No. 5

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

MINISTRY OF WORKS AND ENERGY

REPUBLIC OF KIRIBATI

A STUDY OF UTILIZATION OF PHOTOVOLTAICS FOR RURAL ELECTRIFICATION IN THE REPUBLIC OF KIRIBATI

EXECUTIVE SUMMARY OF FINAL REPORT

MARCH 1994

YONDEN CONSULTANTS CO., LTD.

MINISTRY OF WORKS AND ENERGY
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CONTENTS

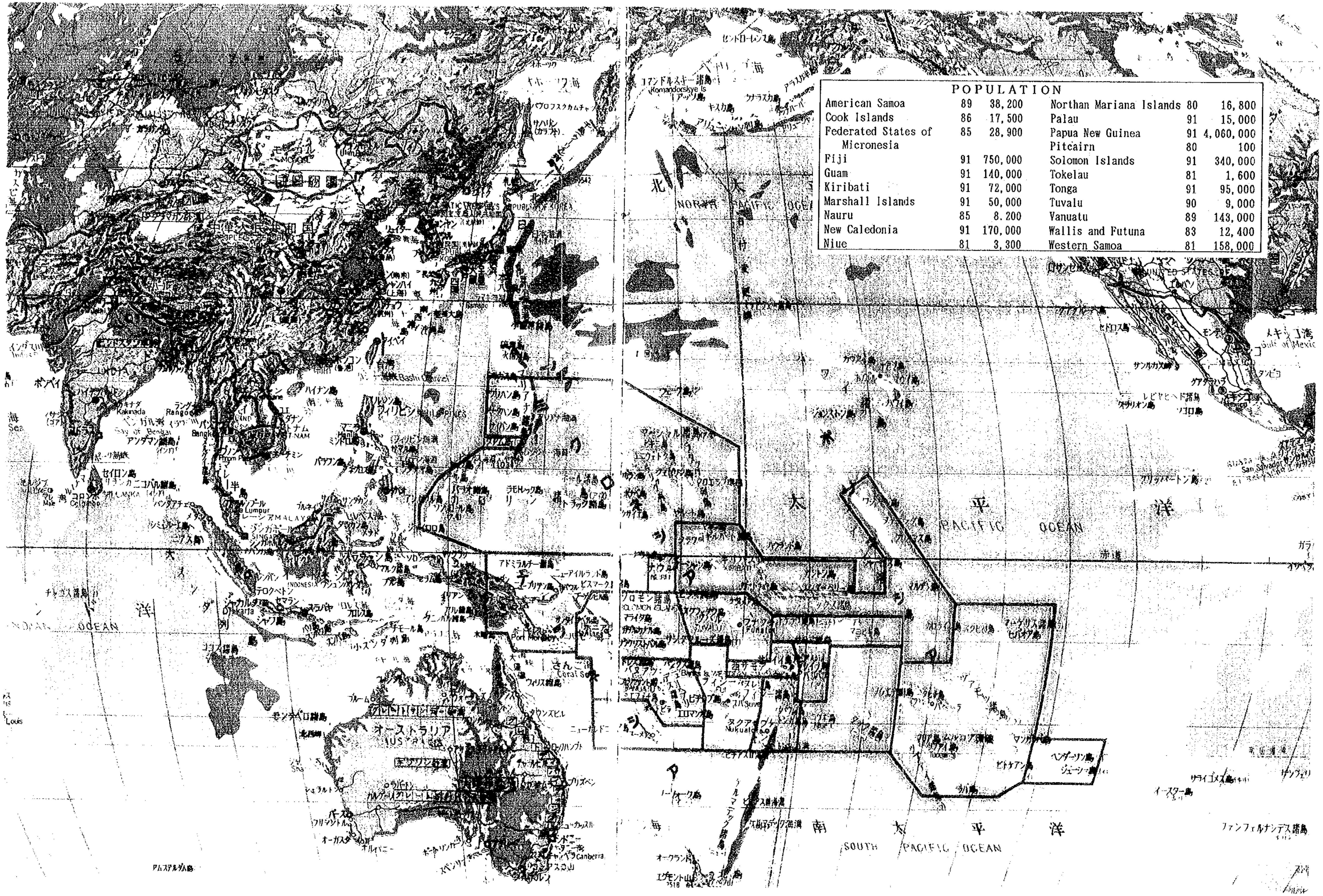
A B B R E V I A T I O N

4C	YONDEN CONSULTANTS CO Ltd.
AC	ALTERNATIVE CURRENT
AGM	ASSISTANT GENERAL MANAGER
Ah	AMPERE-HOUR
C/D	CHARGE AND DISCHARGE
DC	DIRECT CURRENT
EC	EUROPEAN COMMUNITY
EEZ	EXCLUSIVE ECONOMIC ZONE
FL	FLUORESCENT LIGHT
FOB	FREE ON BOARD
GDP	GROSS DOMESTIC PRODUCT
GNP	GROSS NATIONAL PRODUCT
HH	HOUSEHOLD
IEEJ	INSTITUTE OF ENERGY ECONOMICS, JAPAN
JICA	JAPAN INTERNATIONAL COOPERATION AGENCY
KOC	KIRIBATI OIL COMPANY
Kwh	KILO WATT-HOUR(1,000WATT-HOUR)
LED	LIGHT EMITTING DIODE
MFEP	MINISTRY OF FINANCE AND ECONOMIC PLANNING
MWE	MINISTRY OF WORKS AND ENERGY
Mwh	MEGA WATT-HOUR(1,000,000WATT-HOUR)
NEDO	NEW ENERGY AND INDUSTRIAL TECHNOLOGY DEVELOPMENT ORGANIZATION
NFB	NO-FUSE BREAKER
NPO	NATIONAL PLANNING OFFICE
O&M	OPERATIONS AND MAINTENANCE
PPM	PARTS PER MILLION
PUB	PUBLIC UTILITY BOARD
PV	PHOTOVOLTAIC(S)
RERF	REVENUE EQUALIZATION RESERVE FUND
SEC(KSEC)	SOLAR ENERGY COMPANY(KIRIBATI-)
SPMS	SOUTH PACIFIC MARINE SERVICE
TML	TE MAUTARI Ltd.
UK	UNITED KINGDOM
UNDP	UNITED NATIONS DEVELOPING PROGRAMME
VCR	VIDEO CASSETTE RECORDER
Voc	VOLTAGE OF OPEN CIRCUIT
pcs.	PIECES

TABLES & FIGURES

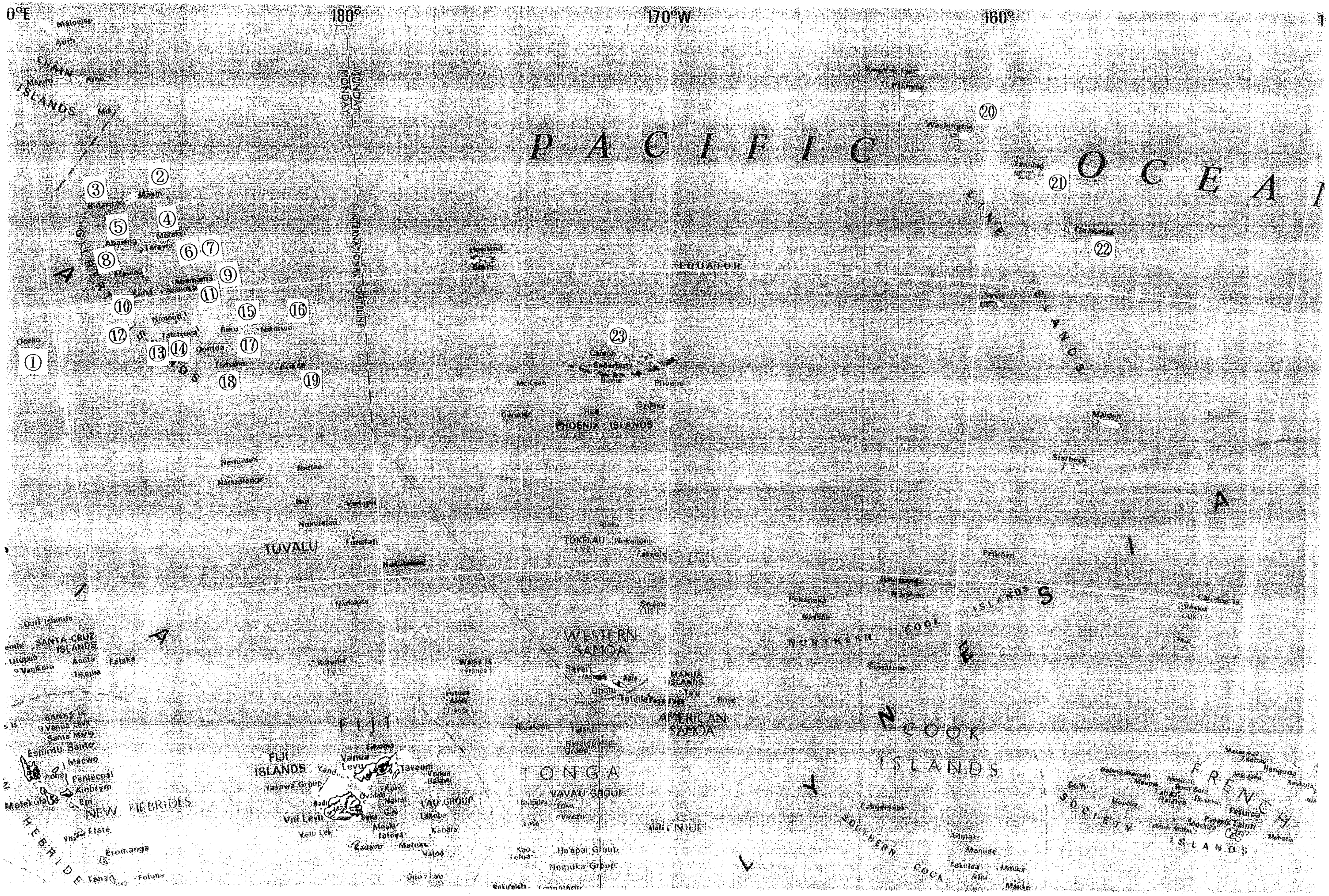
1. Figures

2. Tables



POPULATION

American Samoa	89	38,200	Northan Mariana Islands	80	16,800
Cook Islands	86	17,500	Palau	91	15,000
Federated States of Micronesia	85	28,900	Papua New Guinea	91	4,060,000
			Pitcairn	80	100
Fiji	91	750,000	Solomon Islands	91	340,000
Guam	91	140,000	Tokelau	81	1,600
Kiribati	91	72,000	Tonga	91	95,000
Marshall Islands	91	50,000	Tuvalu	90	9,000
Nauru	85	8.200	Vanuatu	89	143,000
New Caledonia	91	170,000	Wallis and Futuna	83	12,400
Niue	81	3,300	Western Samoa	81	158,000



180°
170°W
160°
P A C I F I C
O C E A
INTERNATIONAL DATE LINE
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MONDAY
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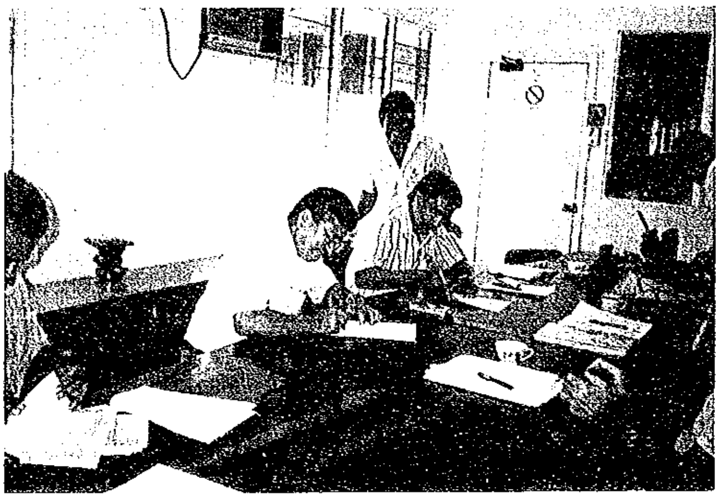
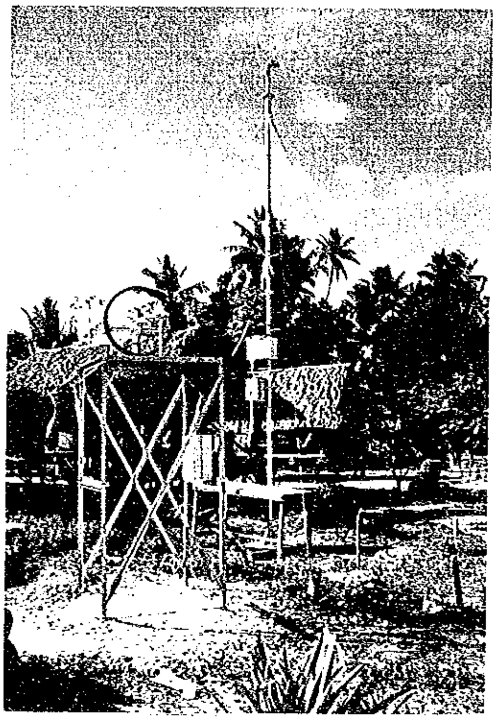
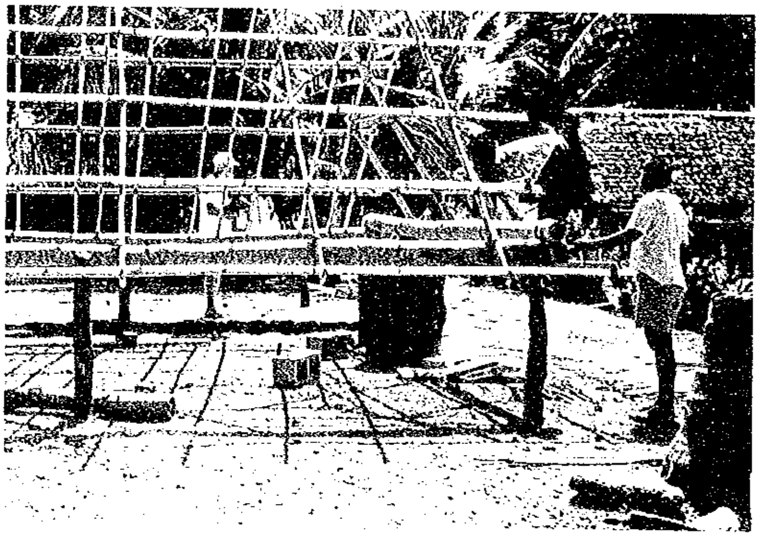
PHOENIX ISLANDS
TUVALU
TOKELAU
WESTERN SAMOA
AMERICAN SAMOA
MANUA ISLANDS
FIJI ISLANDS
Vanua Levu
Taveuni
Viti Levu
LAU GROUP
Yasawa Group
T O N G A
VAVA'U GROUP
Ha'apai Group
Nomuka Group
NIUE
N O R T H E R N
COOK ISLANDS
SOUTHERN COOK
C O O K
I S L A N D S
SANTA CRUZ ISLANDS
BANKS IS.
Espiritu Santo
Maewo
Pentecost
Ambrym
Malekula
Efate
Eromanga
NEW HEBRIDES
SOCIETY ISLANDS
FRENCH



