electrification and Japan International Cooperation Agency (JICA) dispatched to Western Samoa the Basic Design Study team from October 9 to November 11, 1989.

While the team was in Western Samoa, it conducted site investigations of the project sites and collected relevant data for making the basic design for the Project. Further, the team exchanged views with EPC the executing agency of Western Samoa and prepared the minutes of meeting.

Through the site investigation by the team, the following were found;

- (a) The local people in the areas being electrified wish to receive EPC's electric power supply which is low cost and of high reliability.
- (b) The local people living along with the planned routes are voluntarily doing tree trimming on the routes. It is thereby confirmed that the local people are enthusiastic for rural electrification.
- (c) The Government of Western Samoa made budgetary provision for EPC's rural electrification plan in the annual budget of 1989.
- (d) It is confirmed that EPC is capable of erecting the distribution lines if the required materials, route survey and detailed design are done by a Japanese Consultant.

Based on the above and study done by the team in Japan, a basic plan for the Project was formulated as summarized below.

Table-1 Request from Western Samoa and Basic Design

Particulars	Request from Western Samoa			Basic Plan		
	Upolu	Savaii	Total	Upolu	Savaii	Total
66kV T/L	50km	---	50km	---	---	---
66kV S/S	1 lot	---	1 lot	---	---	---
22kV D/L	170km	99.5km	269.5km	103km	64km	167km
L.V. D/L	Required length for distribution			55km	7km	62km

Notes : T/L : Transmission line
S/S : Substation
D/L : Distribution line

The request from Western Samoa was for a 66kV transmission line(50km), 66kV substation facilities in Upolu island, 22kV distribution line(99.5km) in Savaii island and low voltage distribution lines associated with 22kV distribution lines on both islands. However, for the following reasons, part of the request was modified and the basic plan was formulated as summarized in Table-1.

(1)The Afulilo hydroelectric project was suspended because the fund managers of ADB, IDA and EEC requested the Government of Western Samoa to raise the present electric tariff at least ten percent as a condition of the loan, for economical reasons, and the Government of Western Samoa did not accept it. The voltage of the transmission line and substation facilities had been designed to suit the scale of electric energy to be transmitted from the Afulilo hydroelectric power station. These facilities were therefore excluded from the basic plan because they were judged to be premature.

(2) The request of Western Samoa included some 22kV distribution lines being constructed by EPC its own funds and Italian funds. These were, therefore, also excluded from the basic plan.

In consideration of the scale of the Project and the erection capability of EPC's erection gang, it is proposed that the Project be implemented in two phases. The work volume to be executed in each phase will be as summarized in Table-2.

Table-2 Work Volume in Each Phase

Particular	First Phase	Second Phase	Total
22kV D/L	66km	101km	167km
L.V.D/L	14km	48km	62km

If the Project is implemented under the Grant Aid program of the Government of Japan, the following work assignment will be set out.

(a) Japan would undertake the route survey, preparation of tender documents, procurement of the required line materials and a part of construction supervision.

(b) Western Samoa would undertake erection of the distribution lines.

Upon completion of the Project, the electrification ratio of Upolu and Savaii islands will be increased to 92% and 90% from 75% and 70% respectively. Consequently, about 30,000 people (about 18% of the total population) will receive electric power. This means that the total electrification ratio of Western Samoa will reach 91% and development of essential infrastructure aimed as the principal objective of the Sixth Development Plan of Western Samoa will be completed.

Thus, substantial benefits are expected to result from implementation of the Project and the Project will have great significance if implemented under the Grant Aid Program of the Government of Japan. However, there will be some problems, as mentioned below, in implementing the Project. It is judged that these problems will affect operation of the distribution lines after the Project is completed and erection work being done by EPC, if they are not solved beforehand. Therefore, prior to decide to implement the Project, it is necessary to confirm the prospects of solving these problems.

Problems :

- (1) In Western Samoa, the Afulilo hydroelectric project has been promoted with finance from ADB, IDA and EEC, but the project is suspended at present, as stated above. Accordingly it is expected that there will be a shortage of electric power supply of about 3,000kW at the time of completion of the Project in 1993, if the Afulilo project is not restarted. If it not, a diesel power plant with an output of about 4,000kW (4MW) will be required as an alternative power source.
- (2) A strong cyclone visited Western Samoa at the beginning of February 1990. The said cyclone inflicted great damage to the electricity and communications facilities, roads, other infrastructure and the peoples. It is a heavy burden for the Government of Western Samoa to restore the damaged infrastructure and there is apprehension above the sufficiency of funds for the erection works to be done by the government of Western Samoa under the Project. It is therefore necessary to reconfirm expectations of the required funds for the costs to be born by Western Samoa for implementation of the Project.

TABLE OF CONTENTS

	Page
PREFACE	
SUMMARY	
CHAPTER 1 INTRODUCTION -----	1 - 1
CHAPTER 2 BACKGROUND TO THE PROJECT-----	2 - 1
2-1 Outline of Western Samoa-----	2 - 1
2-2 Outline of EPC -----	2 - 2
2-3 Outline of Related Development Scheme-----	2 - 10
2-4 Contents of the Official Request -----	2 - 13
CHAPTER 3 OUTLINE OF THE PROJECT SITES -----	3 - 1
3-1 Location of Project Site and Socio and Economic Situation -----	3 - 1
3-2 Natural Conditions-----	3 - 2
3-3 Social Environment-----	3 - 3
3-4 EPC's Facilities in the Project Sites-----	3 - 3
CHAPTER 4 OUTLINE OF THE PROJECT -----	4 - 1
4-1 Project Objective -----	4 - 1
4-2 Examination of the Official Request-----	4 - 1
4-3 Outline of the Project-----	4 - 11

	Page
CHAPTER 5 BASIC DESIGN -----	5 - 1
5-1 Design Plan-----	5 - 1
5-2 Review of Design Conditions-----	5 - 2
5-3 Basic Design -----	5 - 5
 CHAPTER 6 PROJECT EVALUATION AND CONCLUSION --	 6 - 1
 APPENDICES	

CHAPTER 1
INTRODUCTION

CHAPTER 1 INTRODUCTION

Western Samoa, located in Polynesia in the South Pacific is an island nation comprising two islands, Upolu where the capital is situated and Savaii. Western Samoa was the first South Pacific nation to achieve independence. Total area of the country is approximately 2,900 km² and these two islands accounts for 95 percent of the country. According to the census in 1986, the population is about 157,500, of which about 112,500 (71.4%) are living in Upolu island, and about 44,900 (28.5%) in Savaii. The country has been comparatively well electrified in comparison with other developing countries. About 75% of the people in Upolu and about 70% in Savaii are receiving electric energy.

In order to achieve economic independence and improve public welfare, the Government of Western Samoa decided, in the Sixth (1988-1990) Development Plan, to develop hydroelectric energy to save foreign exchange and to promote rural electrification for the purpose of improving public welfare for the people in rural areas.

