JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

THE REPUBLIC OF MALDIVES
MALDIVES ELECTRICITY BOARD (MEB)

BASIC DESIGN STUDY REPORT
ON
ATOLL ISLAND ELECTRIFICATION PROJECT
IN
THE REPUBLIC OF MALDIVES

JANUARY 1994

YACHIYO ENGINEERING CO., LTD.

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PREFACE

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

JICA sent to the Maldives a study team headed by Mr. Yuji Ogura, Grant Aid Division, Economic Cooperation Bureau, Ministry of Foreign Affairs and constituted by members of Yachiyo Engineering Co., Ltd., from August 19th to September 17th, 1993.

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

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

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

January, 1994

Kensuke Yanagiya

Kensuke Yanagiya
President
Japan International Cooperation Agency

January, 1994

Mr. Kensuke Yanagiya
President
Japan International Cooperation Agency
Tokyo, Japan

Letter of Transmittal

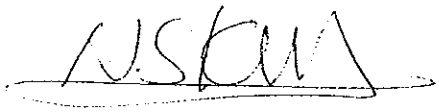
We are pleased to submit to you the Basic Design Study Report on Atoll Island Electrification Project in the Republic of the Maldives.

This study was conducted by Yachiyo Engineering Co., Ltd. under a contract to JICA, during the period August 16th, 1993 to January 31st, 1994. In conducting the study, we have examined the feasibility and rationale of the Project with due consideration to the present situation of the Maldives and have formulated the most appropriate basic design for the Project under Japan's grant aid scheme.

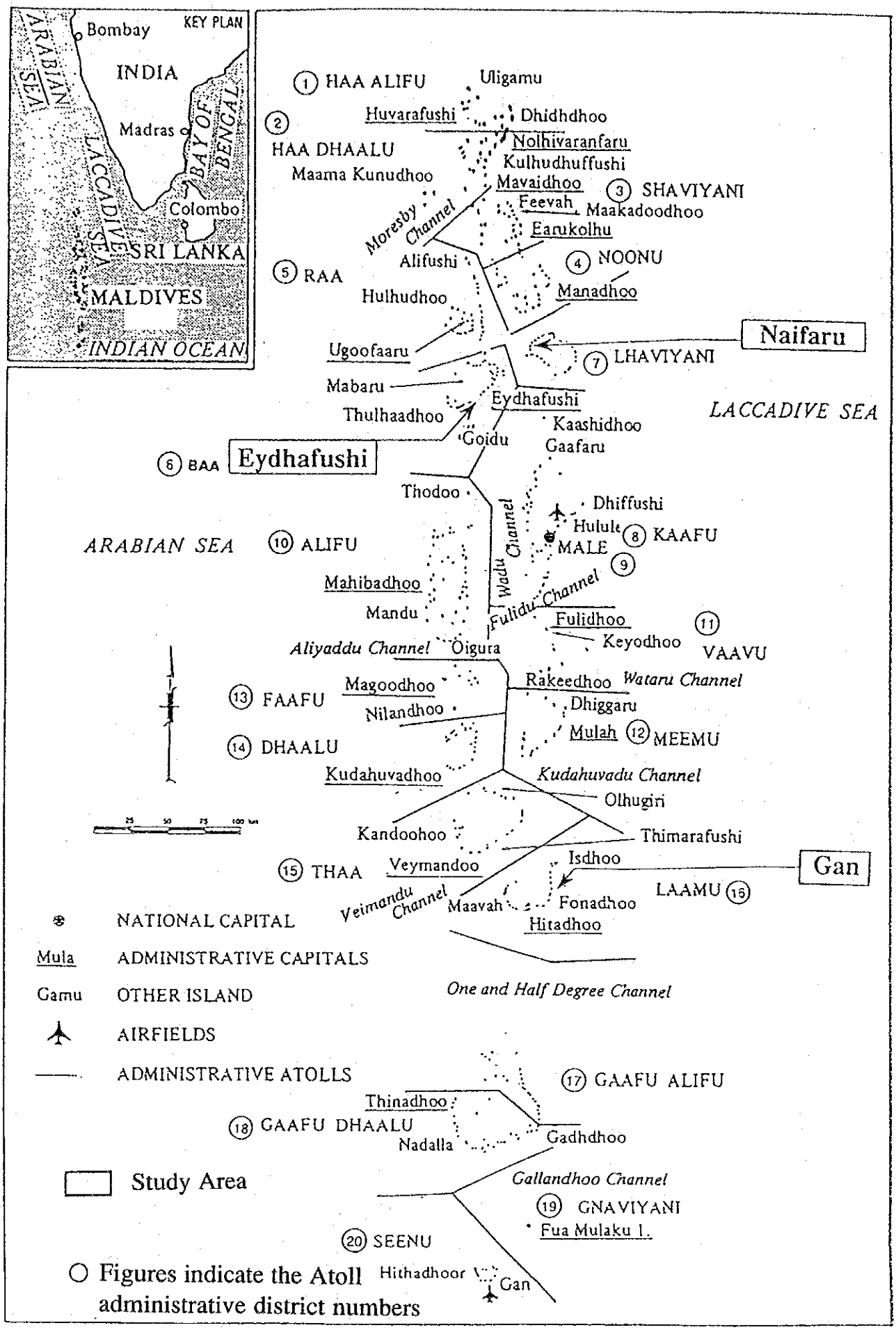
We wish to take this opportunity to express our sincere gratitude to the officials concerned of JICA, the Ministry of Foreign Affairs and the Ministry of International Trade and Industry. We also wish to express our gratitude to the officials concerned of the Ministry of Foreign Affairs of the Government of the Maldives, the Maldives Electricity Board, JICA Sri Lanka Office and the Embassy of Japan in Sri Lanka for their close cooperation and assistance throughout our field survey.