Sign for Inception Report
March 1992

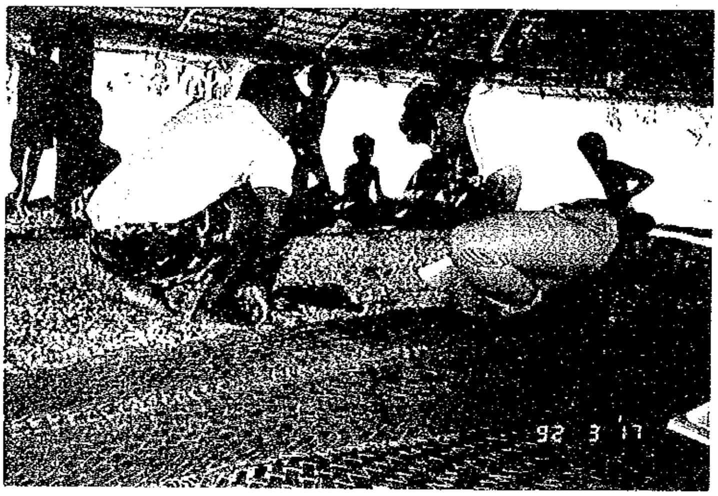


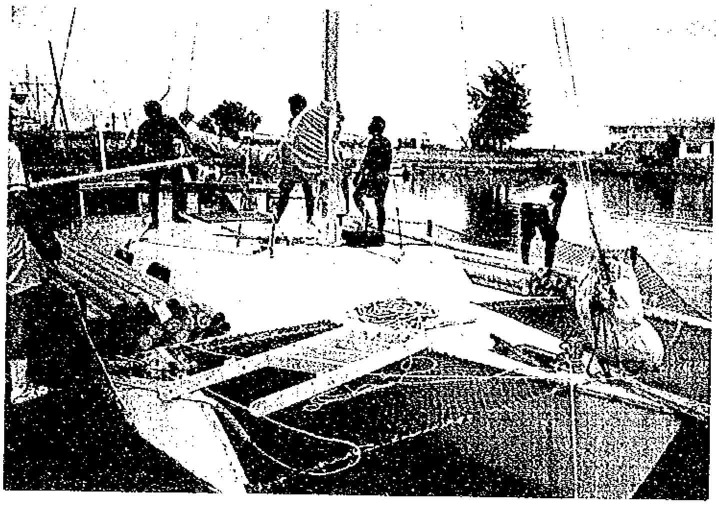
Meteorological Observation
System



Measurement for Detail Design
Size of House

Measurement for Detail Design
Luminous Intencity



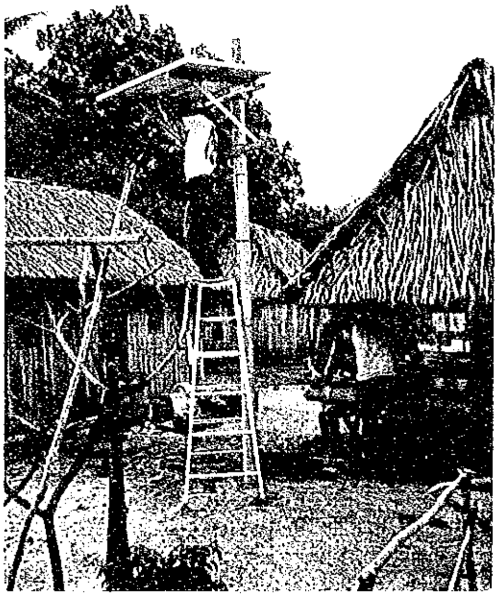


Transportation of Material
South Tarawa to North Tarawa

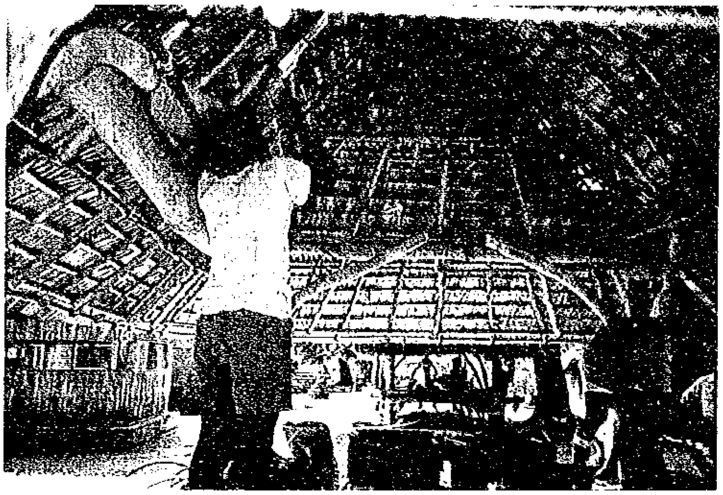
Transportation of Material
In North Tarawa

Assemble of Components

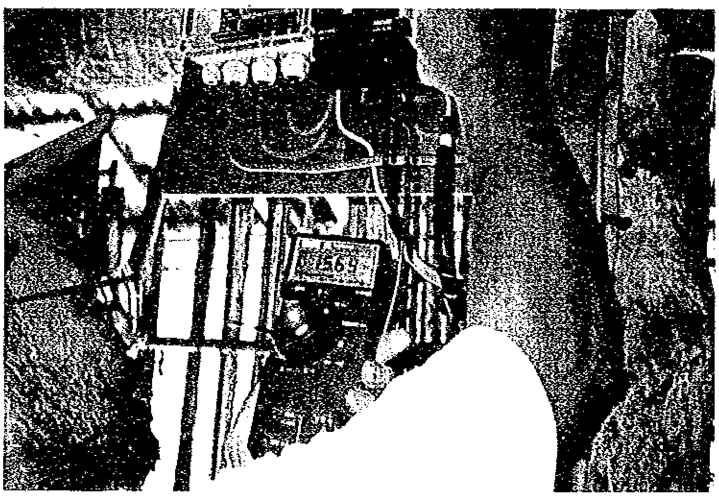
Installation of PV Module



Wiring of PV system
Outside of the House



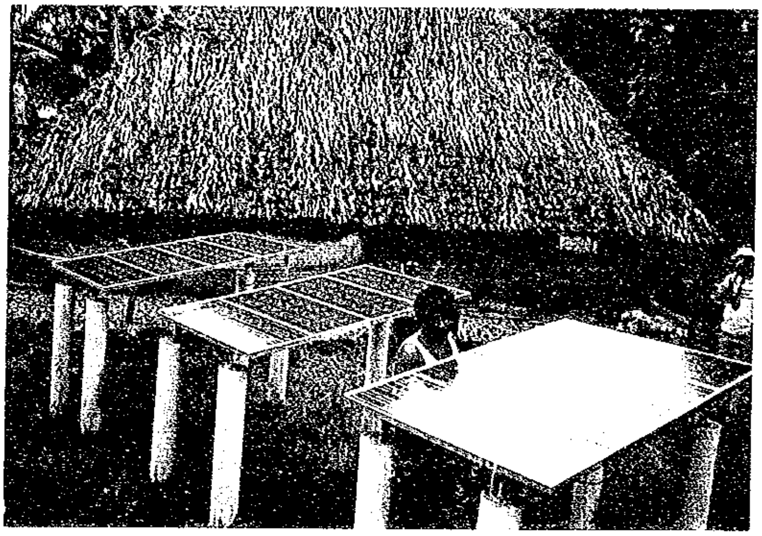
Wiring of PV system
Inside of the House



Check the system

Lighting of PV

Installed PV Panels
For Households



Installed PV Panels
For Maneaba

Night scenaries of
PV Electrified Households

Night scenaries of
PV Electrified Households

PREFACE

In response to a request from the Government of the Republic of Kiribati, the Government of Japan decided to conduct a Study of Utilization of Photovoltaics for Rural Electrification in the Republic of Kiribati and entrusted the study to the Japan International Cooperation Agency(JICA).

JICA sent to the Republic of Kiribati a study team headed by Dr.Masahide Takahashi of Yonden Consultants Co. Ltd., five times during the period from March 1992 to February 1994.

The team held discussions on the project with officials concerned of the Government of the Republic of Kiribati, installed the pilot plant of photovoltaics electricity supply systems at the study area and conducted the survey. After the team returned to Japan, further studies were made and the present report was prepared.

I hope that this report will contribute to the promotion of the rural electrification program in the Republic of Kiribati and to the enhancement of friendly relations between our two countries.

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

March 1994

Kensuke Yanagiya

Kensuke Yanagiya
President
Japan International Cooperation Agency

OUTLINE OF THE STUDY

I. Objects of the study

(1) Clear the problems in the rural electrification and the desire of people for the electrification in the rural area.
(2) Compare the PV system and Diesel generation system, suggest the plan of the rural electrification and the organizational arrangement.
(3) Install and operate the pilot plant to verify the sustainability of the rural electrification plan by the PV system.
(4) Suggest the full-scale rural electrification plan based on the experience of the pilot plan.

II.History of the study

(1) March 1988 "The study of utilization of solar energy in the South Pacific Island Country"
Conducted by Mr.Nonouti to introduce the Japanese technology on Photovoltaics for rural electrification in South Pacific Countries funded by NEDO.
(2) November 1989 Submitted "Terms of Reference for Technical Assistance of PV rural electrification" from the Republic of Kiribati.
(3) December 1989 JICA Project Formation Mission Study
Nominated three Islands for PV electrification such as:
Nonouti, Marakei, and North Tarawa
(4) March 1991 JICA Preliminary Study Mission
The place of the installation for the pilot plant was decided as in North Tarawa by the request of the Government of the Republic of Kiribati.
(5) March 1992 The main study started (Inception Report)
Yonden Consultants Co Ltd. was nominated as the main consultant.
The Institute of Energy Economics, Japan and South Pacific Institute for Renewable Energy(French Polynesia) were collaborated.
(6) June 1992 the Second Visit
Designed 55 Household and one Maneaba
Installed the Weather Observation Instruments in North Tarawa

(7) January 1993 the Third visit

Installed the Pilot Plant in six villages of North Tarawa

55 Households and One Maneaba

The Installed PV systemS are:

	Household	Maneaba
PV array	60w x 2	60w x 12
Battery	12V 100Ah x 1	24V 100Ah x 2
Light	11w FL x 1	20w FL x 4
	7w FL x 2	
	1w LED x 1	
Controller	1	2

(8) July 1993 the Fourth visit

Survey the Pilot Plant and check the institutional system for the maintenance and the fee collection, they worked well but pointed out some problems.

(9) January 1994 the Fifth visit(Final visit in the study)

Checked the Pilot Plant and discussed the result of the study. The SEC and systems were working well, and JICA handed them to the Government of the Republic of Kiribati.

III. Photovoltaics electrification in the Republic of Kiribati

(1) Installed PV system in Kiribati

Before the JICA study, there are about 280 PV systems in Gilbert Islands. Most of them are workable but not maintained satisfactorily.

(2) JICA installed 56 systems in North Tarawa and are maintaining by SEC.

(3) EC(European Community)is going to install 250 systems in Nonouti, Marakei and North Tarawa in 1994 by the fund of Lome-II.

(4) UNDP(United Nations Developing Programme) is going to install some solar pump systems in rural Islands.

Also UNDP will provide US$ one million for the PV rural electrification if the Government of Kiribati make up the plan to fit the requirement of the UNDP.

CONCLUSION

Rural electrification in the Republic of Kiribati is now being promoted in accordance with a mid-long term project concerning national energy supply measures. We have selected an electricity supply method to optimally match the requirements based on our survey conducted on the inhabitants needs as well s considering the specific living environment, such as economic status of each inhabitant, and considering the equatorial weather conditions in this specific geographic area.

The following shows an preliminary conclusion of this study.

(1) The Government of Kiribati is now planning a project for the purpose of improving the quality of the life in the rural area, by rural electrification and people in the area also strongly desire to have it.

(2) The economic data shows that the investment of the government mostly depends on the funds or aids from overseas and cash income of rural family is estimated about 2,000 to 3,000 Australian $/year/family, they will be possible to pay about 10 A$/month as the maintenance fee of electrification.

(3) The comparison of electrification systems between PV(photovoltaics) and diesel generation is concluded as the PV system is suitable for the rural electrification of low electricity consumption, scattering of users and small number of users.

(4) The organization to maintain the rural electrification system is the most important requirement to be the system is sustainable, the organization that is responsible for the rural electrification by maintains the system, trains and controls field technicians, and collects monthly the maintenance fee strictly.

(5) The evaluation of pilot plant should be continued but we had the confidence to apply the PV system as the means for the rural electrification.

(6) The proposal of expanding the rural electrification plan that based on our study is prepared as expecting the 20% of rural households will be electrified with the PV system.

1.Background of the Study

1.1 Outline of the Republic of Kiribati

(1)General Introduction

Kiribati consists of 33 islands located in the mid-Pacific, astride both the equator and the international date line in three main groups: the Gilbert, Phoenix and Line Islands. The total land area, which amounts to only 725 square km, is distributed over approximately 3.5 million square km. Most of the islands are low lying coral atolls except for Banaba, which is of lime stone origin. The geographical fragmentation of the islands, their remoteness, and their small size represent fundamental constraints to Kiribati's development.

Kiribati faces difficult challenges in the agricultural sector due to an inhospitable natural environment. Only coconuts, breadfruits, pandanus, swamp taro, papaya, bananas and pumpkins grow well in the infertile soils of Kiribati. There are no forest resources and no known exploitable mineral resources, except for the residual phosphate deposit in Banaba. The nation does, however possess abundant ocean resources, including both fish and a significant amount of manganese nodules within its 200 mile exclusive economic zone(EEZ).