In their quest for development of hydroelectric energy, the Western Samoa government has been promoting the Afulilo 4.2 MW hydroelectric power Project on Upolu island with funds from the Asian Development Bank (ADB), International Development Association (IDA) and European Economic Community (EEC) and for completion in 1991. The Project has been suspended however, for financial reasons.

The Government is proceeding, nevertheless, with their rural electrification scheme, for improvement of the distribution network in rural areas with by its own funds. However, the Government officially requested from the Government of Japan grant aid for procurement of distribution line materials and

consultancy services for the rural electrification Project because of the difficulties in financing and erection work over the lava beds.

In response to the official request, the Government of Japan decided to conduct the Basic Design Study. Japan International Cooperation Agency (JICA), thereby, dispatched to Western Samoa a Basic Design Study Team headed by Mr. Munekazu URANO, Electric Power Technology Division, Agency of Natural Resources and Energy, the Ministry of International Trade and Industry for 34 days from October 9 to November 11, 1989. The team surveyed the Project areas, collected relevant data and information for reviewing the Basic Design, and discussed technical aspects of the Project with the Electric Power Corporation (EPC).

The members and schedule of the study team, a list of the collected materials, data and information, minutes of meeting, field survey report, etc. are given in Appendices 1-1, 1-2, 1-3, 1-4 and 1-5.

The report includes conclusions & recommendations, a project evaluation and an implementation program referring to the review and study results for adequacy, technical aspects, and scale of the Project based on the analysis of the results of the site investigation.

CHAPTER 2
BACKGROUND TO THE PROJECT

CHAPTER 2 BACKGROUND TO THE PROJECT

2-1 Outline of Western Samoa

Western Samoa is located between 13 deg. and 14 deg. of south latitude and between 171 deg. and 173 deg. of west longitude. The distances to Japan, Australia and New Zealand are about 7,000 km, 4,300 km and 3,300 km respectively. Western Samoa is located just to the east of the international date line and the time of Western Samoa lags 20 hours behind Japan.

About 32,000 out of 112,500 of the population in Upolu island are concentrated in the capital, Apia. This concentration of population especially in the capital of Apia has become a social problem.

Western Samoa does not have any system of the local autonomy and accordingly, there are no city, town or villages councils. Thus, no capital exists in the strict sense of the word. It is said, however, that Apia is the capital for the sake of convenience. Constitutionalism is employed in this country and the national assembly selects the head of nation.

The national finance of Western Samoa is heavily in debt and a great part of the annual revenue is derived from loans and grants from developed countries and international agencies. Although the national finances have tended to improve in recent years, there is an accumulated trade deficit and chronic insufficiency of foreign currencies.

The main industry in Western Samoa is agriculture producing copra, cocoa, banana, taro and so on. As for the fisheries, although the surrounding seas area are good fishing banks for oceanic bonito and tuna fishes, full-

scale fisheries have not been developed so far and the fisheries at present are solely for home-consumption.

Western Samoa has great potential in the tourist industry, being spotlighted gradually as country in Polynesia which retains and maintains its original Polynesian culture. Tourists visiting Western Samoa have increased at the rate of 5 to 10 percent per annum in consequence. This tourist industry is expected to be developed further in the near future as a valuable industry capable of earning foreign currencies.

The annual gross exports in 1987 were WSS\$25 million (about ¥1,500 million) against imports of WSS\$92 million (about ¥5,500 million). The trade balance was therefore in great deficit.

Other informations on Western Samoa is given in Appendix 2-1 "Outline of Western Samoa".

2-2 Outline of EPC

The electric power supply in Western Samoa is operated by EPC established in 1972, which is an agency under the Ministry of Public Works. The general operating policies of EPC are decided by a board of directors of which the chairman is the Minister of Public Works. Further, the said board of directors selects the general manager of EPC who is responsible for management and operation of EPC. The present general manager is a New Zealander and there are two deputy general managers under him. One Deputy General Manager is responsible for engineering and the other for administration. EPC has a staff of about 250 of whom 200 are engineering/technical and the other 50 are accounting/administrative personnel. However, EPC has only a few graduate engineers under the Deputy General Manager (Engineering). Furthermore, as they are

responsible for operation and maintenance of the existing electric power facilities, EPC cannot properly attend to planning and design of new electric power facilities.

As regards the rural electrification planned in the Sixth Development Plan by the Government, a committee for rural electrification, headed by the Minister of Public Works, plans the scale, priorities, electrification programme, finance scheme, etc.. The official request for this Project has also been provided by the Committee.

EPC has two separate power systems, one in Upolu island and the other in Savaii. The power plants are directly connected to the distribution system and electric energy is distributed to consumers after being stepped down to low voltage at pole mounted distribution transformers. It may be said, therefore, that the power system in this country is an initiative power system without transmissions and substations facilities.

(1) Existing electrical power facilities

(A) Power plants on Upolu island

There are two types of power plant on Upolu island, hydroelectric and diesel. The climate has two seasons a rainy season from December to April and a dry season from May to November. During the dry season, it is desirable to utilize effectively surplus water stored in rainy season, but because both Upolu and Savaii islands are formed of porous lava beds, it is difficult to store rainwater in reservoir. For this reason, all of the existing hydropower plants are run-of-river type and the generating output of the hydroelectric power plants in the dry season goes down to about 20% of the rated output. During the dry season, diesel power plants supply the balance of the power requirements

and the additional diesel power plants have an output of the about 80% of the total output of the hydroelectric power plants to meet their reduced output. EPC has, at present, hydropower plants having rated installed output of about 8,300kW and diesel power plants with rated output of about 12,600kW. The hydro and diesel plants have been re-rated to 7,800 kW and 9,100 kW respectively by EPC because of damage to penstocks of the hydropower plants and to cooling system of the diesel power plants. It seems, however, that the actual output capability of these plants may be even lower than these re-rated outputs because the existing power plants are old and suffer from lack of spare parts.

Occasionally load shedding has been required when some diesel power plants have been in trouble, especially in the dry season.

Plants in Upolu	Q'ty	Rated Output (kW)	Re-rated Output (kW)	Dry Season Output (kW)
Diesel	8 units	12,650	9,100	9,100
Hydro	7 units	8,270	7,820 (20%)	1,560
Total	15 units	20,920	16,920	10,660

Further details are given in Appendix 2-2 "Western Samoa Power Plants".

(B) Power generating plants on Savaii island

The power system on Savaii island was divided into two until 1988. One was the Salelologa system having its power source as diesel power plants in Salelologa where a port for ferry boats between Upolu and Savaii islands is located. The other was

Asau system having diesel power plants in Asau located in the northern part of the island. Salelologa and Asau power systems have now been interconnected by means of a 22 kV distribution line and re-formed into one system named the Salelologa power system in 1988.