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

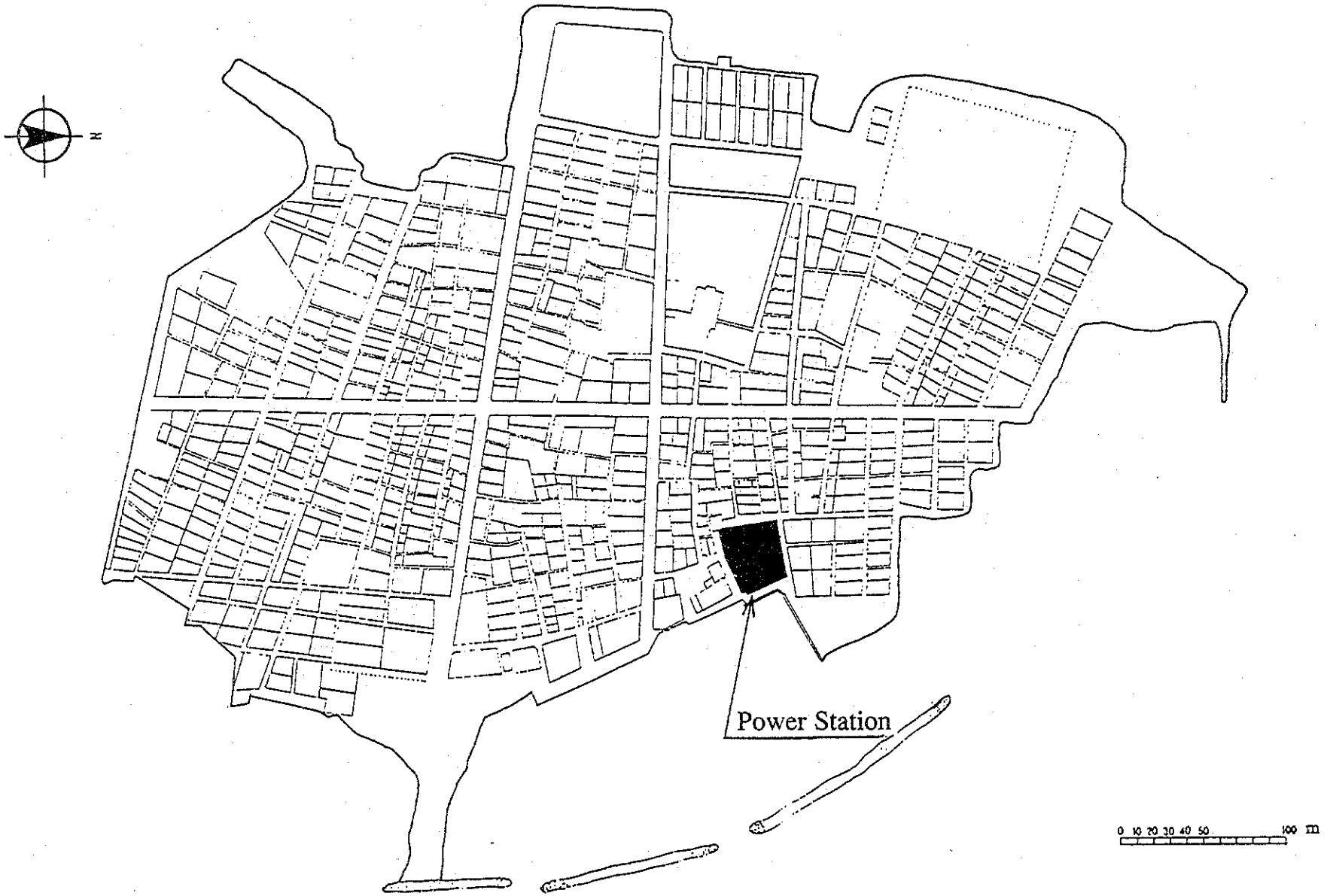
Very truly yours,



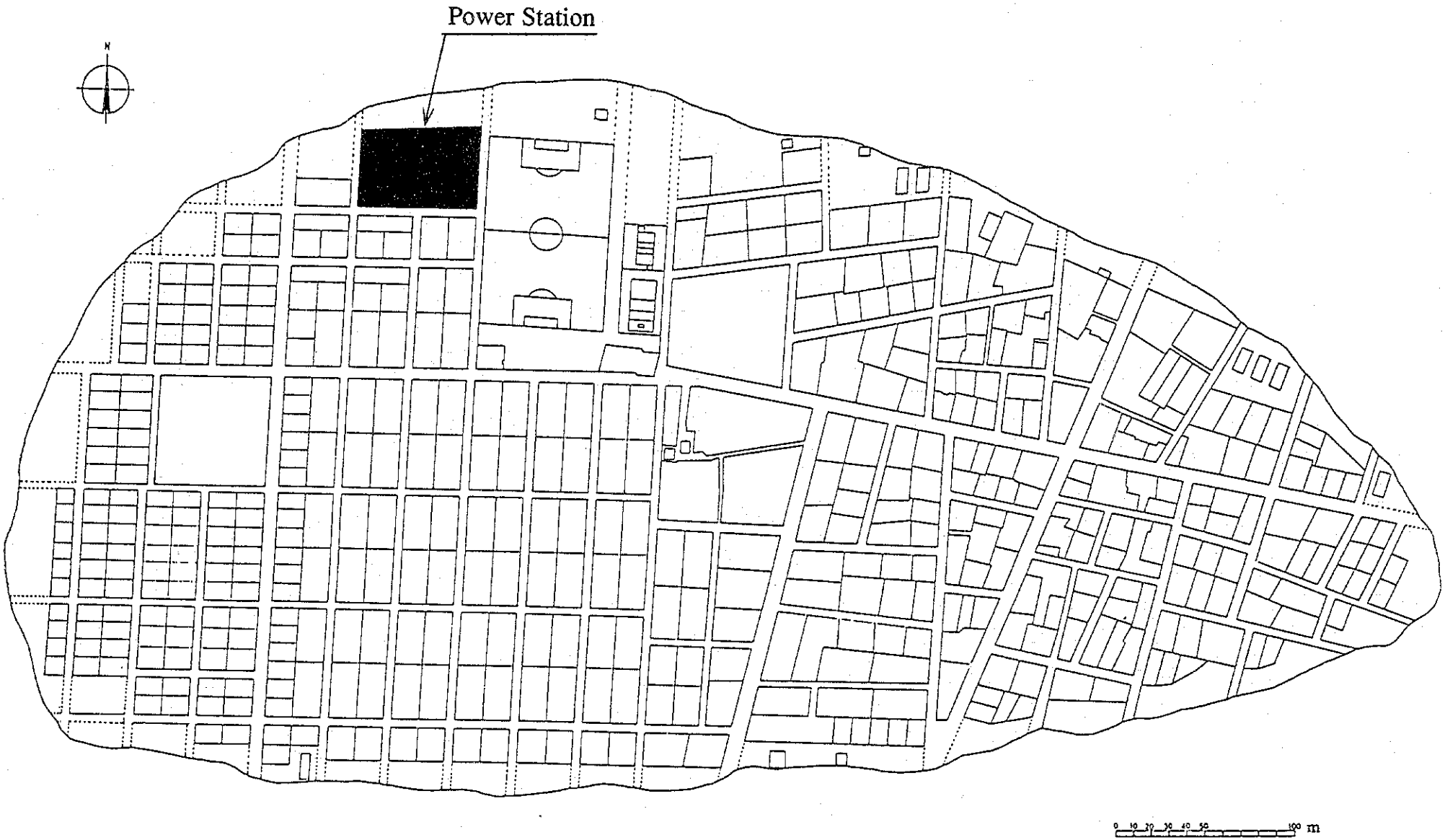
Mitsuhisa NISHIKAWA
Project Manager
Basic Design Study Team on
Atoll Island Electrification Project
in the Republic of the Maldives
Yachiyo Engineering Co., Ltd.