Kiribati gained its independence from Britain in 1979. The I-Kiribati (native people) have a strong cultural tradition and possess an egalitarian ethic which is based on mutual help and cooperation. Kiribati's subsistence economy has been self-sufficient in the past but as urbanization proceeds Kiribati is becoming increasingly dependent on international trade to meet essential requirements.

The population of Kiribati was estimated at 68,200 in 1988 and 72,300 in 1991. Population distribution among the islands is highly skewed; South Tarawa, with only two percent of the land area, accounts for one third of the total population, implying a population density of 1,345 persons per square km. Over-crowding in South Tarawa is considered to be a serious problem and the government has launched a resettlement scheme.

Table 1.1-1 KIRIBATI: Population & Households in Islands

Name of Islands	Area (km2)	Population 1985	Population 1991	Population +/-	Households 1985	Households 1991	Households +/-
① Banaba	6	46	284	238	10	62	52
② Makin	8	1,777	1,762	- 15	287	295	8
③ Butaritai	13	3,622	3,774	152	581	633	52
④ Marakei	14	2,693	2,863	170	464	443	- 21
⑤ Abaiang	17	4,386	5,233	847	648	743	95
⑥ North Tarawa	15	3,205	3,648	443	456	551	95
⑦ South Tarawa	16	21,393	25,380	3,987	2,907	3,297	990
⑧ Maiana	17	2,141	2,180	39	353	378	25
⑨ Abemama	27	2,966	3,218	252	492	534	42
⑩ Kuria	15	1,052	990	- 62	172	187	15
⑪ Aranuka	12	984	1,002	18	173	169	- 4
⑫ Nonouti	20	2,930	2,814	- 116	534	539	5
⑬ Tabiteua North	26	3,171	3,201	30	591	586	- 5
⑭ Tabiteua South	12	1,322	1,331	9	246	250	4
⑮ Beru	18	2,702	2,909	207	521	539	18
⑯ Nikunau	19	2,061	1,994	- 67	360	369	9
⑰ Onoptoa	16	1,927	2,100	173	377	431	54
⑱ Tamana	5	1,378	1,385	7	267	263	- 4
⑲ Arorae	9	1,470	1,440	- 30	292	276	- 16
⑳ Washington	10	451	936	485	67	163	96
㉑ Fanning	34	445	1,309	864	69	244	175
㉒ Christmas	388	1,731	2,537	806	288	341	53
㉓ Canton	9	24	45	21	5	8	3
Total	726	63,877	72,335	8,458	10,160	11,301	1,141

Table 1.1-2 Social and Demographic Indicators 1988

Indicator	units	Kiribati	Asia
Population	Persons	68,207	
Growth rate	% p.a.	2.1	1.8
GDP per capita	US $	470	
Daily caloric supply	Per capita	2,935	
Crude birth rate	Per '000	37.5	26.8
Crude death rate	Per '000	14	8.8
Infant mortality rate	Per '000 births	82	
Life expectancy at birth	years	53	63.7
Population per			
-Doctor	Persons	1,967	1,422
-Hospital bed	Persons	209	--
Access to safe water			
-Urban	% population	95.0	72.5
-Rural	% population	54.0	--
School enrollment ratio	%	84.0	
Adult illiteracy rate	%	10.0	39.5

(2)Recent Economic Development

Prior to independence, growth of the Kiribati economy was closely linked to exports of phosphates from Banaba Island, whose deposits were exhausted in 1979. However the colonial administration established a Revenue Equalization Reserve Fund (RERF) in 1956 to serve as a trust fund to supplement revenues in the post-phosphate era. Notwithstanding revenues from this source, real GNP fell dramatically when phosphate deposits ran out around the end of the 1970s and had recovered to only US$15.4 million by 1987, compared to US$35.2 million in 1978.

During the 1980s, output followed a highly erratic pattern, reflecting the vagaries of weather and the vulnerability of the country's only export commodities (copra and fish) to price and environmental shocks. Stabilizing influences have been exerted over the years by a steady inflow of aid, budget grants and overseas workers' remittances together with revenues generated by the RERF. In 1988, the per capita GDP of Kiribati stood at US$470, placing it in the category of low income countries.

Available evidence on the fiscal balance of Kiribati indicates a prudent and conservative approach to public expenditure management. Current and development expenditures of the government have been guided by three main principles: (a) to avoid budgetary deficit; (b) to restrain outlays on public services to levels that could be sustained in the medium-term, and (c) to invest in the development of economic and social infrastructure as a foundation for future growth.

Kiribati's dependence on two primary exports, copra and fish, which accounted for 71.8 and 27.4 percent of merchandise exports respectively in 1988, has had important implications for the country's economic development. The sharp decline in copra prices in 1982-86 and a drought in 1984-85 significantly reduced export earnings leading to a severe deterioration in the balance of payments. To offset the fall in export earnings, the governments of UK, Canada and New Zealand assisted with projects to support copra and related production as well as other agricultural and farm products.

The fishery sector provides an important source of wage employment and fish is an important food source in the subsistence sector. In an effort to spur development of this sector, in 1981 the government established Te Mautari Ltd. (TML) in South Tarawa as a

Table 1.1-3 Selected Economic Indicators, 1985--1989

Indicators	1985	1986	1987	1988	1989Est
Production and Expenditure					
Real GDP (mil 1978 US$)	17.35	17.84	16.45	19.25	19.44
Growth Rates (% p.a.)					
-Real GDP	-6.4	2.8	-7.8	17.0	1.1
-Agriculture	-25.2	-20.7	-25.6	87.0	--
-Industry	11.8	11.2	-23.6	1.2	--
-Services	2.2	11.7	0	2.9	
Central Government Budget (% of GDP)					
Revenue	52.6	38.6	54.9	44.4	40.9
Tax Revenue	16.1	16.7	21.3	17.3	18.2
Non-tax Revenue	37.6	22.7	33.3	28.3	22.5
Expenditure					
Current	51.2	46.3	47.8	45.4	74.6
Capital	33.5	45.6	41.4	34.3	43.1
Overall balance	5.9	-9.5	5.1	-1.6	-5.3
Excluding Grants)	-32.2	-53.4	-34.6	-34.3	-39.2
Money and Prices					
Consumer Price Index (1975=100)	160.2	172.7	183.9	189.6	197.0
GDP deflators (1978=100)	168.2	179.3	191.0	196.9	204.6
Balance of Payments (mil US$)					
Exports (fob)	4.3	1.6	2.1	4.5	4.7
Imports (cif)	-15.1	-14.4	-12.6	-19.0	-22.3
Trade Balance	-10.8	-12.8	-15.5	-14.5	-17.6
Services	0.9	6.2	3.1	3.2	4.0
Private transfers (net)	0.9	1.6	2.2	2.4	2.9
Official transfers	12.5	14.8	16.4	13.2	16.5
Current Account Balance	3.5	9.8	6.2	4.3	5.8
Overall Balance	2.9	4.6	2.1	-1.2	6.3

commercial fishing company to export bulk frozen tuna. However, the initiative has encountered difficulties due to inadequate financing, management practices, technical problems and a low catch in 1987 due to bad weather.

The emergence of seaweed as a new export commodity and production output, especially in the outer islands, accounted for increased activities in marine resource development and diversified output structure of the sector between 1987---1991. Its commercialization phase was started in 1986, has gained social acceptance and secured overseas markets.

(3)Medium-Term Outlook and Prospects

Given its exceptionally narrow resource base, the economic future for Kiribati depends to a large extent on the degree to which policies can be set on a path to exploit the country's few major development assets. These include: fisheries resources, which are vast in terms of ocean area; the lightly populated Line (and possible Phoenix) Islands; and a small but highly capable workforce with overseas experience in mining operations (phosphate in Nauru), shipping and construction.

The primary source of growth in Kiribati is expected to be in the maritime area. Further development of the fisheries resource depends primarily on the introduction of new techniques to extend the range, expand the volume and increase the market value of fish caught by domestic enterprises. Kiribati should also seek greatly expanded revenues from licensing income derived from foreign fishing operations in its EEZ. Increased fishing rents depends in substantial part on Kiribati's ability to police its EEZ more effectively.

Tourism is the second major development possibility in the Line Islands. There, where people are few, land is relatively abundant and the Government wants to resettle a sizeable part of the total population, which already has a small but viable tourism trade based on sports fishing and bird-life. In addition, settlement is constrained by the prevalence of droughts that prohibit most agricultural development on that island. On the other hand, Tabueran (Fanning Island) appears to have significant potential for tourism development mainly for topographic reasons, if airport and related infrastructure can be developed.

Kiribati has a sizeable overseas labor force, including 1,070 (as of 1987) seamen serving on South Pacific Marine Service (SPMS) vessels and about 500 working for the Nauru Phosphate Company. Cash remittances from these and other external sources appear to benefit up to one-third of Kiribati households; private transfers amounted in 1988 to A$4.5 million of about A$300 (US$250) per household.

Prospects for growth in agriculture (excluding fisheries) are limited. No significant increase in copra production or exports can be expected and possibilities for export diversification are small. One notable exception is seaweed, which appears to be replacing copra production in some of the islands.

The manufacturing sector, which is in a rudimentary state, contributes merely 2.5 percent of GDP. This minor contribution underscores the heavy dependence of the economy on imports of manufacturers and the considerable scope that exits for import substitution in basic consumer items. A strategy of small scale, labor intensive manufacturing for the home market is expected to yield industrial growth of 6 percent during 1990-94 and 7 percent in 1995-99.

The potential of the service sector to generate growth and employment remained underutilized in the 1980s. The projected growth rate of 3-4 percent for services during 1990-99 is predicated upon expansion of transport and retail services and rapid growth in tourism.

(4)Strategies for Implementing the Development

Features of the plan include (a) promoting private sector participation in investment, (b) a greater emphasis on rural and outer island development through settlement and development of the Line Islands, (c) strengthening family planning activities, and (d) ensuring fiscal discipline, balance of payments stability, and limiting future debt-service liabilities. Although plan objectives and emphasis appear commendable, the challenge is to translate them into effective programs and policies. Serious deficiencies still exist in project preparation, monitoring and implementation of investment programs. The coordinating role of the National Planning Office (NPO) needs to be strengthened and further training of personnel in developing a comprehensive project monitoring system would be in order.

Table 1.1-4 Medium Term Balance of Payments, 1988--1993
(in millions of US$)

Items	1988	1989	1990	1991	1992	1993
Exports (fob)	4.5	4.7	4.6	4.7	5.0	5.1
Imports (fob)	19.0	22.3	23.2	24.2	25.5	26.8
Trade Balance	-14.5	-17.6	-18.6	-19.5	-20.5	-21.7
Services, net	3.2	4.0	2.8	3.1	3.5	3.7
Receipts	18.5	20.0	19.6	20.6	21.9	23.1
RERF Interest Receipt	9.1	9.0	8.8	9.1	9.5	9.9
Payments	15.3	16.0	16.8	17.6	18.5	19.3
Transfers, net	15.6	19.4	21.5	22.7	23.8	25.1
Private	2.4	2.9	3.3	3.6	4.0	4.4
Official	13.2	16.5	18.2	19.0	19.9	20.8
Current Balance	4.3	5.8	5.8	6.3	6.8	7.3
Capital Account	-5.5	0.5	-0.6	-0.8	-1.2	-1.4
Overall Balance	-1.2	6.3	5.1	5.4	5.6	6.0

Table 1.1-5 Medium-term Projections, 1990--1999

Items	Estimates	Projections	
	1985--89	1990--94	1995--99
Growth Rates (% per annum)			
GDP	1.9	3.3	4.5
Agriculture & Fisheries	1.5	3.5	5.0
Industry	4.0	6.0	7.0
Services	1.8	3.0	4.0
Consumption	1.0	2.5	3.0
Gross Investment	7.0	7.5	8.0
Exports	2.4	5.0	8.0
Imports	7.8	4.1	4.5
Prices	5.1	5.0	5.0
Ratio to GDP (%)			
Gross Investment	30.8	35.8	40.0
Gross Savings	53.5	--	--
Debt Service Ratio (%)	1.4	1.5	1.5

1.2 Energy Situation in Kiribati

(1) Energy Supply and Consumption

Kiribati is currently importing approximately 30 percent of her total energy, relying for the balance on indigenous biomass resources i.e. locally obtained fuelwood. From 1982 to 1991 about 10 thousand kiloliters of mineral fuel was imported. (see Table 1.2-1) About 90 percent of the imported fuels are consumed on South Tarawa while the remaining 10 percent is consumed on outer islands reflecting their different levels of development.

Biomass resources will be expected to provide the bulk of the country's energy needs for the foreseeable future. Other energy sources including solar, and in specific area wind, offer limited alternative energy sources for exploitation. These alternative may offset future dependence on imports and contribute to the overall aim of achieving the maximum degree of energy independence while providing opportunities for development primarily in the rural sector.

(2)Electricity supply and demand

At present only the capitol, South Tarawa and Kiritimati, the administrative center of for the Line and Phoenix groups have centralized power distribution systems. All other islands have small scattered populations living largely in a subsistence economy with some money activity. None of these islands have any centralized power distribution system but small diesel generators are used in some council centers, maneaba and missions or secondary schools. These are only operated for a few hours each evening, and troubles with supply of fuel can mean those generators are unable to operate. The existing Diesel generator sets in South Tarawa are shown in Table 1.2-2.

The peak demand of electricity in South Tarawa increases year by year, it records 1,350kw in 1992 February. The composition of user in 1991 January was: residential 80 percent, commercial 10 percent industrial 9 percent and the fee of electricity is: for residential 32A¢/kwh, for commercial and industrial 36A¢/kwh.