The present power plants in Salelologa consist of seven (7) units of diesel power plants and with a generating output of about 1,000 kW in total, whereas the Asau power system was initiated to distribute surplus power to the public from a private turbo power plant of rated output of 1,500 kW provided for private use by Samoa Forest Product established by an American Company, and has been being operated by burning waste timber produced during sawing. However, this private power plant had a rated frequency of 60 Hz since the plant was provided by an American company. Therefore, EPC installed two (2) sets of frequency convertor with a combined output of 600 kW at the boundary of Samoa Forest Product. The converted power at 50 Hz is distributed to consumers. EPC further installed two (2) diesel power plants at the same place and the Asau power system now has both the said private power plant and EPC's diesel power plants.

EPC proposes to shift the two (2) diesel units from Asau for overhauling at Apia and to reinstall them in Salelologa after overhauling for the following reasons.

- The two power system have been interconnected.
- Operation and maintenance costs for separate stations is greater than for one station.
- There is a complaint from local people about the land used for the power plant.

The existing diesel power plants cannot operate at full output because of aging of the plants and lack of spare parts as on Upolu island. The generating output at present is as summarized in the following table. However, it seems that actual output is rather lower than the figures in the table.

Plants in Savaii	Q'ty	Rated Output (kW)	Re-rated Output (kW)	Actual in 1989 Output (kW)
Salelologa	7 units	1,073	920	840
Asau	2 units	712	662	(under overhaul)
Total	9 units	1,785	1,582	840

Details are given in Appendix 2-2 "Western Samoa Power Plants". There is no hydro power plant on Savaii island

(2) Distribution facilities

There are two (2) distribution line voltage on both Upolu and Savaii islands, i.e. 22 kV and 6.6 kV. However, EPC intends to unify the distribution line voltage at 22 kV in future.

Distribution facilities in 1987 are as summarized in the following table.

Distribution System	22 kV Line	6.6 kV Line	L.T. Line
Upolu system	182 km	73 km	419 km
Savaii system (Salelologa)	93 km	23 km	150 km
Total	275 km	96 km	569 km

Details are given in Appendix 2-3 "Western Samoa Distribution Facilities".

(3) Distribution Transformers

EPC had two (2) types of distribution transformers in 1987, i.e. single-phase and three-phase transformers as shown below;

Distribution System	22 kV 1-phase (kVA)	22 kV 3-phase (kVA)	6.6 kV 1-phase (kVA)	6.6 kV 3-phase (kVA)	Total (kVA)
Upolu system	1,850	14,250	345	5,350	21,795
Savaii system	645	300	365	250	1,560
Total	2,495	14,550	710	5,600	23,355

Details are given in Appendix 2-3 "Western Samoa Distribution Facilities".

(4) Power Market

(A) Electric energy balance in Upolu power system

The total electric energy sold in Upolu island in 1988 was approximately 35 GWh, 29.7% of which was consumed by domestic consumers, 42.4% by commercial enterprises, 10.8% by industries, 6.8% by religious institutions, 5% by hotels and 4.5% by schools. Annual sold energy in 1988 grew by about 10 percent.

The generated and sold energy of EPC in Upolu from 1982 to 1988 was as summarized in the following table and the annual sold energy from 1983 till 1988 was grown by 6.3 percent per annum on the average.

Generation and Sales of EPC in Upolu Power System

Year	Generated (MWh)	Soled (MWh)	Loss (MWh)	L.F (%)	Peak Power (kW)
1982	30,279	24,478	5,532	55	6,285
1983	31,104	25,426	5,435	55	6,456
1984	32,952	27,595	5,104	56	6,717
1985	34,764	27,712	5,432	56	7,086
1986	35,950	30,037	5,191	56	7,328
1987	38,254	32,078	5,534	57	7,661
1988	41,284	35,144	5,499	57	8,268

The load factor of Upolu power system is comparatively high based on calculation of daily load curves.

For calculation of the load factor, Appendix 2-4 "Load Factors Calculated by Daily Load Curves" should be referred to. Based on the generation in the above table, the peak power in 1988 was calculated to be approximate 8,300 kW on the assumption of a load factor of 55 to 57 percent. Upon this, as already mentioned, even though generating output in the dry season is approximate 10,660 kW, it seems that the actual output is less than that and no margin is available. It will be possible to supply power to meet future demand increase by completing Afulilo hydro power project (approx. 4,200 kW) being developed. However, the Afulilo project has been suspended due to shortage of funds. For executing the rural electrification Project, it is necessary to provide an alternative power plant, such as a diesel power plant, in lieu of the Afulilo project.

(B) Electric energy balance in Savaii Power system

Electric power sold in Savaii island in 1988 was only 1.6 GWh which was only 4.6 percent of that of Upolu island. The reasons are that 75 percent of the total population is living in Upolu island and the industries in Savaii island are very few.

The generated and sold energy of EPC in Savaii power system from 1982 to 1988 was as summarized in the following table.

Generation and Sales of EPC in Savaii Power System

Year	Generated (MWh)	Sold (MWh)	Loss (MWh)	L.F (%)	Peak Power (kW)
1982	898	748	43	35	293
1983	883	717	171	35	288
1984	853	679	194	35	278
1985	1,017	660	175	35	332
1986	1,865	818	185	35	608
1987	1,972	1,450	395	35	643
1988	2,113	1,555	372	35	689

The load factor of Savaii power system is unknown because of non-availability of load curves. It is, however, assumed to be around 35 percent considering domestic consumers representing 60 percent of the total and the peak demand being presumed to occur in the evening time. The peak output in 1988 was calculated to be approx. 690 kW on the above basis. On the other hand, though the generating output is approx. 840 kW, there is, in reality, no margin because there is frequent trouble with the equipment. However, it will be possible to cope with future electric power demand

increases by re-installing the two diesel power plants at Salelologa which were removed from Asau for overhaul.

2-3 Outline of Related Development Scheme

(1) National development plan

The principal long-term national objective of the Government of Western Samoa is "Improvement of the Livelihood of the Peoples" and the Sixth Development Scheme for three years from 1988 to 1990 provides for development of essential infrastructure such as transportation, communication and energy.

The following development schemes related to the Project were included in the Sixth Development Plan.

(A) Road Development

(i) Renovation scheme of Lemafa and Richardson roads

Lemafa road:

This road is located in the eastern part of Upolu island and crosses the island from north to south. The road branches off on the way to the site of the Afulilo hydropower project. The total route length is about 22 km.

Richardson road:

This road branches off Lemafa road and traverses the hills from the branch point to the east coast. This road is important for accessing the reservoir of the Afulilo project. The total route length is about 30 km.

A distribution line has been planned to be constructed along Lemafa road from the Afulilo

hydropower plant and to be connected at Lotofaga with a distribution line to be provided under the Project.

(ii) Apia-Faleolo road renovation scheme

This is for approximately 30 km from the capital of Apia to Faleolo where an international airport is located. The road will be utilized to transport distribution line materials for constructing the lines in the western area under the Project.

(iii) Apia-Sium road renovation scheme

This is for approximately 22 km from the capital of Apia to Sium on the south coast. A distribution line under the Project will be constructed along this road.