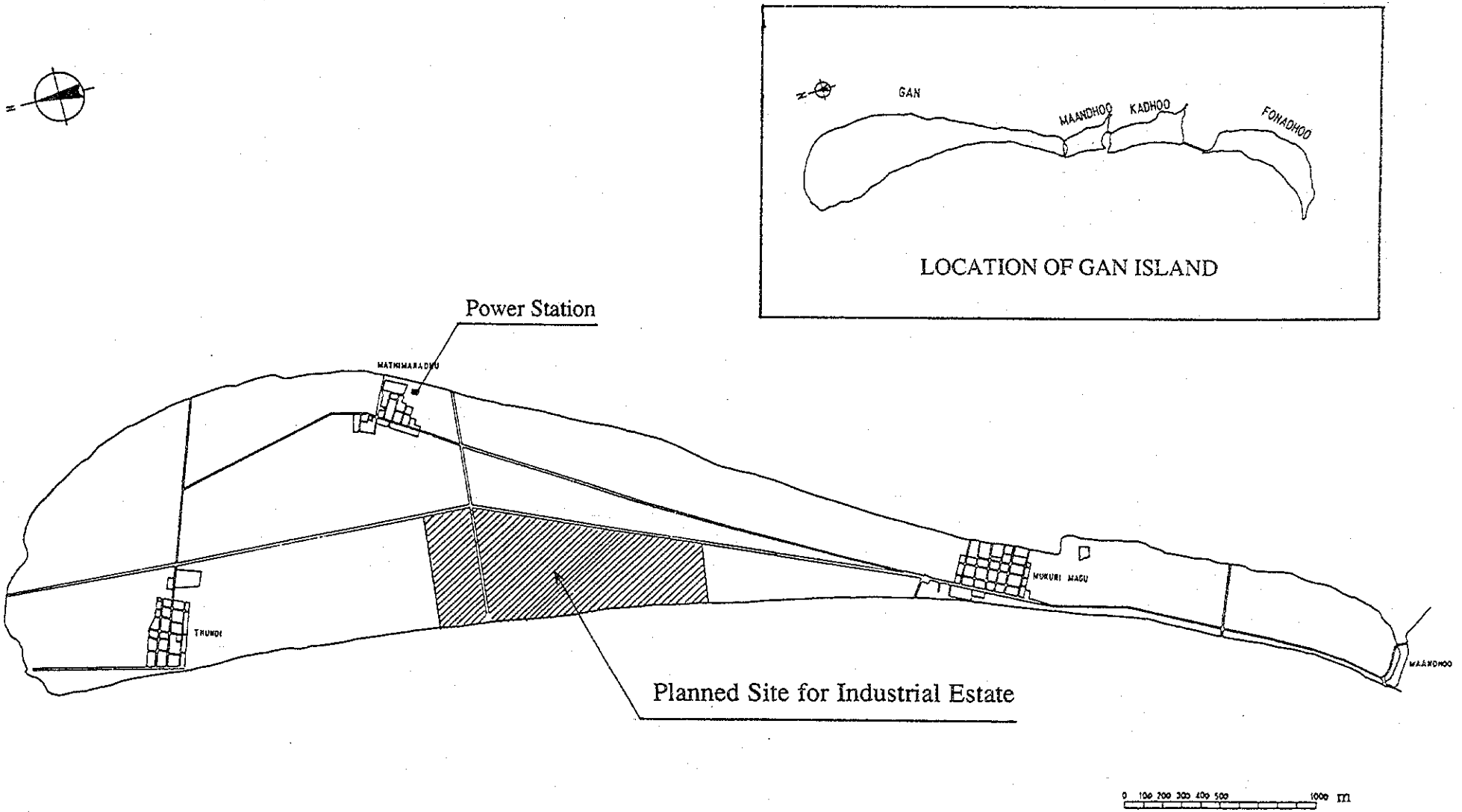
MALDIVES LOCATION MAP



LOCATION OF NAIFARU POWER STATION



LOCATION OF EYDHAFUSHI POWER STATION



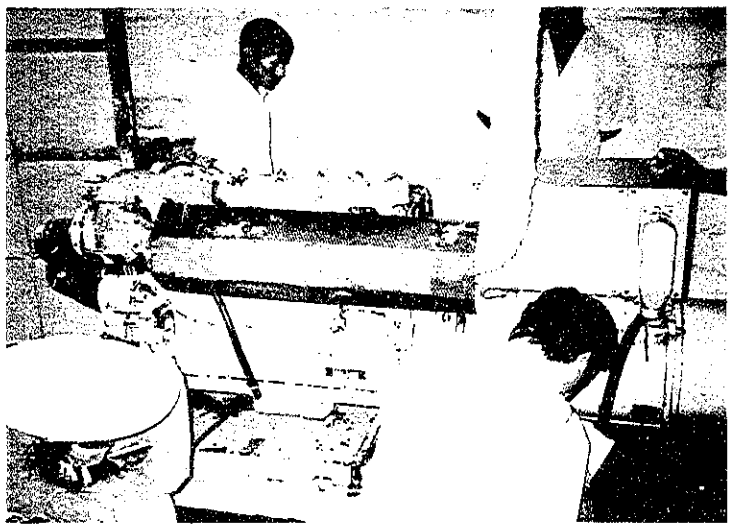
LOCATION OF GAN POWER STATION

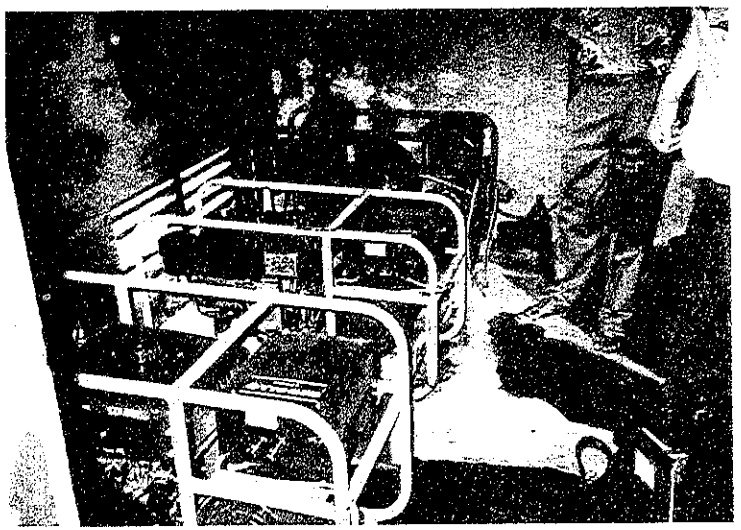
NAIFARU

Planned Site for Power Station
(Removal of the existing structures including a werehouse and the land preparation work will be conducted by the Government of the Maldives)

NAIFARU

Deteriorated power house owned by the local community

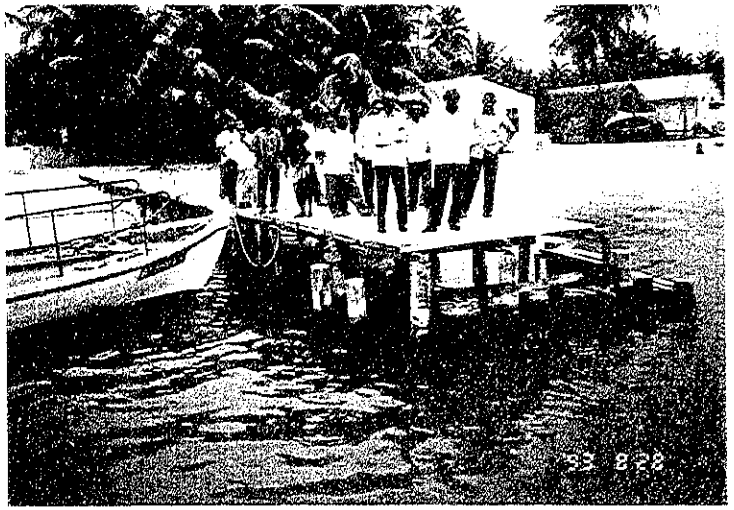




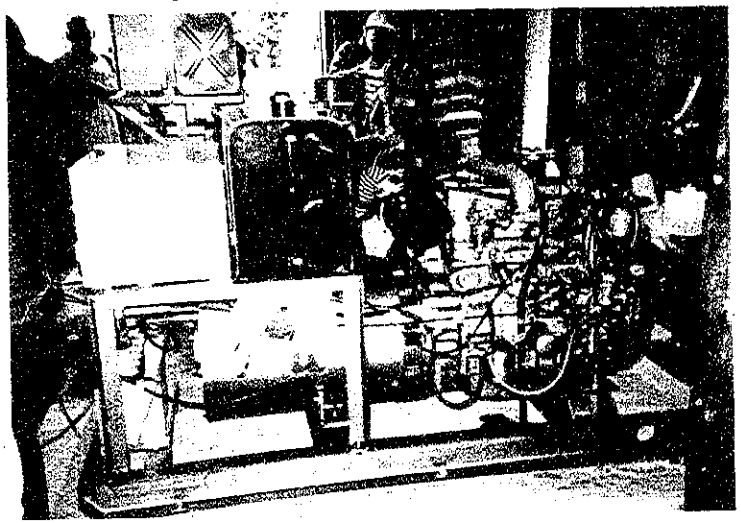
Generating facility owned by the local community

EYDHAFUSHI

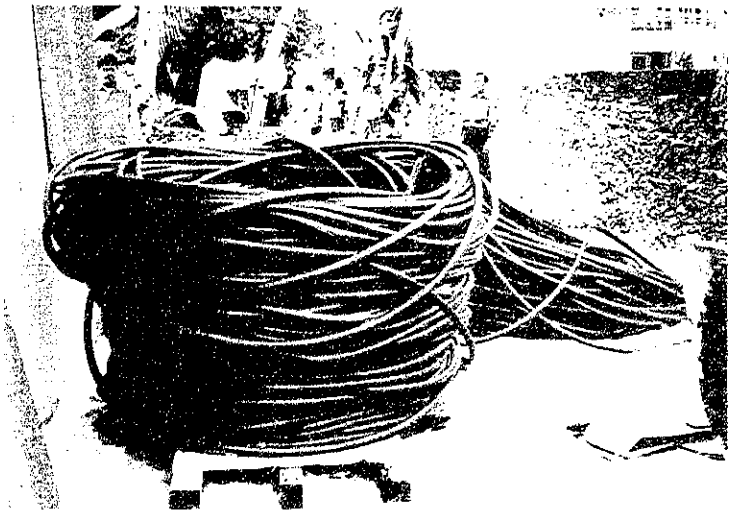
Planned Site for Power Station
(The land preparation work will be conducted
by the Government of the Maldives)



Jetty which can unload only light cargoes using a "Dhoni"



Generating facility owned by the local community,
which has never been used since its installation 5 years ago



Trunk line under construction by the local community

SUMMARY

SUMMARY

The Republic of the Maldives (hereinafter referred to as "the Maldives") consists of some 1,200 coral islands which form a series of 24 large atolls over a distance of 880 km in a north-south direction and 140 km in an east-west direction. The Maldives has a total national land area of 280 km^2 and a sea territory of 900,000 km^2. The GNP per capita as of 1991 is US$ 462.