Table 1.2-1 KIRIBATI: Import of Oil Products (Kilo-liter)

Oil Products	1983	1984	1985	1986	1987	1988	1989	1990	1991
Jet fuel	1001	1017	702	1098	1555				1647
Motor spirit	1716	1954	1797	1511	1738	1883			2698
Aviation gasoline	586	550	443	413	234				402
Kerosene	644	669	660	557	888	773			875
Distillate	4122	5526	5100	5114	5277	6548			5979
Lubricant	18	123	148	147	172				109
Total	8037	9839	8850	8840	9864	9204*	7200*	9100*	11610
Imported value (mil A$)	2.52	3.09	3.24	2.24	2.67	2.96	3.20	3.69	3.63

* Excluding Jet fuel and Aviation gasoline

Fig. 1.2-1 Transportation of Oil Products

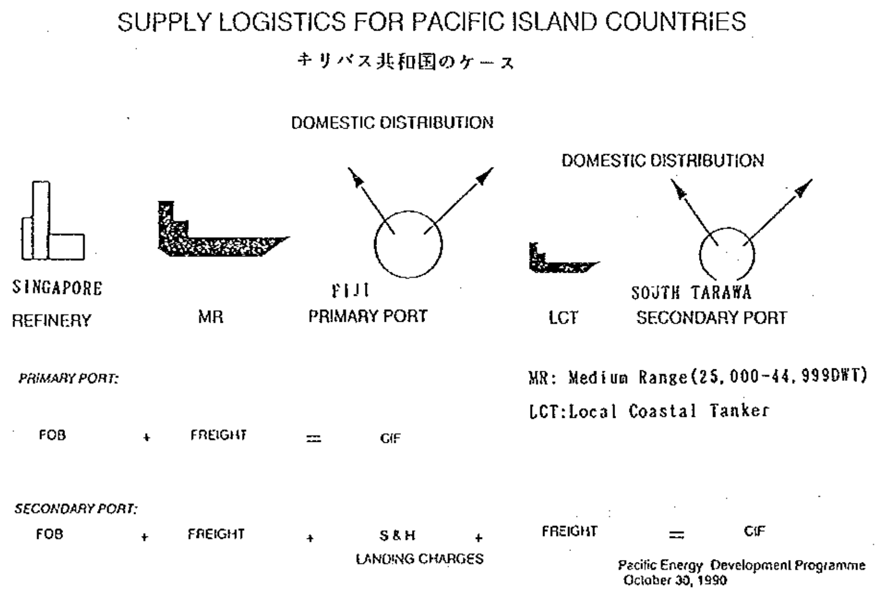
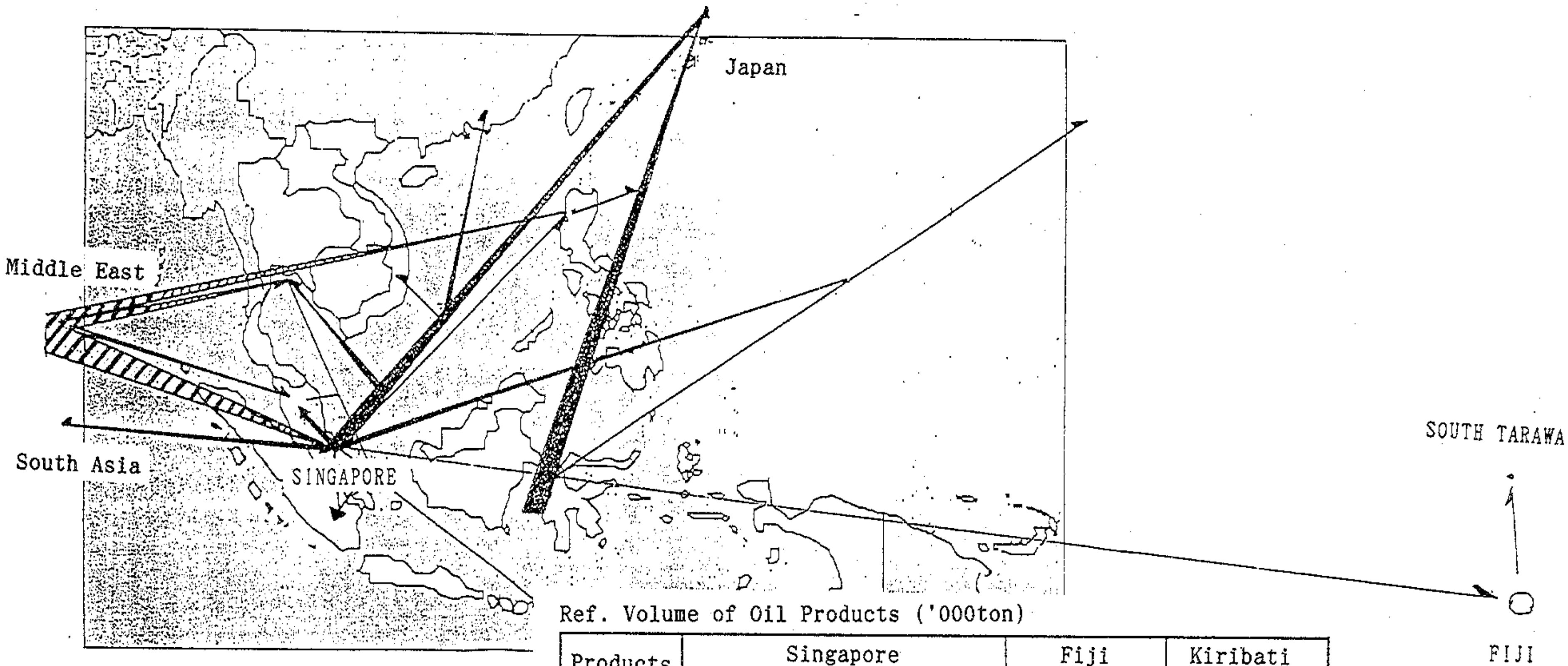


Fig. 1.2-2 Flow Scheme of Oil Products in Southeast Asia



Ref. Volume of Oil Products ('000ton)

Products	Singapore		Fiji	Kiribati
	Export	Import	Import	Import
Gasoline	4、300	2、100	75	1
Naphtha	2、700	400	—	—
Kerosene	1、100	90	37	1
Jet fuel	5、900	20	95	1
Light oil	10、900	1、200	172	5
Heavy oil	9、700	13、700	13	—

Table 1.2-2 Facilities for generation in South Tarawa

maker & Model	Rating Nominal	Rating Actual	Year of Install.	Operation H. 1987	Operation H. 1989	Actual state
English Electric (4 SRK)	300kw	260kw	1968	57,119	57,367	Working
ibid	300	260	1968			Broken down
ibid	300	260	1968	45,050	46,250	Working
ibid	300	260	1968	15,912	--	Broken down
ibid (6RK3C)	750	600	1976	45,579	56,006	Working
ibid	750	600	1976	46,265	57,851	Working
Wartsila F38	1,000	1,000	1988	--	9,900	Working

Table 1.2-3 Power Supply of PUB (South Tarawa)

Items	1983	1984	1985	1986	1987	1988	1989
Power generated (Mwh)	5,161	5,521	5,990	6,371	6,536	6,758	7,233
Power sold (Mwh)	4,103	4,333	4,554	5,056	5,342	5,759	6,026
Increse ratio (%)	--	5.6	5.1	11.0	5.7	7.8	4.6
Loss (%)	20.5	21.5	24.0	20.6	18.3	14.6	16.7

Table 1.2-4 Composition of User (Jauary 1991)

Class of Customer	Number of customer Number	%	Consumption of Power Kwh	%
Residentuial	1,937	79.5	166,954	30.9
Commercial	237	9.7	66,873	12.4
Industrial	216	8.9	272,833	50.6
Governmental	49	1.9	32,789	6.1
Total	2,436	100.0	539,449	100.0

(3)Organizations Concerned to Energy

Ministry of Works and Energy (MWE) is responsible organization for energy mater and the organizational scheme of MWE is as follows:

- MINISTER (Hon. Baitika Toum)
  - SECRETARY (Mr. Tinian Reiher)
    - SENIOR ASSISTANT SECRETARY
    - ASSISTANT SECRETARY
    - REGISTRY, ACCOUNT
    - ENERGY DIVISION (Mr. Rutete Ioteba)
    - PUBLIC WORKS DEPARTMENT (Mr. Pita Iateba)
    - ----KIRIBATI OIL COMPANY (Mr. Arintetaake Aran)
    - ----PUBLIC UTILITY BOARD (Mr. Rameka Takirua)
    - ----SOLAR ENERGY COMPANY (Mr. Terbentau Akura)

(4) Recommendation for Rural Electrification

The extent of rural electrification and technology to be used are issue to be addressed in Kiribati. Rural electrification is unlikely to be a driving force for economic development and should be viewed primarily as an important in comfort and convenience to rural households. Since the application for rural electricity in Kiribati is for home lighting and small appliance operation, the least cost method for electrification for most rural sites will be solar photovoltaics for the foreseeable future.

Kiribati has recognized the appropriateness of photovoltaics for rural electrification, as shown by the establishment of the Kiribati Solar Energy Company (KSEC) in 1984. However, the initial development of rural electrification through the sale of photovoltaic systems to users on outer islands has been a failure. Most of these systems are not working and the users do not have the skills necessary to properly install and maintain them. On the basis of this experience, the transform of KSEC from component sales to utility format with systems owned by KSEC and a fee charged customers for electrical service.

2. Selection of Project site

2.1 Selection of village

There are 23 inhabited islands in Kiribati and main items of each island are shown on Table 2.1-1. and only South Tarawa and a part of Christmas island are electrified by commercial electricity. The rest of above, 21 islands, about 150 village, about 8,000 households are unelectrified or only have their own stand alone diesel or PV as their power source or dry cells for radio/cassette.

At the beginning of the JICA project, the Kiribati government suggested three islands as the candidates for installation of PV pilot plant, they were North Tarawa, Nonouti and Marakei, then North Tarawa was decided as the Island for JICA project. The main reason was the convenience of transportation from South Tarawa as the place for pilot project.

In North Tarawa, there are 15 villages and total households is 550, population is 3,650 in 1991. The SEC and the JICA study team selected six villages to install the individual household PV system from 15 North Tarawa villages by considering the efficiency of maintenance that one field technician will be able to take care of the system without car or motorbike. The six villages installed PV systems are shown in Table 2.1-2

Table 2.1-2 Six villages installed PV system

Name of Village	Number of HH	Population	Average income(A$/HH)*
Taratai	41	195	1,938
Notoue	54	324	1,876
Abaokoro	32	218	2,165
Marenanuka	10	60	1,760
Tabonibara	43	300	3,215
Kainaba	21	150	2,033
Total	201	1,247	2,152

* from the survey in 1992

Table 2.1-1 Representative data of each Islands of Republic of Kiribati

Name of Island	Area km²	Population	Household	Number of Village	Number of Maneaba	Fish Sales 1000A$	Copla Sale 1000A$	Number of Employee	Wage income 1000A$	Remittance 1000A$	Total income 1000A$	Income/person A$
		1991	1991			1985	1985	1985				
①BANABA	6	284	62	3	0			12	32	2	34	748
②MAKIN	8	1,762	295	2	2	48	143	83	224	268	683	384
③BUTARITARI	13	3,774	633	8	6	188	228	230	621	586	1,623	448
④MARAKEI	14	2,863	443	8	7	144	222	116	313	352	1,031	383
⑤ABAIANG	17	5,233	743	18	15	127	243	241	651	368	1,389	317
⑥NORTH TARAWA	15	3,648	551	14	10	293	128	118	319	192	932	291
⑦SOUTH TARAWA	16	25,380	3,297	17	8	1,738	0	4,076	11,005	1348	14,091	659
⑧MAIANA	17	2,180	378	13	9	34	184	109	294	336	848	396
⑨ABEMAMA	27	3,218	534	8	6	235	296	185	500	378	1,409	475
⑩KURIA	15	990	187	4	3	69	133	50	135	104	441	420
⑪ARANUKA	12	1,002	169	3	2	23	330	76	205	152	710	722
⑫NONOUTI	20	2,814	539	8	6	211	225	184	497	438	1,371	468
⑬TABITEUA NORTH	26	3,201	586	12	10	54	274	157	424	292	1,044	329
⑭TABITEUA SOUTH	12	1,331	250	6	4	26	0	91	246	122	394	298
⑮BERU	18	2,909	539	9	6	147	95	162	437	270	949	351
⑯NIKUNAU	19	1,994	369	6	4	33	175	93	251	274	733	356
⑰ONOTOA	16	2,100	431	7	7	112	144	92	248	266	770	400
⑱TAMANA	5	1,385	263	3	2	20	96	79	213	166	495	359
⑲ARORAE	9	1,440	276	2	2	38	81	64	173	270	562	382
⑳WASHINGTON	10	936	163	5	2	0	68	0	0	0	68	151
㉑FANNING	34	1,309	244	8	4	0	22	107	289	20	331	744
㉒CHRISTMAS	388	2,537	341	4	4	0	23	439	1,185	26	1,234	713
㉓CANTON(KANTON)	9	45	8	1	1	0	0	5	14	4	18	729
							0		0		0	
TOTAL	726	72,335	11,301	169	120	3,542	3110	6,769	18,276	6,234	31,162	488