(iv) Salelologa-Asau road renovation scheme

This is for approximately 90 km from Salelologa in the south to Asau on the north coast of Savaii island. The road will be utilized to transport materials for the distribution lines in the western and northern areas under the Project.

(v) Development of communications system

This is a plan to extent the communications facilities of Afiamalu ground satellite station. The electric power will be supplied to this satellite station through Tanugamano-Sium distribution line to be constructed under the Project.

(vi) Other development schemes

The Government of Western Samoa plans to develop and to maintain small-scale industries in rural areas for the purpose of establishing economic independence and improvement of the livelihood of the peoples.

(2) Development scheme of EPC

EPC has two related development schemes, the Afulilo hydropower development scheme and the rural electrification scheme on the north coast of Savaii island with the assistance of Italian Aid. The present situations of these schemes are as mentioned below.

(A) Afulilo hydropower development scheme with ADB, IDA and EEC

The Government of Western Samoa is now proceeding with its first storage hydropower development scheme having output of about 4,200 kW for reducing oil imports which is the Government's policy as a principal objective in energy sector.

After completion of the said development scheme, the storage hydropower plant will be able to utilize water resources in the dry season and will contribute greatly to the national economy.

Electric power will then be able to be distributed effectively to the east coastal area from this hydropower plant through a distribution line to be constructed under the Project.

Tendering for the Afulilo hydropower scheme was closed in June 1989 and tenders were evaluated by the consultant. Contract signing was scheduled to

be made after approval of ADB, IDA and EEC. However, during the detailed design, it was discovered that the expected construction cost would be about twice as much as estimated under the feasibility study. Upon learning this, ADB, IDA and EEC requested the Government of Western Samoa to raise the present electric tariff by at least 10 percent from economical view points which means sound refund of the construction cost and healthy management of EPC. Because the Government of Samoa did not accept this recommendation, the Project has been suspended.

The electric tariff is at present being re-evaluated by a British consultant. If it is recommended that the tariff be increased as a result, the Afulilo Project will be restarted. Accordingly it is recommended that the possibility of resumption of the Afulilo Project be confirmed or alternatively the provision of an alternative generating scheme.

(B) Rural electrification scheme in north coast of Savaii island under Italian Aid

Unelectrified areas still remain in mainly north coast areas of Savaii island and EPC has, therefore, wanted to electrify these areas. The Government of Western Samoa requested the Government of Italy for an electrification program of these areas. Details of the said program will be mentioned in Chapter 4-2 "Examination of the Request".

2-4 Contents of the Official Request

The Government of Western Samoa decided to proceed with the rural electrification scheme, as an objective of development, to improve the livelihood of the local people

and to prevent concentration of people on Upolu island especially in the capital, and to keep them in the rural areas by means of improvement of employment opportunities by maintaining medium and small-scale industries in the rural areas. To accomplish this objective, the Government of Western Samoa officially requested financial assistance from the Government of Japan for procurement of materials and consultancy services. The contents of the request were as summarized below;

(1) State of rural electrification at the time of preparation of the request

In May 1988, major areas in Western Samoa where EPC's power system has not yet been established were limited to parts of the south and east coasts of Upolu island and the north coast of Savaii island after completion of distribution lines in parts of both Upolu and Savaii islands with ADB's financial assistance and by improvement of the distribution system in Savaii island with assistance from the United Nations. Therefore, distribution lines to be included in the Project were in the said major areas, Aleisa area and its suburb of inland areas of Upolu island, and west coastal areas in Savaii island.

(2) Facilities proposed by Western Samoa

Facilities proposed by Western Samoa are as follows:

Upolu Island

66 kV T/L	Tanugamanono-Afulilo	50 km
22 kV D/L	On same poles with 66 kV T/L	40 km
- do. -	Siumu-Lefaga (Leulumoega)	40 km
- do. -	Leili (unknown)-Aleisa	40 km
- do. -	Richardson road (Amaile-Afulilo)	20 km
- do. -	Aleipata-Lotofaga (Lotofaga-Amaile)	30 km
Total 22 kV D/L		170 km

66 kV S/S	12.5 MVA transformer	2 sets
- do. -	1 MVA transformer	1 set
- do. -	Circuit breakers and protective equipment	2 sets
- do. -	Power fuses	1 set

Savaii Island

22 kV D/L	Saleaula-Sasina	19 km
- do. -	Falealupo-Tafutafoe	13.5 km
- do. -	Tafuatai	39 km
- do. -	Puapua-Saleaula	28 km
- do. -	6.6 kV stepping up	8 km
Total		61.5 km

Notes T/L:Transmission line
D/L:Distribution line
S/S:Substation

(3) Implementation schedule

As rural electrification of Upolu island, a 66 kV transmission line and a 22 kV distribution line on the same poles will be constructed in the first phase and other distribution lines will be constructed in the second phase. The first phase is scheduled to be completed within three years and the second phase within four years. Further, on Savaii island, both the Saleaula-Sasina and Falealupo-Tafutafoe lines are scheduled to be completed within three years and other lines after completion of the second phase on Upolu island.

(4) Administration of the Project

For executing the Project, EPC intends to employ a consultant for the following works.

- Route survey
- Preparation of tender documents
- Procurement of goods for the Project
- Administration of the Project
- Construction supervision
- Provision to provide foremen

(5) Expected effect of Rural Electrification listed in the Official Request from Western Samoa

The immediate effect of completing the rural electrification project will be to supply economical and reliable power by which it is expected that the livelihood of the local people and rural industries (such as an ice manufacturer and a freezing facility for marine products) will be improved and extended. This will reduce the need for kerosene now being consumed in these areas and for imported oil, and will save foreign exchange accordingly.

CHAPTER 3
OUTLINE OF THE PROJECT SITES

CHAPTER 3 OUTLINE OF THE PROJECT SITES

3-1 Location of Project Sites and Socio and Economic Situation

The planned line routes are mainly in the central, east coastal and north west inland areas of Upolu island and in the north coastal areas of Savaii island. Upolu and Savaii islands are interconnected by air and ferry boats. It takes about thirty minutes by the air and about one hour by the ferry boat to cross between the islands.

The Project includes twelve line routes, mainly coastal routes and routes toward inland areas. These may be classified as follows. Routes of the various lines are as shown on map Appendix 3-1 "Proposed Distribution Lines".

Upolu Island

Tanugamanono-Siumu	Crossing at central
Lotofaga-Amalei	South and east coastal route
Saluafata-Sauniatu	North inland route
Siusega-Tanumalala	North inland route
Aleisa-Saleimoa	North inland route
Nuu-Faleula	North inland route
Lepale-Fasitoota	North inland route
Satuimalufilufi-Satapuala	North inland route

Savaii Island

Puapua-Samalaelu	East coastal route
Sasina-Matavai	North inland route
Tafutafoe-Falealupotai	West coastal route
Tafuaufa-Tafuatai	South inland route

The planned routes in Upolu island are located within 40 km from the capital of Apia except for an east coast area and these are all comparatively accessible. The east

coast area is about 70 km away from Apia. On the other hand, the planned routes in Savaii island are about 100 km away from Salelologa where diesel power plants are installed.