The main industries in the Maldives are tourism and fisheries. Some 231,000 people live on 266 islands, including 64 resort islands. Male comprise a large population concentration of some 60,000 (26% of the total) and an annual population increase rate of 4.0% which is more than the national average of 3.7 percent.

The Government of the Maldives has prepared a series of national plans with the highest priority given to alleviating the unipolarisation to Male in order to improve the standard of living throughout the country and understands the urgent necessity to establish social and economic infrastructure for the development of outlying atoll islands. As part of efforts to achieve the national development goals, the Government of the Maldives and the Maldives Electricity Board (MEB) prepared the Atoll Island Electrification Project and have tried to implement the Project throughout its three National Development Plan periods since 1985. As implementation of the Project throughout the country has been difficult due to financial constraints, therefore, the Government of the Maldives and MEB have selected priority islands and have requested the Government of Japan's provision of grant aid for the electrification of these high priority islands.

In response to a request, the Government of Japan sent the Project Formulation Survey Team to the Maldives with a view to formulating an appropriate grant aid project. The Project Formulation Survey Team examined the viability and priority of the requested grant aid based on the current conditions of development in the Maldives and likely problems related to infrastructure development on the islands.

The Project Formulation Survey Team found that the inhabitants of only 10 islands directly receive electricity supply from the MEB even though 177 islands out of the 266 inhabited islands have been electrified. The electricity supply on 167 islands is limited to special facilities owned by the State Trading Organization (STO), Maldives Air Services, Ltd. (MAA), Addu Atoll Development Association (ADA), wealthy individuals, and companies running tourist resorts.

In conclusion, the Project Formulation Survey Team found that electrification of outlying atoll islands which do not currently enjoy electricity supply would be extremely useful for solving a number of problems the Maldives face and that the implementation of the Project should be given high priority. Further, given the fact that the electrification envisaged by the Project will result in highly desirable welfare improvement, the viability of the Project as a grant aid project of the Government of Japan was identified.

In response to the original request of the Government of the Maldives and the positive findings of the Project Formulation Survey Team, the Government of Japan agreed to conduct the Basic Design Study for the Project and entrusted the Japan International Cooperation Agency (JICA) to conduct the said study. JICA subsequently dispatched the Basic Design Study Team to the Maldives for the period of August 19th to September 17th, 1993, and again from November 1st to November 11th, 1993, to explain the contents of the Draft Final Report to the Maldive side.

The objectives of the Basic Design Study team were to examine the state of electrification on six subject islands as requested by the Government of the Maldives, and to examine the contents of the Project, its perceived effects, and the viability of the Project as a grant aid project of the Government of Japan.

Through a series of discussions with the Maldive side, it was agreed that the Basic Design Study would examine the possibility of providing Japan's grant aid to electrify up to three islands out of the six islands for which electrification with such grant aid was originally requested by the Government of the Maldives as the highest priority. The subject islands of the final request were Naifaru Island, the administrative seat of Lhaviyani Atoll, Eydhafushi Island, the administrative seat of Baa Atoll, and Gan Island of Laamu Atoll.

The Basic Design Study Team examined the current conditions of the atoll islands as well as those islands already electrified by the MEB through a series of discussions with government officials and others related to the Project and also from a field survey. Particularly in the case of Naifaru Island and Eydhafushi Island, the electricity supply was found to be inadequate in spite of the fact that these islands are the administrative seats of the relevant atolls (each atoll comprises an administrative district equivalent to a prefecture in Japan). Electric power supply fails to meet domestic demand and the demand of such communal facilities as schools and health centres. Consequently, the urgency of the Project's implementation for these islands was confirmed.

Gan Island of Laamu Atoll has road links with neighbouring Maandhoo Island, Kadhdhoo Island and Fonadhoo Island, the administrative seat of Laamu Atoll. An industrial estate

development plan (the feasibility study for which was conducted in 1988 by the ECFA of Japan) exists for Gan Island while a fishing base and cold storage were constructed on Maandhoo Island with Japanese grant aid and Kuwaiti funding. A domestic airfield was constructed on Kadhdhoo Island. The existence of these facilities, and the prospect of further development throughout Laamu Atoll illustrate the need for the electrification of Gan Island. However, upon completion of the research studies after returning to Japan, the Study Team decided to eliminate Gan Island from the scope of the Project on the grounds that (i) villages on Gan Island enjoy a high electrification rate of approximately 80% despite an unstable supply, (ii) it would be difficult to estimate the combined future electricity demand of the four islands due to uncertainties surrounding a comprehensive development project, particularly the commencement year for such a project, and (iii) the appropriateness of electrifying only Gan Island of the four islands cannot be clearly argued for.

Efforts by the Government of the Maldives and MEB to provide outlying atoll islands with electricity have been in progress since the launching of the First National Development Plan in 1985. Nevertheless, only 10 islands, including Male Island, have so far been electrified although work is underway on four additional islands. Assistance provided by other overseas aid organizations for the electrification of the Maldives has mainly concentrated on Male Island. While some outlying atoll islands have received such assistance, the scope does not extend further than the subject islands as in the case of the Project, confirming that there is not an overlap between the Project and other similar aid projects.