Average remittance/HH:2,000A$

Average wage:2,700A$/Y

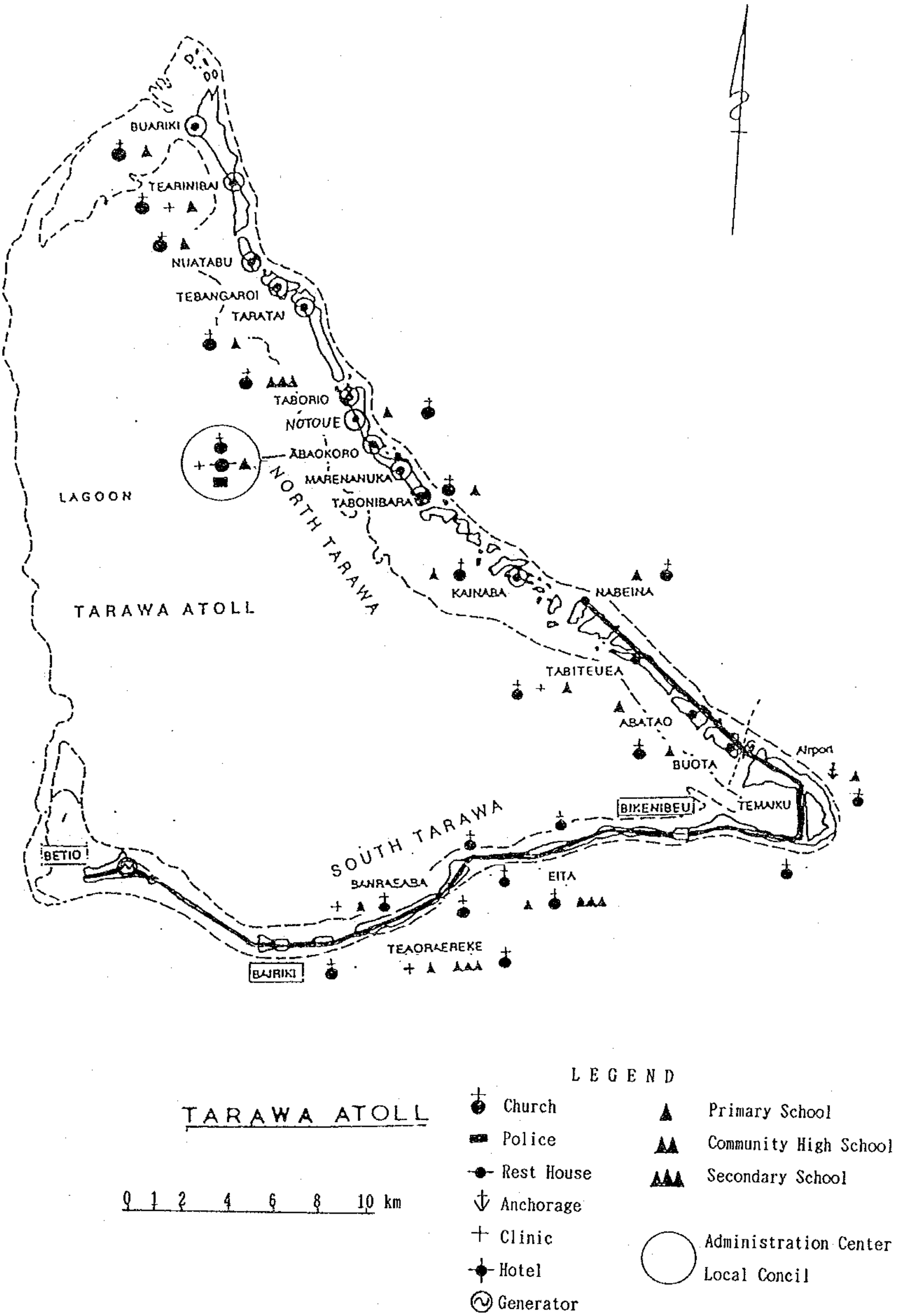


Fig 2.1-1 Villages PV electrified in North Tarawa

2.2 Selection of Household to install PV systems

The selection of household which to be installed the PV system was done by under the control of the Island president and SEC. The owners of household who expected to install the PV system in their households were informed to come to Maneaba of Abaokoro with 50 A$ as initial installing fee and listed as the candidates.

The number of candidate was less than 55 that JICA provided as the number for studying the utilization of PV system and added some official households in Abaokoro to make up 55 households. The number of household of each villages is shown in Table 2.2-1

Table 2.2-1 Number of household to be installed PV system in North Tarawa

Name of Village	Desired at July/92	Installed at Jan./93
Taratai	5	2
Notoue	12	15
Abaokoro	20	25
Marenanuka	5	3
Tabonibara	4	6
Kainaba	9	4
	(Maneaba 1)	(Maneaba 1)
Total	55	55
	(Maneaba 1)	(Maneaba 1)

3. Selection of Technology and System

3.1 Power generation in Kiribati

The domestic energy resources available in Kiribati are only biomass and renewable energies such as solar, wind, wave and ocean. The biomass energy collected in island is consumed as their cooking fuel and not enough to introduce biomass fuel power generator, the wind is also not enough strong except Christmas Island and wave power, ocean thermal power generation technologies are still under experimental state.

Otherwise the photovoltaic power generation technology has developed and proved their availability in many countries of world and South Pacific Countries are blessed with rich sunshine therefore the PV is considered as only one to compare the fossile energy base power generation method.

The most popular electric generation method in rural area that the demand of electricity is small as a few Kw to a few Mw, is a diesel or gasoline engine generator and generated electricity is distributed by transmission and distribution lines.

According to above situation, the comparison in this study is based on the photovoltaic electric generation systems and diesel generation.

3.2 Comparison of PV system and Diesel Generation system

Solar PV and diesel systems have been compared on the basis of life-cycle costs for providing the final services that the customer desires: household lighting, refrigeration, or video for a number of years. The broad components of life-cycle costs are: (i)initial and future replacement costs of customer end-use appliances;(ii)initial and future replacement costs of generation equipment;and (iii)operations and maintenance(O&M)costs.

Based on data and assumptions that appear appropriate for the Pacific Islands, the life-cycle costs of solar PV systems are lower than those of diesel systems for households in remote rural areas. The difference in overall costs is about 3-14%,with the higher savings applicable to households with low energy consumption, and lower savings applicable to households with higher energy consumption.

Table 3.2-1 Life cycle costs per customer

(1) Solar PV system:(US$)

Cost element		Lights only		Lights & TV/VCR		Lights & Refrigerator
Customer Appliance cost		265		1,208		1,784
Initial costs	(132)		(732)		(1,322)	
Future costs	(133)		(476)		(452)	
Generation Equipment cost		984		2,670		5,897
Initial costs	(741)		(2,216)		(4,436)	
Future costs	(243)		(454)		(1,461)	
Operation & Maintenance cost		137		137		137
Based on monthly cost	(1.5)		(1.5)		(1.5)	
Total cost		1,386		4,015		7,818

(2) Diesel system: (US$)

Cost element		Lights only		Lights & TV/VCR		Lights & Refrigerator
Customer Appliance cost		72		858		1,228
Initial costs	(51)		(551)		(953)	
Future costs	(21)		(307)		(275)	
Generation Equipment cost		939		2,151		2,347
Initial costs	(750)		(1,719)		(1,875)	
Future costs	(189)		(432)		(472)	
Operation & Maintenance cost		593		1,369		4,518
Based on generation cost(/KWh)	(0.65)		(0.60)		(0.55)	
Total cost		1,604		4,378		8,093

3.3 Comparison of PV system and Grid Extension System

A recent study of the costs of electrification of North Tarawa in Kiribati, between the villages of Nabeina and Buariki is provided by the Asian Development Bank. In this study the costs of 'Grid extension' and 'Stand-alone Diesel' were compared. The costs for PVs were derived from a 1990 tender for an EC-funded household PV electrification project.

The cost comparison is based on the overall resource cost of each electrification option, including the initial cost of power generating and distribution equipment, maintenance and fuel costs and household costs including wiring and the purchase of electrical appliances.

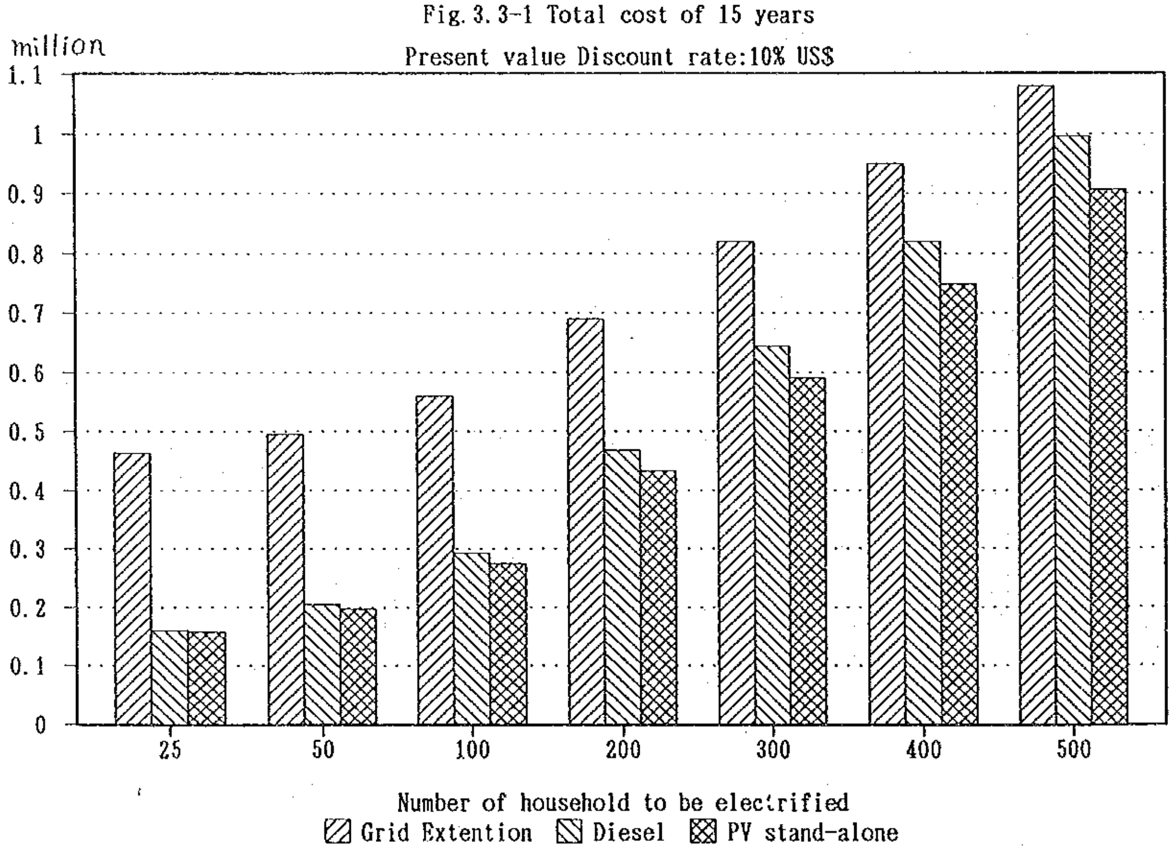
The calculation results of comparing the total present value for 15 years in each electrification method are shown in Table 3.3-1 and Fig. 3.3-1, the grid extension cost is most expensive through the electrification of 500 households (almost all households in North Tarawa).

The diesel generation and PV stand-alone cases are nearly equal at small number of electrification household in financial calculation and they are mainly varied by the cost of diesel generator and PV panels.

Table 3.3-1 Total cost(Present value: discount rate as 10%) US$

Number of Household	Grid extn.	Diesel	PV
25	462,908	160,727	157,248
50	495,340	204,645	196,703
100	560,204	292,480	275,540
200	689,932	468,150	433,215
300	819,660	643,820	590,890
400	949,388	819,490	748,564
500	1,079,116	995,160	906,239

Fig. 3. 3-1 Total cost of 15 years
Present value Discount rate:10% US$



3.4 Comparison of Stand-alone and Centralized PV system

The comparison a stand-alone PV system and a centralized PV system both serving about 60 households as capacity of demand of each household is function of calculation, based on the cost from our Kiribati project and Thailand village electrification project.

The stand-alone PV system is less costly than the centralized PV system through the electricity consumption of each household is 1,000w.

The assumption and calculation results are shown in Table 3.4-1 and Table 3.4-2.

Table 3.4-1 Assumption for Comparison (per household) US$

Item	Stand-alone(100w/HH)		Centralized(30kw/village)	
	unit cost	total cost	unit cost	total cost
PV panel	7/w	700/HH	7/w	3,500/HH
C/D Controller	2/w	200	1/w	333
Battery	0.2/Ah	240	0.2/Ah	1,232
Inverter	---	---	1/w	333
Wiring	100/HH	100	500/HH	500
Panel board	---	---	50/HH	50
Meter	---	---	50/HH	50
Total		1,240		5,998

Table 3.4-2 Comparison by Electricity demand(US$/HH)

Capacity	Stand-alone	Centralized
100 w/HH	1,240	1,680
200	2,380	2,760
300	3,520	3,840
500	5,800	5,998
700	8,080	8,160
1,000	11,500	11,400

3.5 Conclusion

Considering above comparisons, in the case of rural electrification which the main object is for lighting, the stand-alone PV system is most preferable in economic and technical(maintenance) point of view.

In the case of grid extension from Bouta to Nabeina in North Tarawa, 60% of residential household user's electricity consumption was less than 30kwh/month(<1kwh/day; 100--200w/hour).(see, Table 3.5-1)

This result shows even after electrification by grid extension, main purpose of electricity is for lighting.

Table 3.5-1 Consumption of electricity (Bouta-Nabeina Expansion)
64 Customers connected(48 residential, 15 commercial 1 industrial)

Reading(kwh/M)	Commercial		Residential	
*	Number	%	Number	%
0-- 10	6	12.2	31	21.7
11-- 20	8	16.3	32	22.4
21-- 30	1	2.0	23	16.1
31-- 40	4	8.2	8	5.6
41-- 50	6	12.2	9	6.3
51--100	8	16.3	19	13.3
101--200	12	24.5	15	10.5
201--300	2	4.1	3	2.1
301--500	1	2.0	2	1.4
501--	1	2.0	1	0.7
Average monthly consumption	97.8kwh/M			54.3kwh/M

* Reading of December '92, January '93, March '93, May '93

4. Detail Design and Determination of Specification

4.1 Meteorological Data

A survey and analysis of meteorological data(Solar Radiation, Temperature, and Humidity) has been made for the 7 years from 1980 to 1986 on the island of Tarawa of the Republic of Kiribati. These results are shown as follows.

(a) Quantity of Solar Radiation:

In the above mentioned 7 years, the average quantity of daily solar radiation was 5.69(KWh/m²/day), which is about twice as high as Japanese conditions. About 60% of the days had radiation 6(KWh/m²/day).

(b) Atmospheric Temperature:

The daytime range of temperature peaks sharply at 28 to 30℃.