The populations along the planned routes are about 19,000 in Upolu island and about 9,200 in Savaii island. The planned routes are located in areas away from the major cities and there are only agricultural and forest industries. Owing to the limited opportunities for employment, young people in rural areas are tending to move to the capital, Apia, in search of employment. The Government of Western Samoa intends to develop small-scale industries for improving employment opportunities to prevent this tendency.

3-2 Natural Conditions

The project sites generally cover all areas of Upolu and Savaii islands.

All the islands of Western Samoa are volcanic but inactive at present. The last volcanic eruption was in 1911. The planned areas are covered by porous lava beds. The central parts of Upolu and Savaii islands are mountainous and the highest peaks are 1,116 m and 1,858 m respectively.

The geological features of the lava beds can be seen in parts of the planned line routes, especially in the north coast area of Savaii island.

The climate of Western Samoa is tropical and oceanic climate throughout the year, and the annual mean temperature is 26-27 deg. Celsius. The annual rainfall is 2,800 mm to 3,000 mm. The rainfall is distinctly divided into wet and dry seasons. The dry season with little

rainfall is from April to October and the humid season is from November to March in every year. The meteorological data are given in Appendices 3-2 "Maximum Temperature", 3-3 "Minimum Temperature", 3-4 "Gust Wind Velocity" and 3-5 "Days with Thunder".

3-3 Social Environment

Improvement of the social environment is taking place especially in the capital of Apia, but it is lagging in the rural areas. Main roads and a central crossing road on Upolu island have been paved. Other roads have been paved in the southern part of Savaii island but are not paved yet in the south coastal and inland areas of Upolu island, and in the north coastal areas of Savaii island. Overseas telephone calls and facsimile services in Apia are on direct dialing but are not available in the rural areas except at limited places such as resort hotels, etc. A water supply service system has been established in Apia and the north coast areas of Upolu island but not yet in other areas where the local people mainly depend on rain water, river and spring water even though some hamlets have some small-water supply systems. There is no sewerage system except in Apia. Septic tanks are used elsewhere.

3-4 EPC's Facilities in the Project Sites

EPC's facilities in the Project sites at present are may be summarized as follows:

Upolu Island

Tanugamanono-Siumu Distribution Line

From Tanugamanono to the center point of the line, distribution voltage of 6.6 kV is employed. It is scheduled that EPC will up grade the 6.6 kV line to 22 kV line. Important facilities such as a

satellite ground station, etc. is connected to the line.

Lotofaga-Amaile Distribution Line

There are no facilities at present. A private diesel power plant is located in the vicinity and is distributing electric power to local consumers through this line.

Saluafata-Sauniatu Distribution Line

There is a 22 kV distribution line up to Salufata

Siusega-Tanumalala Distribution Line

There is a 22 kV distribution line up to Siusega. There are no facilities beyond Siusega

Aleisa-Saleimoa, Nuu-Faleula and Lepalu-Fasituuta Lines

Saleimoa, Faleula and Fasituuta are located along the north coast adjacent to the existing 22 kV distribution lines. However, the inland areas are not yet electrified.

Satuimalufilufilu-Satapuala Distribution Line

Both Satuimalufilufilu and Satapuala are located in the coastal area and have been electrified. However, the inland areas between these areas have not yet been electrified.

Savaii Island

Puapua-Samalaelu, Sasina-Matavai and Tafutafeo-Falealupotai Distribution Lines

EPC has no facilities in these areas.

Tafuauta-Tafuatai Distribution Line

There is an existing 22 kV distribution line in Tafuauta. This will be extended under the Project.

CHAPTER 4
OUTLINE OF THE PROJECT

CHAPTER 4 OUTLINE OF THE PROJECT

4-1 Project Objective

The Gross National Product per head of Western Samoa in 1987 is presumed as US\$660 (WS\$1,300). The major industry of the country is agriculture. Industries other than agriculture are lagging and employment prospects for local people in the rural areas are poor. They tend to concentrate on Upolu island especially in Apia when seeking employment. To cope with this, the Project aims to promote economic independence of Western Samoa through (i) improvement of living conditions and (ii) settlement of the local peoples in the rural areas by improving employment opportunities by development of the industries other than the agriculture.

4-2 Examination of the Official Request

(1) Necessity and appropriateness of the Project

The Basic Design Study team has exchanged views with the officials of the Government of Western Samoa and EPC and confirmed the appropriateness of the Project as mentioned below.

- (A) The local peoples in the areas being electrified wishes to receive EPC's electric power supply which is of low cost and high reliability.
- (B) The local people living along with the planned routes are voluntarily doing tree trimming on the routes. It is thereby confirmed that the local people are enthusiastic for rural electrification.
- (C) The Government of Western Samoa took a budgetary measure for EPC's rural electrification plan in the annual budget of 1989.,

(D) It has been confirmed that EPC is capable of erection of distribution lines if the required materials route survey and detailed design are done by a Japanese Consultant.

(2) Examination of execution and operation plan

EPC's working gangs, although in principle set up for operation and maintenance of the distribution system, are now mainly employed on erection of new distribution lines because of the importance of rural electrification in unelectrified areas and because there are no skilled erection firms in Western Samoa for this type of work. After completion of the Project, the said working gangs will be entrusted for operation and maintenance works as their primary task. It is therefore judged that there will be no problems in regard to maintenance after completion of the Project as the gangs will have been involved with its execution.

(3) Examination of related and/or overlapping plans

Plans to be examined are EPC's similar program for erection of distribution lines with their own funds and other development plan with funds from foreign countries and international agencies. There are also related development plans for roads, communications systems, etc.. Their relationship to the Project is described below.

(A) EPC's plans with own funds

At the time of the Preliminary Study, the Project included about 22 km of Siumu-Lotofaga line in the south coastal area of Upolu island and about 7 km

of Safa-Vaiola line in the east coastal area of Savaii island in the grant aid.

However, it was discovered at the time of the Basic Design Study survey that EPC had already commenced erection work on these distribution lines because of strong requests from the local people and erection funds had been given by the Government and churches. These lines were therefore excluded from the grant aid application after exchanging views with EPC. Detailed reasons are given in Appendix 4-1 "Reasons for EPC Construction in Areas Previously Allocated to Japanese Aid". Further, these routes are scheduled to be completed by the EPC's erection gangs in June 1990 before the Project is commenced.

(B) Electrification plan in north coastal area of Savaii island with Italian financial assistance

The unelectrified areas remain mainly in the north coastal area of Savaii island where the objective population of about 6,000 is living and EPC was therefore keen to electrify these areas. The Government of Western Samoa therefore requested the Government of Italy for an electrification plan by construction of distribution lines and the Government of Italy promised to dispatch a consultant for survey. However, there has been no progress since then. However, EPC has been considering the use of other funds because it is strongly requested by the local people to realize electrification of this area.