The finalised scope of the Project is the construction of a new power station on Naifaru Island and Eydhafushi Island and the supply of equipment and materials for a distribution network and VHF radio station. The installation of the equipment to be provided by the Japanese side under the Project will be conducted by the Maldives side. Based on the past performance of islands already electrified by the MEB, the domestic electricity demand/household in the year of project completion is set at 200 W with a subsequent annual increase of 10 percent. The scale of the facilities and equipment will be sufficient to meet the medium-term demand level five year after the completion of the Project. The basic components of the Project, finalised by the Basic Design Study Team upon its return to Japan, takes into consideration the field survey findings and requirements agreed to during discussions between the Japanese and Maldives sides and are the same for both Naifaru Island and Eydhafushi Island, except for the installed capacity of the generators.

Project Outline

Construction	• Power station building to accommodate diesel generators (184.0m^2) • Foundations for generating facilities, fuel tank and auxiliary equipment • Administrative office building (88.0m^2) • Rainwater storage tank and well • Premise roads • Building services
Supply of Equipment and Materials	• Supply and installation of 3 diesel engine generators (one as stand-by) (three 100 kW generators for Naifaru and three 75 kW generators for Eydhafushi) • Supply and installation of following mechanical equipment/ systems to support generating system - Fuel handling system (with fuel tank) - Ventilation system - Piping with fittings • Supply and installation of following electrical equipment/ systems to support generating system - Remote control panel - DC power supply system - Earthing system - Main distribution board - Local control panel mounted on generator - Cables and wires • Supply of following equipment and materials for distribution network - Main distribution cables - Branch distribution cables - Local distribution panel - Household panel board (with Watt-hour meter) • Supply of VHF radio station, repair tools and street lighting • supply of spare parts for generating facilities and auxiliary equipment and maintenance tools for generating facilities • Supply of operation and maintenance manuals
On-The-Job training (OJT)	• Education and training of MEB engineers by engineers dispatched by Japanese contractor on following (to be conducted during installation work period) - Installation of diesel generators and auxiliary equipment - Operation of diesel generators and auxiliary equipment - Maintenance and repair of diesel generators and auxiliary equipment

The authority responsible for the implementation of the Project for the Maldives side is the MEB, and, following the completion of the Project, the Outer Male Electricity Generation and Management Bureau of the MEB will be responsible for the laying of distribution cable, operation and maintenance of the newly constructed generating facilities and the collection of

rates from users. The Bureau manages the electricity service for nine local atoll islands and is, therefore, deemed to have sufficient management capability to run the new facilities.

In the case of the Project's implementation as a grant aid project of the Government of Japan, the Maldives side will be responsible for, among other things, the construction of gates and boundary fencing at the power station, installation of distribution networks, and the removal of existing generators and distribution network on Eydhafushi Island [at an estimated cost of approximately US$134,000].

The Project is expected to require three months for the detailed design, five months for the manufacture and procurement of the necessary equipment and materials and ten months for construction and installation at the actual sites.

The MEB is required to secure the necessary work sites, including temporary facility yards, to leveled the land, to remove existing structures from the sites and to secure access roads by a predetermined date. The MEB is also required to establish the necessary arrangement and to conduct the necessary coordination with the related government organizations of the Maldives in view of the Project's smooth implementation through close cooperation with the Japanese side.

The direct effect of the Project will be the availability of a state public electricity service for the social welfare and other public facilities, such as health centres, schools and atoll offices in addition to all houses on both islands with the construction of a new power station and distribution network on each island. The annual maintenance cost of the new facilities is estimated to be approximately US$359,000 which can be met by the estimated annual income of some US$423,000 in 1995, the year of project completion.

The electrification of Naifaru Island, the administrative seat of Lhaviyani Atoll, and Eydhafushi Island, the administrative seat of Laamu Atoll, will help to improve the standard of living on these islands, improve the quality of life on all neighbouring islands, and vitalise social and economic activities in the relevant regions. With some 17,400 people directly benefiting from the Project, implementation with Japanese cooperation is highly significant and appropriate in view of the objectives of Japan's grant aid system.

CONTENTS

ABBREVIATIONS

ADA	Addu Atoll Development Association
ADB	Asian Development Bank
ECFA	Engineering Consulting Firms Association, Japan
E/N	Exchange of Notes
GDP	Gross Domestic Product
GNP	Gross National Product
GWh	Giga Watt Hour (= 1,000 Mh = 1,000,000 kWh)
IEC	International Electrotechnical Commission
ISO	International Organization for Standardization
JEAC	Japan Electrical Association Code
JEC	Japanese Electrotechnical Committee
JEM	Standard of the Japan Electrical Manufacturer's Association
JICA	Japan International Cooperation Agency
JIS	Japanese Industrial Standards
MAA	Maldives Air Services, Ltd.
MEB	Maldives Electricity Board
MNSML	Maldives National Ship Management, Ltd.
O & M	Operation and Maintenance
OJT	On the Job Training
STO	State Trading Organization
UK	United Kingdom
UNCTAD	United Nations Conference for Trade and Development
UNDP	United Nations Development Programmme

CHAPTER 1 INTRODUCTION

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The Republic of the Maldives (hereinafter referred to as the Maldives) consists of some 1,200 coral islands which form a series of 24 large atolls over a distance of 880 km in the north-south direction and 140 km in the east-west direction. The total national land area is 280 km^2 with a sea territory of 900,000 km^2. The Maldives' GNP per capita in 1991 was US$462 and tourism and fisheries are the two main industries.

At present, some 231,000 people live on 266 islands, including 64 islands which have tourist resort facilities. There is a high population concentration of 60,000 people (26% of the total) in Male, the capital, where the annual population increase rate of 4.0% is higher than the national average of 3.7%, indicating further concentration in the future. The national plan prepared by the Government of the Maldives gives priority to alleviating this population concentration in Male by means of the urgent establishment of socioeconomic infrastructure to encourage the development of all atolls.