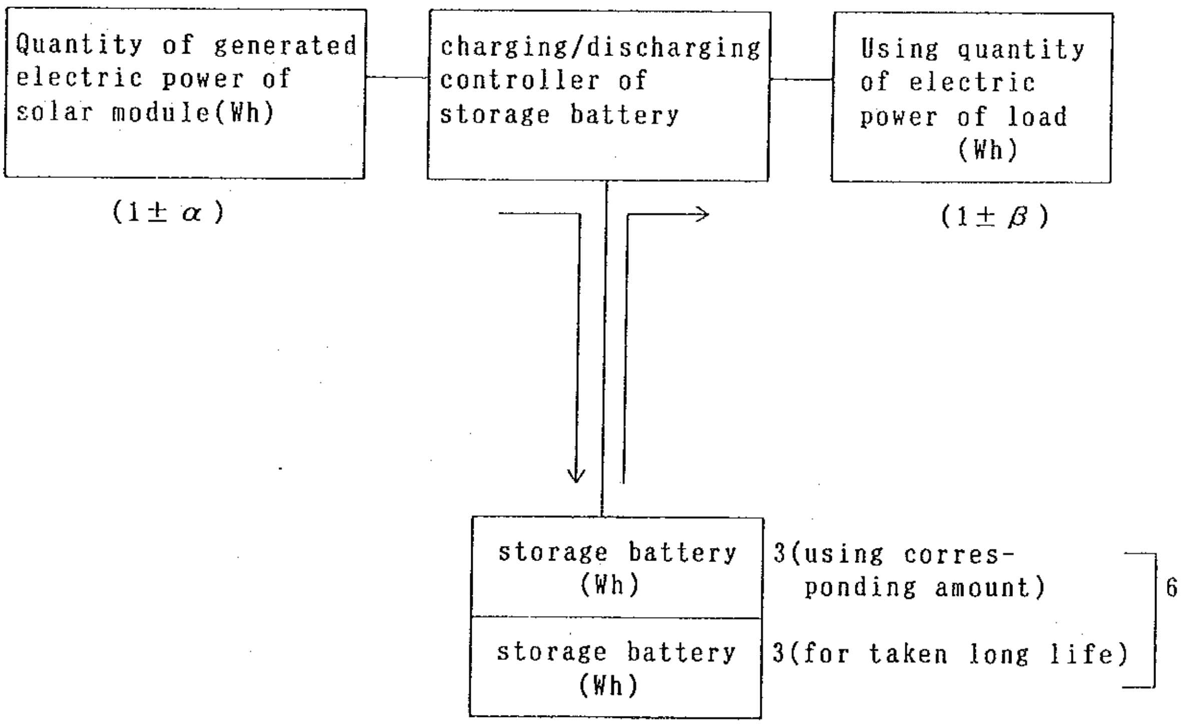
(c) Humidity:

During the daytime, the range of values of relative humidity also peaked 72 to 82%.

4.2 Design for the PV system

For design concepts, fundamentally, the design of a PV system must result in a balance between the generation of electricity from the solar modules and the use of electricity at the load. Additionally, for best results the battery should not be discharged more than 50% of its capacity and 50% should be sufficient for about three days of electricity use.

A block diagram showing these relationships is shown below.



The result is that the quantity of electrical energy used per day is nearly equal the yearly average of generated electricity each day. In a practical sense, there are days with higher and days with lower than the average level of solar radiation($\pm\alpha$). Also the actual use of electric energy is not the same each day as it is determined by the time of turning on and off the lamps($\pm\beta$). The PV system actually operates with an energy balance based on the use conditions and the solar radiation conditions.

A battery with a total capacity twice the average use is chosen because of the longer life for the battery that results. Additionally, the solar radiation as measured in Kiribati was used to simulate the electric energy generation capability of this system and the charge/discharge rate of the battery.

The results showed a very stable solar radiation quantity throughout the year and additional battery capacity was not considered necessary.

The illumination at the guest house ranged from 20~100lux and a general target for the design was set at 100lux.

Specifications for the solar modules, storage battery, distribution board and wiring materials need to take into consideration the difficult environmental conditions such as ambient temperature and salt in the North Tarawa environment.

Specifically, equipment and wiring needs to be tightly sealed or coated. Where steel is used, it needs to be hot dip plated with zinc and brass or stainless steel used where practical.

4.3 Design as Executed

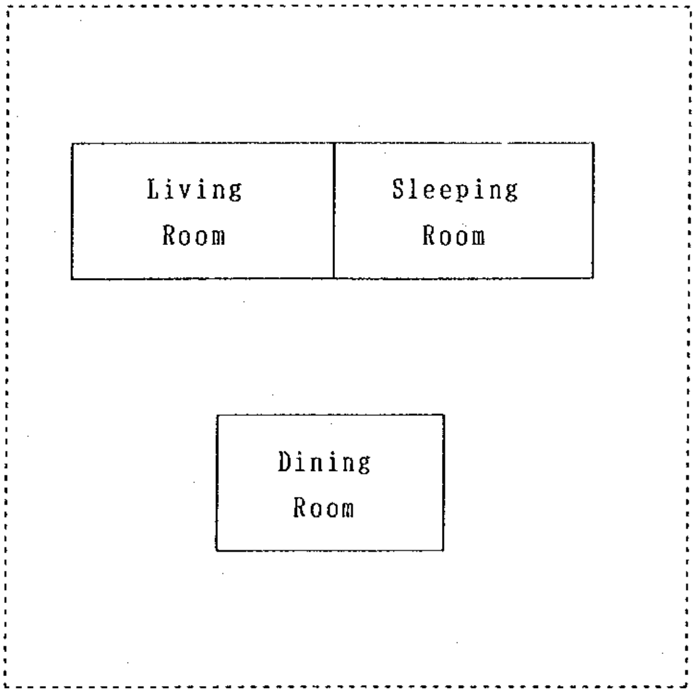
(a)Lamps

Table 4.1-1 Lamps in design

	Location	Number and size of lamp
Houses (12V)	Living room	11W×1, 1W×1
	Sleeping room	7W×1
	Dining room	7W×1
Maneaba (24V)	Hall of Maneaba	20W×4

(b)Room Arrangement of a Typical House

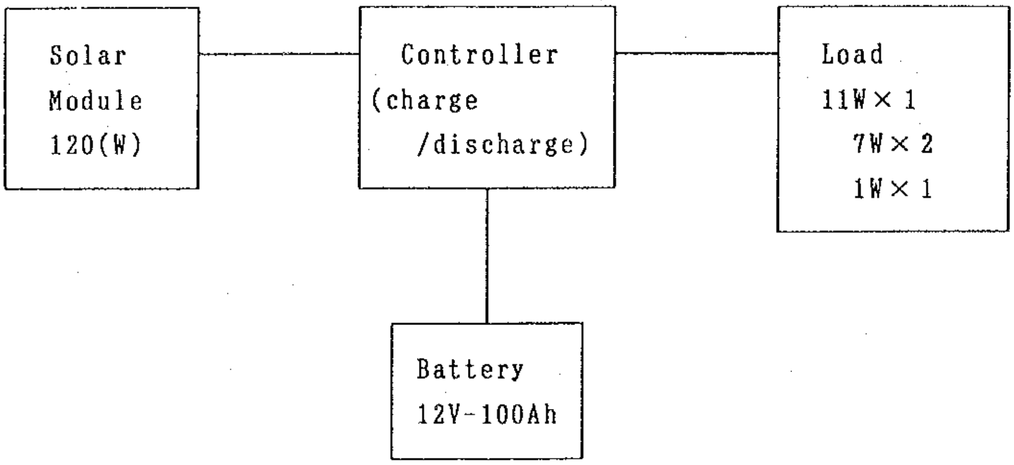
Fig.4.3-1 Room arrangement of general house



The system composition of general house and maneaba is shown as follow.

(a)General House

Fig. 4.3-2 System composition of General House



(b)Maneaba

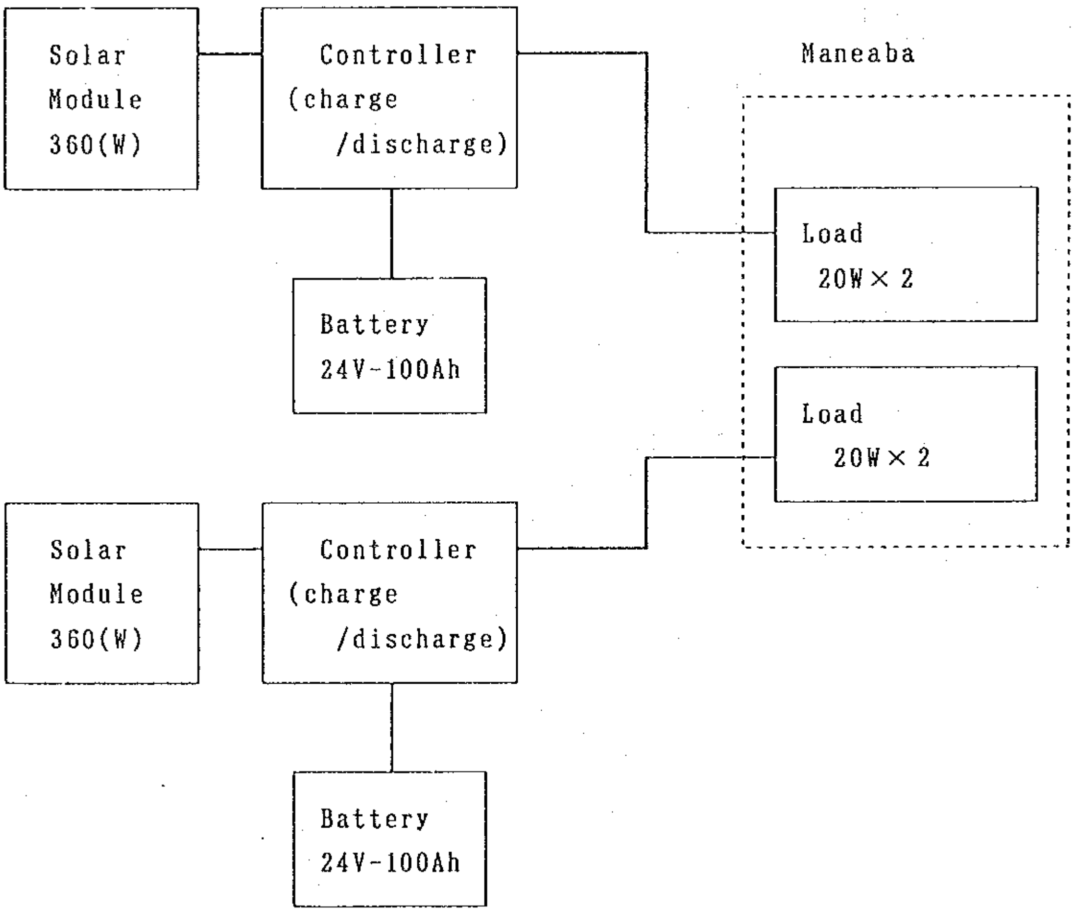
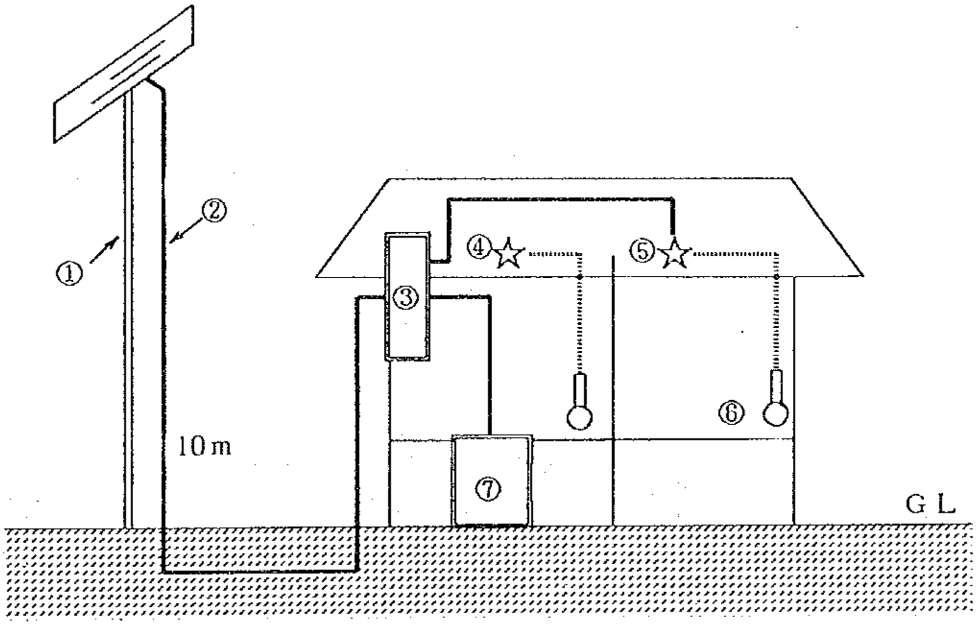


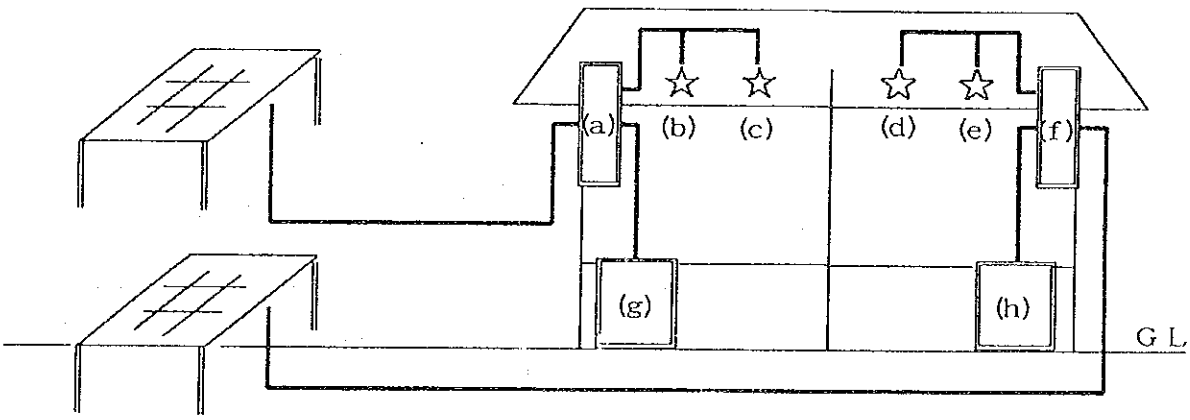
Fig. 4.3-3 System composition of Maneaba

Fig. 4.3-4 The Image for General House



①Pole ②Electric wiring ③Controller/Distribution panel ④Fluorescent lamp ⑤Fluorescent lamp ⑥Switch ⑦Storage battery

Fig 4.3-5 Image for Maneaba



(a)Distribution panel (b)Fluorescent lamp
(c)Fluorescent lamp (d)Fluorescent lamp
(e)Fluorescent lamp (f)Distribution panel
(g)Storage battery (g)Storage battery

4.4 Equipment and Material

Using the results of the site survey carried out in June 1992, the quantity of materials and equipment necessary were calculated after designing the wiring for each house.

The materials and equipment are devided into those locally procured and those procured from Japan.