The benefits of the 17 km Puapua-Samalaeulu and 25 km Matavai-Sasina lines under the Project may not

be significant without completion of the distribution lines by Italy.

However, the objective populations to receive electric power by the routes in question will be about 3,300 on the Puapua-Samalaeulu line and about 1,700 on the Matavai-Sasina line amounting to about 5,000 (including apart of objective population of electrification in the north coastal areas).

(C) The Sixth Development Plan includes:

(i) Lemafa road (distance about 22km) and Richardson road (distance about 30km) renovation plan

Apia-Faleolo road (distance about 30 km) renovation plan

Apia-Siumu road (distance about 22 km) renovation plan

Salelologa-Asau road (about 90 km) renovation plan

Each of these roads will be the routes of the Project or will be utilized for transporting distribution line materials for the Project. Therefore, after renovation, it is expected that these roads will contribute to transportation of construction materials, erection works, etc..

(ii) Development of communication system

This is an improvement plan for increasing the communication circuits of Afiamalu ground satellite station. It is scheduled that

Tanugamance-Siumu line to be constructed under the Project will supply electric power to the said satellite station.

(iii) Other development plans

The Government of Western Samoa planned to promote the following small-scale industries for the purpose of economical independence and improvement of the livelihood of the people:

- Refining of coconut oil
- Furniture and wooden goods
- Dried coconuts
- Tinned goods
- Flour milling
- Dairy products
- Electrical conductor manufacture

Detailed scales and locations are unknown. It is however expected that these will contribute development and growth of rural industries.

(4) Examination of the project contents

The following table shows the planned routes mentioned in the official request of the Government of Western Samoa, the planned routes confirmed at the time of the preliminary study and the basic design study.

(A) Transmission and distribution lines

<u>Upolu island</u>	EPC's request	Preliminary study	Basic design study	
Tanugamanono-Afulilo	50 km	-	-	#1
Tanugamanono-Siumu	12 km	]	25 km	
Sium-Lotofaga	20 km	] 49 km	excluded	#2
Lotofaga-Afulilo	8 km	]	excluded	#3

Lotofaga-Amaile	30 km	] 38 km	22 km	
Amaile-Afulilo	20 km	]	excluded	#4
Leulumoega-Siumu	40 km	48 km	excluded	#5
Siusega-Tanumalala	40 km	25 km	36 km	
Saluafata-Sauniatu	X	] 99 km	7 km	#6
Satuimalafilufi-Faleatiu	X	]	13 km	#7
Total 170 km		259 km	103 km	

<u>Savaii island</u>	EPC's request	Preliminary study	Basic design study	
Puapua-Samalaeulu	28 km	12 km	17 km	
Samalaeulu-Sasina	19 km	excluded	excluded	#8
Sasina-Matavai	X	26 km	25 km	#9
Falealupo-Avata	7 km	excluded	excluded	#10
Neiafu-Tafuafoe	6.5 km	]	15 km	
Tafuauta-Tafuatai	39 km	] 20 km	7 km	
Fusi-Viola	X	]	excluded	#11
Total	99.5 km	58 km	64 km	

(B) Substation facilities

	EPC's request	Preliminary study	Basic design study	
66kV, 12.5MVA transformer	2 sets	-	-	#12
66kV, 1MVA transformer	1 set	-	-	#12
66kV circuit breaker/protective equipment	2 sets	-	-	#12

The reasons for additions and exclusions in relation to EPC's request and at the time of both the preliminary study and Basic Design Study are as given below:

- #1 The 66kV transmission line was planned to construct from Afulilo to Tanugamanono to transmit generated power at Afulilo. It was concluded that the 66kV transmission line was excluded in the project since the Afulilo project was suspended.
- #2 Siumu-Lotofaga line was included in the plan at the time of the preliminary study (June 1989). It was however discovered that erection of the said line had already been commenced by EPC with its own funds and the said line was excluded accordingly as already explained in Section 4-2 (3) A above.
- #3 Lotofaga-Afulilo line was excluded because the said line was included as a part of the Afulilo hydroelectric project which was underway with funds from ADB, IDA and EEC.
- #4 Amaile-Afulilo line was excluded at the time of the preliminary study. At the time of the Basic Design Study, its exclusion was reconfirmed because it could not be expected to have any effect due to the small objective population.
- #5 Leulumoega-Siumu line was confirmed to be constructed by EPC with its own fund at the time of the preliminary study, and that at the time of the basic design study the said line had almost been completed.

- #6 Saluafata-Sauniatu line was added at the time of the preliminary study. According to the said study, Sauniatu had the reservoir of the existing Sauniatu power station and it was thereby confirmed that electric power was needed for the reservoir facilities and local people. The said power station supplies electric power for low voltage distribution.
- #7 Satuimalafilufilu-Faleatiu line was added at the time of the preliminary study for distributing electric power to an inland part of a north coastal area. However, following the survey, the route length of the line was reduced because it was judged to be enough to construct the line between Satuimalafilufilu and Faleatiu due to small number of consumers.
- #8 Samalaeulu-Sasina line was excluded because a line is planned to be constructed with Italian aid.
- #9 Sasina-Matavai line was added at the time of the preliminary study, at EPC's request. According to the results of the survey, the population of this section amounts to about 720. A total of 1,670 people including about 950 of the population of Sasina and Fagai will be the object of electrification. If Samalaeulu-Sasina section (objective population for electrification about 6,000) is not completed, the effects of this line will not be sufficient. However, about 1,700 people in this area will receive electric power by completion of the Sasina-Matavai line and this

line was therefore included in the Project after exchange of views.

#10 Falealupo-Avata line was excluded from the Project because there was little power demand in the areas before Avata, which could be served by another line to be constructed in Tafutafeo, west of Avata, which could be extended.

#11 Fusi-Viola line was added at the time of the preliminary study. This line was however excluded from the Project because it was confirmed that EPC would construct the said line with its own funds and contributions from local churches.

#12 66kV substation facilities were proposed to deliver electric power from Afulilo power station by 66kV transmission line. Because for the same reasons as #1, these facilities were also excluded from the Project as premature.

(5) Examination of facilities and materials requested

Major areas not electrified in Western Samoa at the end of 1989 are as summarized below:

Upolu Island South coastal hamlets, Siumu, Lotofaga, etc.

East coastal hamlets, Amaile, etc.

North-west inland areas, Aleisa, etc.

Savaii Island North coast and inland hamlets, Samalaelu, Safotu, Sasina, Letoi, Aopo, etc.

West coast, Tafutafeo, Avata, etc.

South coast, Tafuatai

There are two ways, to electrify of these areas; construction of independent generating facilities, and extension of distribution lines connected to EPC's existing power station. It is technically and economically preferable to extend the existing distribution lines near these areas since additional maintenance crews will be required if a new power station is constructed, and even if a new power station is constructed, new distribution lines will be required to be constructed for distributing electric power.