As part of the above national development effort, the Government of the Maldives and the Maldives Electricity Board (MEB) prepared and have been implementing the Atoll Island Electrification Project (the Project) since its First National Development Plan was launched in 1985. However, the fiscal difficulties faced by the Maldives means that all the project components cannot be simultaneously implemented, making it necessary to give priority order to the subject atolls. Having selected those atolls with a particularly strong electrification need, the Government of the Maldives requested grant aid for the implementation of the Project on these atolls. In response to this request, the Government of Japan sent the Project Formulation Survey Team to the Maldives with a view to formulating an appropriate grant aid project. The Project Formulation Survey Team examined the viability and priority of the requested grant aid based on the current conditions of development in the Maldives and likely problems relating to infrastructure development on these atolls.

The Project Formulation Survey Team found that the inhabitants of only 10 islands directly receive electricity supply from the MEB. The other electricity supply on 167 islands is limited to special facilities owned by the State Trading Organization (STO), Maldives Air Services, Ltd. (MAA), Addu Atoll Development Association (ADA), wealthy individuals and companies running tourist resorts.

As of 1990, the electrification rate was as high as 69% in terms of the national average. While the rate in Male is 93.8%, the rate for outlying atoll islands of 63.3%, including the supply of electricity for the special facilities mentioned above, is much lower, suggesting a generally

low rate of electrification of outlying atoll islands. In conclusion, the Project Formulation Survey Team found that the electrification of outlying atoll islands which do not currently enjoy electricity supply will be extremely useful to solve a number of problems faced by the Maldives and that the implementation of the Project should be given high priority. Further, given the fact that the electrification envisaged by the Project will result in highly desirable welfare improvement, the viability of the Project as a grant aid project of the Government of Japan was identified.

In response to the original request of the Government of the Maldives and the positive findings of the Project Formulation Survey Team, the Government of Japan decided to conduct the Basic Design Study for the Project and entrusted the Japan International Cooperation Agency (JICA) to conduct the study. JICA subsequently sent the Basic Design Study Team, headed by Mr. Yuji Ogura of the Grant Aid Division, Economic Cooperation Bureau, Ministry of Foreign Affairs, to the Maldives for the period between August 19th and September 17th, 1993. (See Appendix 1 for the list of the study team members and Appendix 2 for the field survey schedule.)

The objectives of the Basic Design Study Team were to identify the state of electrification on six subject islands as requested by the Government of the Maldives and to examine the contents of the Project, its perceived effects and the viability of the Project as a grant aid project of the Government of Japan.

The Basic Design Study Team identified the current conditions of the subject outlying atoll islands, as well as of those islands already electrified by the MEB, through a series of discussions with government officials and others related to the Project and a field survey. The state of electrification for the subject islands is inadequate to meet the demands of residential requirements and communal facilities such as schools and health centres. Further, each island houses the central administrative offices of a specific atoll (an administrative district equivalent to a prefecture in Japan), confirming the urgency of the Project's implementation on these outlying atoll islands.

Efforts by the Government of the Maldives and MEB to provide outlying atoll islands with electricity have been in progress since the launching of the First National Development Plan in 1985. Nevertheless, only 10 islands, including Male Island, have so far been electrified although work on four additional islands is underway. While some outlying atoll islands receive external aid, it has been confirmed that there is no overlapping between the envisaged grant aid and aid provided by other countries or organizations.

The Basic Design Study Team concluded the Minutes of Discussions (M/D) on August 30th, 1993 based on the confirmed background and objectives. of the Project (see Appendix 4). (See Appendix 3 for the list of the counterparts and related persons in the Republic of the Maldives.) Following the signing of the M/D, the Basic Design Study Team continued to collect information and data and to analyse their relevance and submitted the field report to the MEB on September 14th, 1993 to confirm the basic design principles for the Project with the Maldive side (see Appendix 5).

Upon its return to Japan, the Basic Design Study Team compiled the Basic Design Study Report on Atoll Island Electrification Project in the Republic of the Maldives, taking into consideration the current local situation of electricity supply, particularly that on outlying atoll islands, the status of the Project vis-a-vis higher plans and the viability, contents and scale of the Project.

CHAPTER 2 BACKGROUND OF THE PROJECT

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2.1 Country Data on the Maldives

2.1.1 Geography

The Maldives is a republic consisting of some 1,200 coral islands which form a series of 24 large atolls in the Indian Ocean covering a distance of 880 km in the north-south direction and 140 km in the east-west direction as shown on the Location Map. It has a total land area of 280 km^2, a sea territory of some 900,000 km^2 and a total population of 205,304 as of March, 1990. The GNP per capita in 1991 was US$462 and tourism and fisheries are the two main industries.

Male, the capital, is located on Male Island which is in turn located at the centre of the country. Male plays a central role in the national politics and economy as it is the location of most government offices and commercial activities. There are no large-scale commercial or industrial activities on any of the other islands and the economy of most outlying atoll islands depends on fisheries except in the case of those islands on which tourist resorts have been developed.

2.1.2 Population and Land Area

While the registered population of Male is some 30,000 as of March 1990, the real figure should be so me 60,000, accounting for 26% of the total population. In addition, some 15,000 foreign workers also live in Male. Of the Maldives 1,200 islands, some 270 islands, including 64 resort islands, are inhabited by the remaining 150,000 people. The island of the administrative seat, land area, population and number of households for each atoll (from the administrative point of view, there is a total of 20 atolls, i.e. districts) as of March 1990 are given in Table 2-1.