Table 4.4-1 Required Quantity of Equipment and Materials as Internal Procurement

Item	Specification	Unit	Quantity
Solar Module	Monocrystal type 63.0[W]	pcs.	80
Solar Module	Polycrystal type 58.7[W]	pcs.	50
Pole mount (L=5[m]) for General House	Mount for two pieces of module	pcs.	55
Dead-end Pole	L=5.0[m]	pcs.	6
Above-ground mount for Maneaba	Mount for 4 pieces of module	set	3
Controller for Maneaba	DC24[V],300[W]	set	3
Controller for General House	DC12[V],100[W]	set	57
Storage battery	Vent type,DC12[V] 110[Ah](0.01C)	pcs.	63

4.5 Changes in between the Planned and Executed Design and their Causes

Between the time of the design survey and the installation, several changes took place.

- ·Cancellation and change of applicants
- ·A change in the applicant's place of residence
- ·A change in the environmental condition (interior layout, trees etc.)
- ·A change in the applicant's wishes which occurred after seeing the actual equipment.

During the construction based on the initial plans, we discussed the location of all components again with the customer and then located the components according to the customer's requests.

Through this experience, we learned that before planning for component locations the customers need to be aware of the actual equipment and consideration must be given to changes in environment, etc.

The following Table shows the details of how houses changed from the original survey to the actual installation as classified by villages.

Table 4.5-1 Number of Change in Houses in Each Village

Name of Village	Number of House (actual)	Number of House (planned)	Type of Change in house		
			Increase (from plan)	Decrease (from plan)	Difference (from plan)
Taratai	2	5	1	4	- 3
Notoue	15	12	5	2	+ 3
Abaokoro	25	20	8	3	+ 5
Marenanuka	3	5	0	2	- 2
Tabonibara	6	4	3	1	+ 2
Kainaba	4	9	0	5	- 5
Total	55	55	+ 17	- 17	0

(1)Reason for Change:

As explained by the SEC,

*Contract money (A$50) was not provided.

*Monthly payment was not continued.

For these financial reasons, some applicants decided not to install a PV system though at the time of the initial survey they requested a system.

·A survey was made to determine the changed reason for changing the location of the system components by sampling 26 houses out of the 36 houses of users requesting a change.

Table 4.5-2 Number of Changed Location

Reason of change	Number of change
Place of residence itself etc.	13
Furniture placement, Interior changes, Changes of trees etc.	5
Householder's demands	8

(2) The elders and villagers of Kainaba Village stated that:

The Maneaba is a place used jointly by many villagers, and it is best that the lamp switch be near to the area to be illuminated so it is easily controlled by the persons using the light.

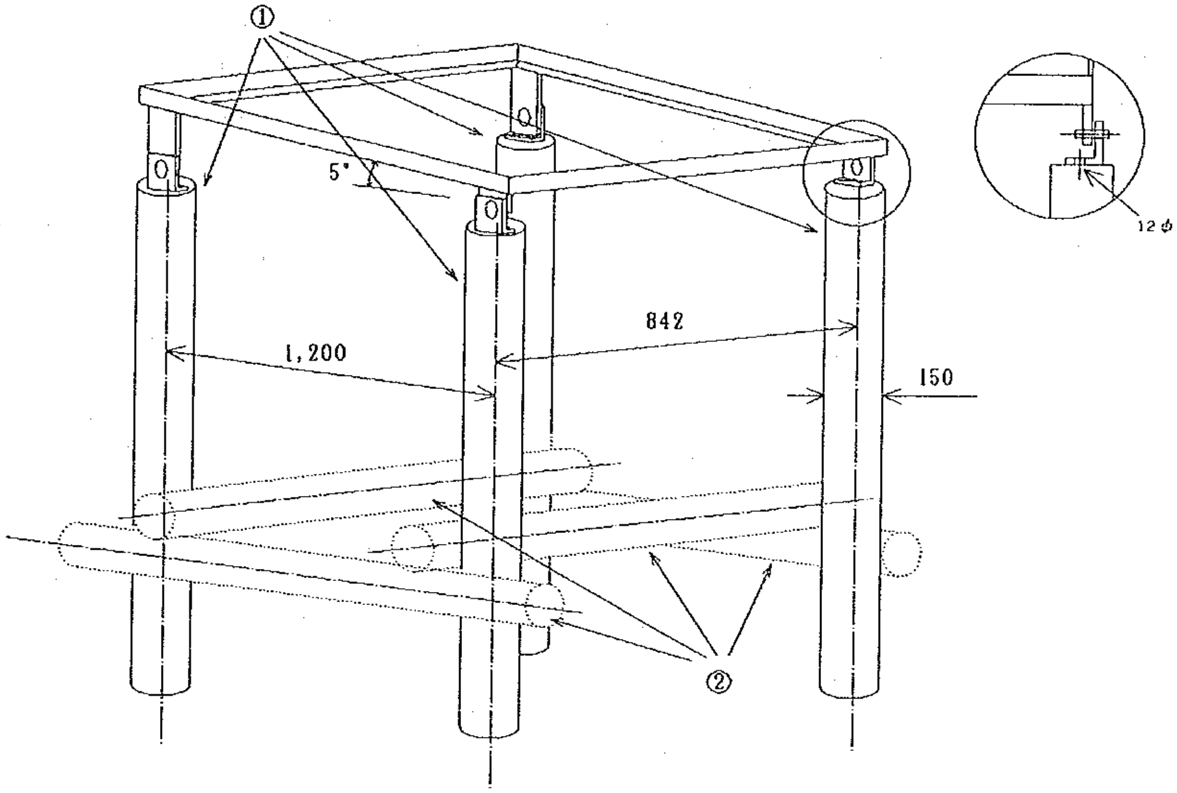
Based on this request, the initially planned "3-way circuit" having two switches controlling each lamp was changed to four lamp circuits each with 1 fluorescent lamp and switch.

·Changes in the method of mounting the modules:

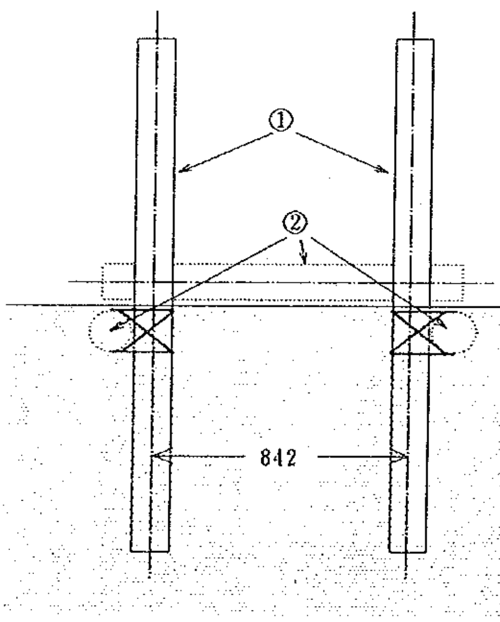
The original plan of using coconut logs to support the modules was changed to PVC pipe filled with concrete because of problems with rotting of the wood.

Also the post holes were dug with a mechanical digger and the planned beam between the posts was not needed so each post has an independent foundation.

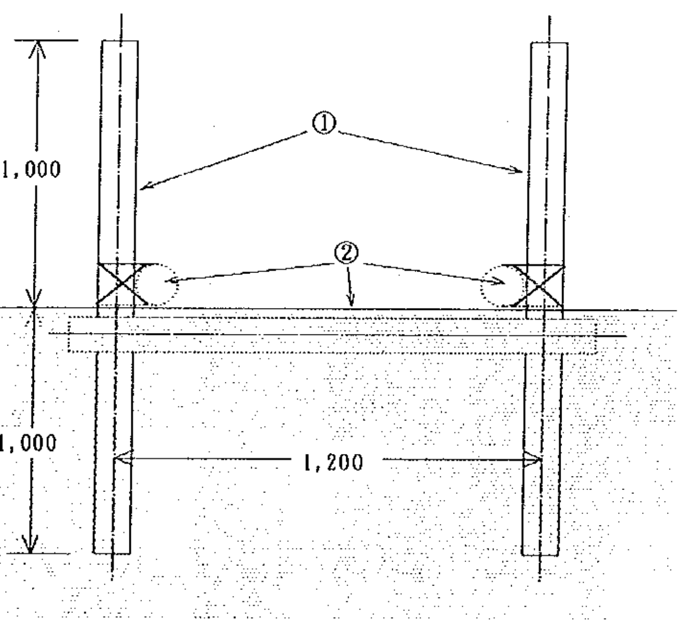
CUBIC FIGURE



FRONT FIGURE



SIDE FIGURE



①:Vinyl Chloride Pipe(concrete filled)

②:Not Provided

The Detail of Structure

4.6 Installation of Meteorological Observation System

This observation system has been sited on North Tarawa in the Republic of Kiribati

(a)Installation Date : June, 1992

(b)Installation Site : To the side of government branch office Abaokoro, North Tarawa

(c)Recording Method : Data recorded every 10 min.

Site is shown as follow.

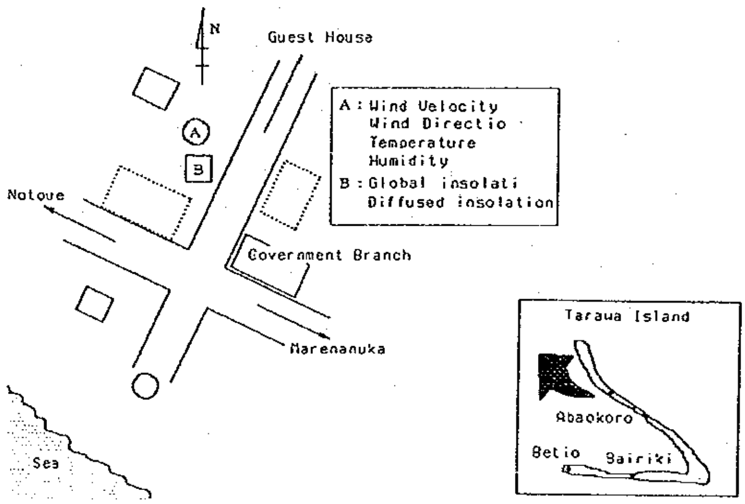
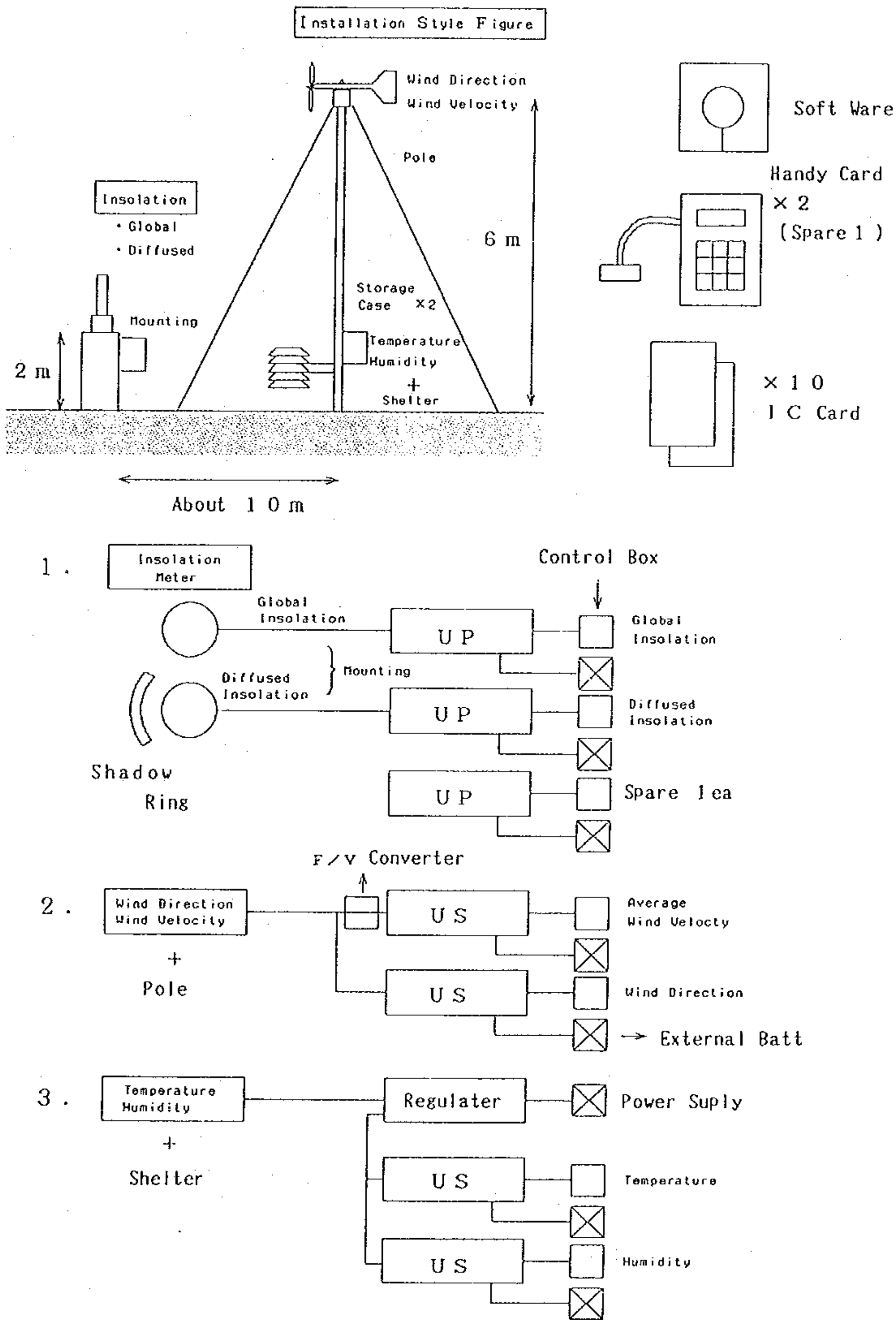


Fig 4.6-1 Site of Meteorological Observation System

Table 4.6-1 Parameters measured by meteorological observation system

Instrument	Remarks
Wind Direction Wind Velocity Temperature Humidity Global Isolation Diffused Isolation	In Kiribati, it is inevitable to find shading from coconut trees so a measure of diffuse radiation is needed to allow estimation of the effect of shade on solar power generation. Records of the level of diffuse solar radiation are not available in Kiribati.

Fig.4.6-2 The State of Meteorological Observation Equipment



5. Installation of PV System

(1) Assemble works of parts

a. Assemble of night light(1w)

Number: 60

Assembled by SEC

b. Assemble of control board

Number: for Maneaba(24V) 2

for household(12V) 55

Assembled by SEC and Study team

c. Assemble of fluorescent light

Number: 20w(24V) for Maneaba 4

11w(12V) for household 55

7w(12V) for household 110

Assembled by SEC and Study team

(2) Installation of Systems in each villages

PV systems were installed after assembling of some compartment at SEC office in South Tarawa and transported to North Tarawa, the installation schedule is shown on Table 5.2-1.