According to EPC, it has a plan to construct a 66 kV transmission line between Tanugamanono and Afulilo. However, after discussion with EPC, it was confirmed that materials for this 66 kV line should not be included in the Project because the 66 kV transmission line would not be required if Afulilo hydroelectric project is delayed. Afulilo hydroelectric project was delayed and the supports for the Tanugamano-Siumu line could be designed for future joint use with the 66 kV transmission line. Materials for service wires from low voltage trunk line to consumers were not included in the Project as confirmed at the time of the preliminary study. However, EPC requested to include watt-hour meters in the Project at the time of survey for the basic design study. It is necessary to be examined.

It is difficult to excavate holes for installing poles in Western Samoa because the geology is lava beds. It is therefore necessary to procure special percussion type equipment for excavating the lava bed and pole installation, the requests for which were also made by EPC.

(6) Basic policy of cooperation

It is judged that implementation of the Project is appropriate by the Japanese Grant Aid because the

effects and reliabilities of the Project and executing capability of Western Samoa side was confirmed and effects of the Project accorded with the system of Japanese Grant Aid. Therefore, being premised on the Japanese Grant Aid, the outline of the Project will be examined and the basic design will be carried out in the following chapters. However, as already mentioned in the foregoing chapters on "Examination of the project component" and "Examination on facilities and materials requested", it was appropriate that a part of the official request was to be revised accordingly.

4-3 Outline of the Project

(1) The executing agency and organization

An organization chart of EPC which is the executing agency of the Government of Western Samoa is as shown in Appendix 4-2 "Electric Power Corporation Organization Chart". Operation and maintenance of the project facilities after completion will be executed by maintenance gangs incorporated under the manager distribution as shown on the said organization chart. Each maintenance gang consists of a foreman, 6-8 electric technicians, and labourers when needed. Normally, two gangs operate on Upolu island and one gang on Savaii island.

(2) Contents of Grant Aid

On implementation of the Project, it is decided that, as already mentioned above, the erection works can be executed by the Western Samoa side because EPC is considered to be well able to cope with the erection work. Therefore, scope of the grant aid will be limited to procurement of the distribution line materials, route survey necessary for construction, detailed design and

part of the construction supervision by a Japanese Consultant.

(A) Materials to be procured:

- Supports, cross arms, stay wires and their accessories
- Conductors, joints, preformed grips and their accessories
- Insulators, clamps and their accessories
- Distribution transformers and its accessories
- Switchgear, lightning arresters and their accessories
- Excavation equipment (including operation guidance) and vehicles (pickup trucks, etc.)
- Distribution line construction tools
- Others

(B) Works by the Japanese Consultant:

Home works

- Detailed design of distribution lines
- Preparation of tender documents for procurement of materials
- Tendering and tender evaluation
- Comments on and approval of design drawings
- Preshipment inspection

Field works

- Preshipment inspection (third country procurement)
- Route survey and preparation of construction drawings and route maps, pole fittings, etc.
- Preparation of construction schedule

The construction supervision requested by Western Samoa has been excluded from the works of the Japanese Consultant and it is decided that EPC should undertake this itself.

(3) Project scale

As the result of site investigation by the Basic Design Study team dispatched from JICA at the official request of Western Samoa, the following are the distribution lines to be implemented under Japanese Grant Aid.

Route	22 kV line	22/LV line	LV line
<u>Upolu island</u>			
1. Tanugamanono-Siumu	16 km	9 km	3 km
2. Lotofaga-Amaile	7 km	15 km	21 km
3. Saluafata-Sauniatu	3 km	4 km	7 km
4. Siusega-Tanumalala	13 km	6 km	9 km
5. Aleisa-Saleimoa	4 km	3 km	3 km
6. Nuu-Faleula	0 km	3 km	2 km
7. Lepale-Fasitoota	4 km	3 km	3 km
8. Satuimafilufilu-Satapuala	5 km	8 km	7 km
Total of Upolu island	approx. <u>52 km</u>	approx. <u>51 km</u>	approx. <u>55 km</u>
<u>Savaii island</u>			
9. Puapua-Samalaeulu	10 km	7 km	1 km
10. Sasina-Matavai	16 km	9 km	1 km
11. Tafutafeo-Falealupotai	5 km	2 km	1 km
12. Tafuauta-Tafuatai	3 km	12 km	4 km
Total of Savaii island	approx. <u>34 km</u>	approx. <u>30 km</u>	approx. <u>7 km</u>
Grand Total	approx. <u>86 km</u>	approx. <u>81 km</u>	approx. <u>62 km</u>

The respective routes are shown in Appendix 3-1 "The Planned Distribution Lines".

(4) Outline of materials

Taking account of EPC's erection capabilities, the following criteria were adopted for selecting the materials of the Project.

- (A) Taking account of maintenance after the Project is completed, the technical specifications of the materials were adopted from the EPC's present specifications for the purpose of using the materials of the existing distribution lines or the distribution lines being constructed under the Project as spare parts.
- (B) Materials not preferred by EPC will not be employed because erection works will be done by EPC itself. However, for ease of foundation work in the lava beds, excavation equipment requested by EPC will be procured with sufficient guidance in operation and maintenance by a guidance engineer to be dispatched from the manufacturer. Detailed examination will be made in the following Chapter 5.
- (C) EPC has been procuring materials from neighboring countries such as New Zealand, Australia, etc.. In particular Australian made wooden poles have been used as supports in Western Samoa. Taking account of EPC's working capabilities and for reduction of initial cost (approx. ¥60,000,000), wooden poles will be employed as supports and will be imported from Australia.

The basic policies for selecting materials for the Project have been outlined above and the materials necessary for the Project are outlined below.

(i) Supports and their accessories

Supports 9 m
Supports 12.5 m
Supports 14 m
Crossarms
Other accessories

(ii) Insulators and their accessories

22 kV pin type insulator
22 kV strain type insulator
L.V. pin type insulator
L.V. strain type insulator
Other accessories

(iii) Conductors and their accessories

Aluminium conductor WASP (approx. 100 sq.mm)
Aluminium conductor FLY (approx. 50 sq.mm)
Insulated aluminium wire
Sleeves
Other accessories

(iv) Stays and their accessories

Steel wire for stays
Grips
Other accessories

(v) Distribution equipment

Step up transformers 6.6/22 kV, 300 kVA
Distribution transformers 22 kV/L.V., 1-phase,
15 kVA
Distribution transformers 22 kV/L.V., 1-phase,
25 kVA
Distribution transformers 22 kV/L.V., 3-phase,
50 kVA
Air break switches 22 kV, 400 A
Cutout switches
Lightning arresters

(vi) Others

Grounding copper conductors
Grounding rods

(5) Maintenance plan

Distribution facilities of both Upolu and Savaii islands after the Project is completed are given below.