(3) Learning from the installation works

a. Transportation

The means of transportation from South Tarawa to the place of installation should have surveyed at the pre survey study and have to be arranged before the installation team arrived.

The material should be packed in the size and weight that can be handled by less than two workers.

The four wheel driven truck was very convenient and useful in this study.

the transportation was much affected by the state of tide so the tide table was an important information for this study.

b. Procurement of local material

The fluorescent lamps were purchased in local but the distinction of fittings of 12V type and 24V type was not clear that they were mixed and after installation some were obliged to be replaced by SEC staff and the study team.

There are shops dealing electric parts, wiring kits and tools in South

Tarawa but the quality is not enough such as so salty atmosphere or hard use.

Coconut rope(string) was very useful for fixing or binding cables and light fittings.

c. Installation

The ground is sand or coral rock that was difficult to dig a narrow deep hole for installing the PV panel/pole using simple tool and the level of underground water was about 80cm to one meter below ground surface.

It was difficult to get the gravel washed by fresh water so the strength of concrete mixed with such gravel should be less than normal one.

Some of lumber used for the columns and beams of houses were very hard that screw nail was hardly fixed by handy screw driver.

d. Technicians and Workers

They were good workers through the all installation period, the study team was satisfied their work.

For the technicians, they had a keen interest in the technology of the PV system and learned the know-how of installing the PV system that should be applied for succeeding EC PV project.

Table 5. -1 Installation schedule of the PV system

P: Installation of PV panel/pole
W: Wiring of PV system

Date	Name of villages Abaokoro	Notoue	Taratai	Marenanuka	Tabonibara	Kainaba
Jan.14	P					
15	P W					
16	P					
17						
18						
19	W	P				
20	W	P	P			
21	W			P		
22	W				P	
23						
24						
25						
26	W					
27	w	W				
28		W				
29		W				
30		W	W			
31						
Feb. 1				W	W	
2					W	
3						P W
4						P W
5						W

Number of PV system installed

	Abaokoro	Notoue	Taratai	Marenanuka	Tabonibara	Kainaba
Household	25	15	2	3	6	4
Maneaba						1

6.Maintenance and Fund Collection

6.1 Maintenance and Training

6.1.1 Training for SEC Personnel

The training for Kiribati's technical management personnel in Japan has been carried out on the following schedule.

(a)Schedule as a Series of 「A Study on Utilization of Rural Electrification in Republic of Kiribati」

Training executing plan

Person trained : Mr.Terubentau Akura

Training Schedule : Following Table

Training Schedule (by Yonden Consultants(4C) 1992)

No	Date	Week Day	Training Items	Lodging Site	Person in charge
11	Sept.30	Wed	Moving Tokyo/Takamatsu Visit Kanden Rokko Island	Takamatsu	IEEJ /4C
12	Oct.1	Thur	Salutation 4C, Shikoku Research Ins Seeing Central Power Supply Commanding Station (10:30--11:30)		
13	Oct.2	Fri	Seeing Sakaide Thermal Power Plant (10:00--12:00)	Takamatsu	
14	Oct.3	Sat	Data Arrangement	Takamatsu	
15	Oct.4	Sun	Seeing Saijo Photovoltaic Power Plant	Saijo	
16	Oct.5	Mon	Seeing Saijo Thermal Power Plant and Honkawa Hydro PS	Matsuyama	
17	Oct.6	Tue	Seeing Ikata Nuclear PS	Takamatsu	
18	Oct.7	Wed	Practice : Electric Work Inc KK Shinsei Densetsu Co.,LTD	Takamatsu	
19	Oct.8	Thur	Practice	Takamatsu	
20	Oct.9	Fri	Practice	Takamatsu	
21	Oct.10	Sat	Data Arrangement	Takamatsu	
22	Oct.11	Sun	Data Arrangement	Takamatsu	

23	Oct.12	Mon	Practice : Electric Work Inc	Takamatsu	
24	Oct.13	Tue	Practice	Takamatsu	
25	Oct.14	Wed	Practice	Takamatsu	
26	Oct.15	Thur	Lecture, PVSystem Designing	Takamatsuso	4C/
27	Oct.16	Fri	Moving: Takamatsu/Tokyo	Tokyo	IEEJ

KK Shinsei Densetsu Ind.

President Otohachi SATO, Vice Manager of Takamatsu Electric Work Union

Address : 2-21, 3chome, Matsushima-cho, Takamatsu City

TEL 0878-31-7691 Employees : 9 members

(b)Items for Practice at KK Shinsei Densetsu Ind.

①Schedule controlling from order-receiving to execution

②Schedule controlling for operations and workers

③Inventory control methods

④Product-ordering methods

⑤Corresponding with the clients

⑥Corresponding with the suppliers

⑦Fee-requesting method

⑧Fee-collecting method

(c)Training in Japan for Installation Work

The training is intended to cover the local tasks in installation of the solar electric systems as in [A Study on Utilization of Rural Electrification in Republic of Kiribati], and also, it is intended to improve the efficiency of the local work by training in the use of tools for the installation.

①Performing Time : Oct. 15, 1992

②Site : Bicycle-Placing site in Shikoku Research Institute.

③Participants of the Training

Takahashi, Semba, Hashizaki(4C), Tani(IEEJ), Takagishi,Yagi(Shoseki) Akura(Kiribati)

④Training Items

Simulation is made of the constitution of local coconut-trees(trunk), and the following items are checked.

- Check of the components and tools
- Check of the materials and suitability
- Training for the mounting of components, distribution panels and cables.

6.1.2 Technical Training for Local Operator

Local operator training was provided in construction, maintenance and inspection methods through the following practical works.

(a)Contents of technical training on construction

1)Solar Module Array

·Assembling and installation method for the pole mount for a house and the above-ground mount for a Maneaba.

2)Switchboard

·Mounting the charging-discharging controller, NFB, main switch and protective device.

·Terminal treatment and method of wiring between each component.

·Actuating and handling method for the charging-discharging controller, NFB, main switch and protective device.

3)Storage Battery

·Handling method for storage battery electrolyte and electrolyte filling apparatus.

·Method of electrolyte filling and level ascertainment.

4)Electrical Equipment

·Mounting and wiring method for each component.

5)Interior and Outdoor Wiring

·Suitable use and method to use with each wiring material.

·Terminal treatment method and wiring using cable.

·Design and actual wiring method for 3way and single-cut type switches.

6)General Matters for Other Work

·Suitable method of use for general tools.

·Suitable place of use for materials.

·Work safety and custody method for materials and tools.

(b)Contents of Technical Direction on Maintenance of the Equipment and Inspection (observation) Method

Regarding maintenance of the equipment and inspection method, training for the local operator was directed with regard to the following.

·A periodic inspection should be done.

·Suitable measure should be carried out when defects were found during the inspection.

·When it is impossible for the local operator to take proper measures, he must immediately contact the SEC's technicians.

The items to be checked during each inspection are as follows

1)Solar Module Array

·To check for damage to the solar modules and looseness in their mounting.

2)Switchboard

·To check for looseness in the mounting of the charge-discharge controller, NFB, main switch and protective device.

·To check for loose connections at each component.

3)Storage Battery

·To check liquid level and refill as needed.

·To visually inspect(To check and see whether or not there is a deformation or dirt on the main body of the storage battery.)

·To check and see whether or not connections are loose.

·Carry out equalizing overcharging when scheduled.

·Other matters as required by the battery as installed.

4)Electrical Equipment

·To check for loose connection at the fluorescent light.

·To check for proper operation of the fluorescent lamp.

·To check for proper operation of 3way and single-cut type switches.

5)Interior and Outdoor Wiring

·To check for damage to cables and wiring materials.

·To check for an unauthorized change in the house.

·To clarify the system operation policy of the SEC.

6.1.3 Maintenance Direction for the SEC's Technician at the Site

(a)Direction at the Site

The technicians of the SEC were instructed using the construction and maintenance procedure which was prepared in Japan, in order to instruct the local operator in the construction and maintenance of the PV system.

These items are shown in following Table.

Table 6.1-1 Items of Measures and Execution

Items	Contents of Measures and Execution
Patrol	·The state of the solar module and shade. ·The state of the lighting equipment and a check to see whether there have been unauthorized changes in the house wires or not. ·The level of liquid in the storage battery. ·The condition of the lighting equipment.

Inspection and Replacement	·Measure the terminal voltage of the solar module and the storage battery. (To check the state of system operation.) ·Refilling cells of the storage battery with water. ·Execution of equalizing overcharging.(To do over-charging with current less than 10A to 120[%] for the whole capacity of the storage battery at one month intervals.) ·Replacement of the storage battery.(If it is properly used, replacement will be done five years later as scheduled.) ·Replacement of damaged lighting equipment.
The Others	·User education on the importance of the restriction of unnecessary energy use. (Saving electricity) ·Consultation on electricity. ·Fee collection.

(b)Additional Direction from Japan

The storage batteries which have been provided as spare parts at the site, must be kept charged and the SEC's technician was requested to charge the storage battery by the following method to maximize its life.

6.1.4 Check List for Maintenance

The study team has recommended to use the check list as below:

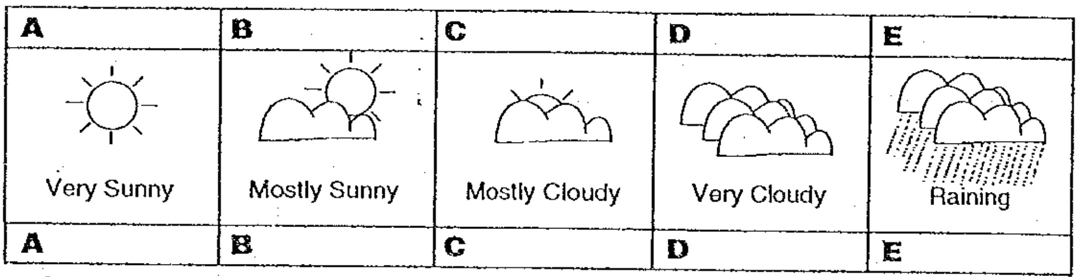
1 Location ______________________________

2 Date of Visit: ___/___/___

3 Time of Visit: ______________

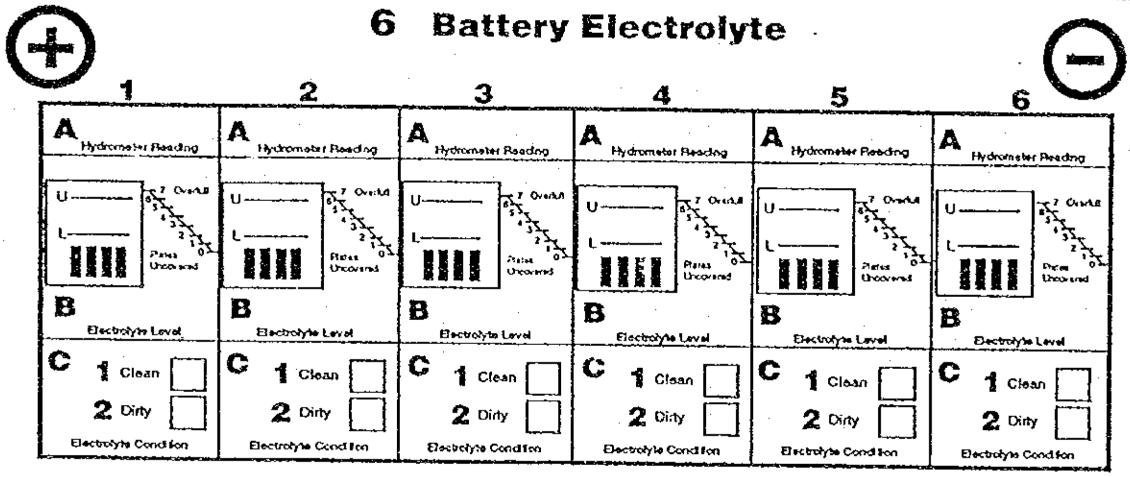
Weather

4 Weather At The Time of the Visit:



5 Average Weather for the Day Before The Visit:

6 Battery Electrolyte



7 VOLTAGE READINGS

A Battery (at the Controller, appliances OFF) ______ V

B Panel (at the Controller, applainces OFF) ______ V

C Load (at the Controller, appliances OFF) ______ V

D At the Battery Posts (appliances OFF) ______ V

E At the Battery Posts (appliances ON) ______ V

8 PANEL SHADE

A No shade

B Half or less shade

C More than half shade

D Fully Shaded

E Cloudy, can't tell

9 RECEIPT FOR SERVICE

Signature of Person Receiving Service ______________________________

Printed Name of Person Signing as Recipient of Service ______________________________

6.2 Funds Collection

(1) Delinquent Payment

As of July 1993 twelve of the North Tarawa users were delinquent more than two months. It is clear that this is a time of testing of the willingness of the SEC to actually perform disconnects for non-payment.

When the technician arrived to actually make disconnections, all but five made payments on the spot. The process used for disconnection was to remove the fuse and in most cases, remove the PL bulbs, but if the fixtures are turned on without a bulb for more than a few seconds, the electronic ballast may be destroyed and strong overcharge causes rapid loss of water of batteries.

The best method of disconnection for one to two months is to disconnect the battery and lock the battery box, and after two months of disconnection and further non-payment, the battery should be reconnected, charged and again disconnected in preparation for moving to another user location.

In December 1993, according to the report of SEC, fees of February to July were 100% collected and from August to October about 30% are delayed.

(2) Funds management

The SEC learned that the family of the field technician who is in charge of maintenance of the system and collecting the monthly payment on North Tarawa "borrowed" the moneys from the collected funds.

The approach recommended is to use a locked cash box with the key held only by the Island Council Treasurer and the SEC in South Tarawa. The money along with the SEC copy of the receipt would be placed in an envelope and slid through a slot in the cash box in the presence of the user. Then after the days collections, the box would be taken to the Island Council Treasurer for deposit of the money and forwarding of the receipts to South Tarawa.

The system, of course, requires the cooperation of the Island Council Treasurer, who would hold the box key and this cooperation will need to obtained immediately. also, users will need to be informed of the need to provide payment in exact amounts and that they should require a receipt personally witness the insertion of the money and copy of the receipt into the cash box.