Area name		Existing	Under the Project	Total
<u>Upolu island</u>	22kV	182 km	103 km	285 km
	6.6kV	73 km	Nil	73 km
	L.V.	419 km	106 km	525 km
<u>Savaii island</u>	22kV	93 km	64 km	157 km
	6.6kV	23 km	Nil	23 km
	L.V.	150 km	37 km	187 km

If two (2) maintenance gangs are stationed on Upolu island and one (1) maintenance gang on Savaii island for maintaining these distribution facilities, each gang will be responsible for maintaining about 160 km of 22 kV line and about 250 km of L.V. line, that is, about 500 m for 22 kV line and about 800 m of L.V. line per day. Because there will be much joint use of 22 kV and L.V. lines, it is judged that maintenance works will be comparatively easy.

Further, EPC anticipated a marginal profit in 1988 because its annual income was WS\$3,865,425 against expenditure of WS\$3,346,971 in the same year. Although cannot be certain to obtain the marginal profit every year, it is considered that the expenditure necessary for maintaining the facilities after the Project is

completed is covered by the profit on selling electric energy.

(6) The big cyclone

Western Samoa was visited by a big cyclone at the beginning of February 1990. The cyclone inflicted severe damage to electric and communication facilities, roads, other infrastructure and the people. As for the electric facilities, power stations and distribution lines were damaged, and the shutdown continued for a long time. According to a local newspaper, EPC will need about US\$8 million to restore the electric facilities which were damaged.

Restoration of the damaged infrastructure is heavy burden for the Government of Western Samoa and it is therefore apprehensive of insufficiency of funds for the erection works to be executed by the Western Samoa side under the Project.

CHAPTER 5
BASIC DESIGN

CHAPTER 5 BASIC DESIGN

5-1 Design Policy

EPC's capability to implement the erection works has been confirmed by the study team as mentioned in Chapter 4. It has been decided that the Government of Japan undertakes to procure the required materials/equipment and to provide assistance for route survey, detailed design and a part of the construction supervision on the distribution lines under the Project. The EPC's design conditions and standards will be used for the Project considering the capability of EPC's erection gangs for the erection work.

(1) Natural Conditions

Natural conditions such as temperatures, wind velocity, earthquake and thunder will be taken into consideration in the design of the distribution lines to allow for the worst conditions in the past records from 1941 to 1985. However, no earthquake has been recorded in the past.

(2) Conditions of the Executing Agency

The EPC's existing design conditions and line materials familiar to EPC erection gangs are assumed since the erection works will be done by EPC's own erection gangs. The electrical facilities under EPC are influenced by the design practices of New Zealand.

(3) Selection of Line Materials

It is considered that the distribution transformers to meet the demand in 1995 will be provided under the Project. Those transformers required for further power demand should be procured by EPC. Supports for the Project may be of wood, concrete or steel supports.

5-2 Review of Design Conditions

(1) Natural Conditions

In Summary:

Conditions	Records	EPC Conditions	Applied
Min. Temp.	14.7 deg.C	15 deg.C	15 deg.C
Max. Temp.	33.8 deg.C	34 deg.C	34 deg.C
Wind Velocity (Gust Wind)	80 knot (1 knot = 1,853 m/hr = 0.5147m/sec, 80 knot = 42 m/sec)	Nil	80 knot
Annual Rain Fall	-	2,800-3,000 mm	-
Ave. Humidity	-	76-82 %	-
Annual Thunder Days	-	117 days	-

The above conditions are not those usually desired for operation and maintenance of distribution lines, for instance thunder days. In addition, Western Samoa being an island country and suffers from the effects of salt contamination, especially along the sea coast. There is also frequent interruption of the system by tree branches touching the line or falling down of trees. There have been few interruptions due to lightning strikes. In all there have been 64 interruptions over 23 months (3 times per month) from August 1987 to June 1988 due to collapse of line supports, breakage of conductors, and trees along the line routes, details of which are summarized below;

Reasons	Nos. of Interruption
Collapse of supports	2
Damage to arms	3
Breakage of conductors	2
Lightning strikes	1
Vehicles strikes	4
Trees (touch/down)	52
Total	64

The reason why interruption due to lightning is so infrequent is that lightning in Western Samoa seldom strikes the ground. There are also few interruptions due to salt contamination since the wind in Western Samoa is comparatively weak and salt adhering to insulators is washed off by rain water. Accordingly no ground wire is proposed for the distribution lines, nor is any provided for the existing lines.

(2) Design Standards

The Australian "CODE FOR OVERHEAD LINE CONSTRUCTION" for the distribution lines is applied to the design of distribution facilities by EPC. The ground clearance, conductor spacing, distance from buildings etc. for the facilities under the Project are designed to conform to the said code.

(3) Other EPC Design Standards

(A) Minimum temperature for conductor: 15 deg.C

The minimum temperature recorded between 1941 and 1987 was 14.7 deg.C recorded on August 1981.

(B) Maximum temperature for conductor: 50 deg.C

The maximum temperature of a conductor is calculated from the sum of the maximum ambient temperature and the temperature rise caused by the maximum load current under operation. The maximum ambient temperature of 33.8 deg.C was recorded in January 1948, and the allowable temperature rise due to the load current is calculated to be about 16 deg. C.

(C) EDS: 18% of breaking strength of conductor

Every Day Stress (EDS) provides a kind of safety factor for the conductor and is normally kept below 20 % of breaking strength. Thus EPC's EDS of 18 % is reasonable.

(D) Wind Pressure

Pressure on conductor: 500 Pa equivalent to 51 kg/sq.m
(100 kg/sq.m in Japan)

Pressure on poles: 700 Pa equivalent to 71 kg/sq.m
(100kg/sq.m in Japan)

The wind pressures of Western Samoa differs from that of Japan because of the difference in average wind velocity of 29 m/sec (Gust pressure 42 m/sec/1.45) in Western Samoa and 40 m/sec in Japan.

The wind pressures are calculated by means of the following Japanese formula;

Basic design pressure

$$p = 1/2 \times 0.115 \times V^2 = 1/2 \times 0.115 \times 29 \times 29 = 48 \text{ kg/sq.m}$$

Where; p: Basic design pressure (kg/sq.m)

V: Wind velocity (m/sec)

Wind pressure $P = C \times p$

Where; P: Design wind pressure (kg/sq.m)

C: Pressure factor

Conductor: 1.2, Supports: 0.75

Wind pressure on conductor $P = 1.2 \times 48 = 58 \text{ kg/sq.m}$

Wind pressure on supports $P = 0.75 \times 48 = 33.75 \text{ kg/sq.m}$

<u>Wind Pressure</u>	<u>EPC's Pressure</u>	<u>Calculation Results</u>
On Conductors	500 Pa (51 kg/sq.m)	58 kg/sq.m
On Supports	700 Pa (71 kg/sq.m)	33.75 kg/sq.m

The wind pressure provision on conductors of EPC's standard pressure is slightly smaller (about 0.88) than the calculated results and that on supports is almost twice that calculated. The EPC's standard wind pressure is reasonable for the Project taking into account the planned area of conductors and supports.

(E) Safety Factor of Supports

Wooden poles: 4 (Japan 4)

Concrete poles: 2 (Japan 2)