Table 2-1 Country Data on the Maldives

	Atoll	Administrative Island	Population (Persons)	Number of Households	Area (1,000m^2)
1	Haa Alifu	Dhidhdhoo	13,800	1,836	16,895
2	Haa Dhali	Kulhudhuffushi	15,016	2,293	20,601
3	Shaviyan	Farcolhufunadhoo	9,986	1,506	15,742
4	Noonu	Manadhoo	9,909	1,408	13,982
5	Raa	Kandholhudhoo	12,987	NA	9,883
6	Baa	Eydhafushi	8,908	1,145	7,709
7	Lhaviyani	Naifaru	8,499	1,038	5,532
8	Kaafu	Thulusdhoo	6,745	920	6,525
9	Male	Male	29,964	5,613	1,773
10	Alifu	Mahibadhoo	5,761	560	7,490
11	Vaavu	Felidhoo	1,688	213	652
12	Faafu	Magoodhoo	3,013	387	1,739
13	Meemu	Muli	4,957	619	3,193
14	Dhaalu	Kudahuradhoo	4,917	647	3,482
15	Thaa	Veymandoo	10,180	1,176	6,718
16	Laamu	Fonadhoo	9,793	1,430	18,867
17	Gaafu Alifu	Vilingili	8,287	1,246	8,851
18	Gaafu Dhaalu	Thinadhoo	13,025	1,809	17,114
19	Gnaviyani	Foamulah	7,052	921	4,080
20	Seenu	Hitadhoo	20,787	2,389	244,587
Total			205,304	27,156	415,415

Source: MEB.

2.1.3 Social and Economic Conditions

Tourism and fisheries constitute the two pillars of the Maldive economy. While the shipping industry, together with fisheries, supported the economy up to the late 1980's, the Gulf War changed the economic picture with the decline of the shipping industry and tourism is currently the largest source of foreign currency. The lack of noticeable natural resources, except marine resources, has prompted the Government of the Maldives to emphasize the promotion of agriculture since the First National Development Plan was launched in 1985. However, the agricultural production level is still far from self-sufficiency, forcing the Government of the Maldives to spend most of its foreign earnings on imports of such foodstuffs as rice, vegetables and meat. Table 2-2 shows the trade balance while Table 2-3 shows changes in the price

index. As mentioned earlier, the GNP per capita as of 1991 is US$462 according to the Statistical Year Book of Maldives 1993.

Table 2-2 Trade Balance of the Maldives

(Unit: 1,000 Rufia)

Item	1988	1989	1990	1991	1992
Export Total	351,255	400,687	491,645	544,335	416,957
Import Total	842,683	1,020,305	1,315,406	1,653,844	2,001,525
Trade Balance	–491,428	–619,618	-823,761	–1,109,509	–1,584,568

Source: Statistical Year Book of Maldives

Table 2-3 Transition of Consumer Price Index in the Maldives

(Base Year: 1981 = 100)

Item	1988	1989	1990	1991	1992
Consumer Price Index	167.47	179.48	186.03	213.40	249.34
Year-on-Year Indicator	–	1.07	1.04	1.15	1.17

Source: Statistical Year Book of Maldives 1993

2.2 Outline of Electricity Sector

2.2.1 Administrative Organizations Relating to Electricity Sector

The public electricity service in the Maldives commenced in 1959 when Male Power House was established by the Government of the Maldives. The subsequent increase of the electricity demand resulted in the reorganization of the Male Power House to the present Maldives Electricity Board in 1982 which is run under the direct control of the President's Office. The MEB is responsible for all aspects of the electricity service, ranging from the planning of generation, transmission and distribution to construction work and collection of the service charges for Male Island and for all other outlying atoll islands.

The organizational status of the MEB within the Government of the Maldives is shown in Fig. 2-1 while the internal organization of the MEB is shown in Fig. 2-2. The post of the MEB's Chairman is concurrently held by the Minister of Public Works and Labour. The daily activities of the MEB are divided into six bureaus, Administration, Finance and Accounts, Engineering, Maintenance, Greater Male

Electricity Generation and Management and Outer Male Electricity Generation and Management.

The body responsible for the implementation of the Project is the Outer Male Electricity Generation and Management Bureau. The MEB has a total of 537 employees as of July, 1993 (70 for administration, 39 for accounting, 154 for the electrical sections, 236 for engine room operation and 38 for general work).

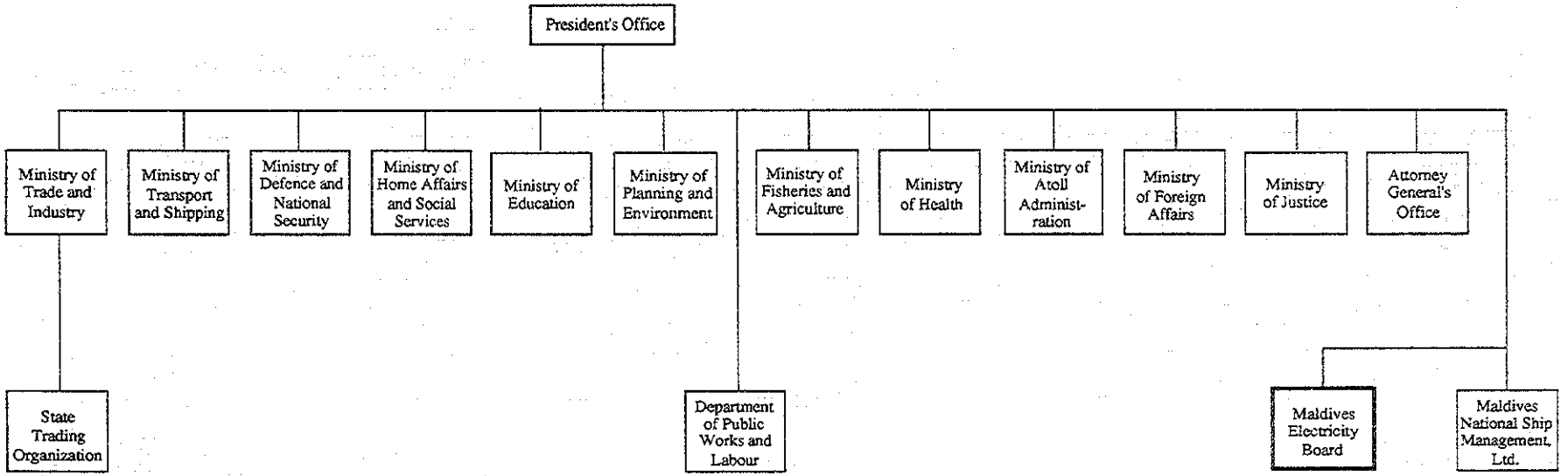

Fig. 2-1 Government Structure of the Maldives (as of September in 1993)

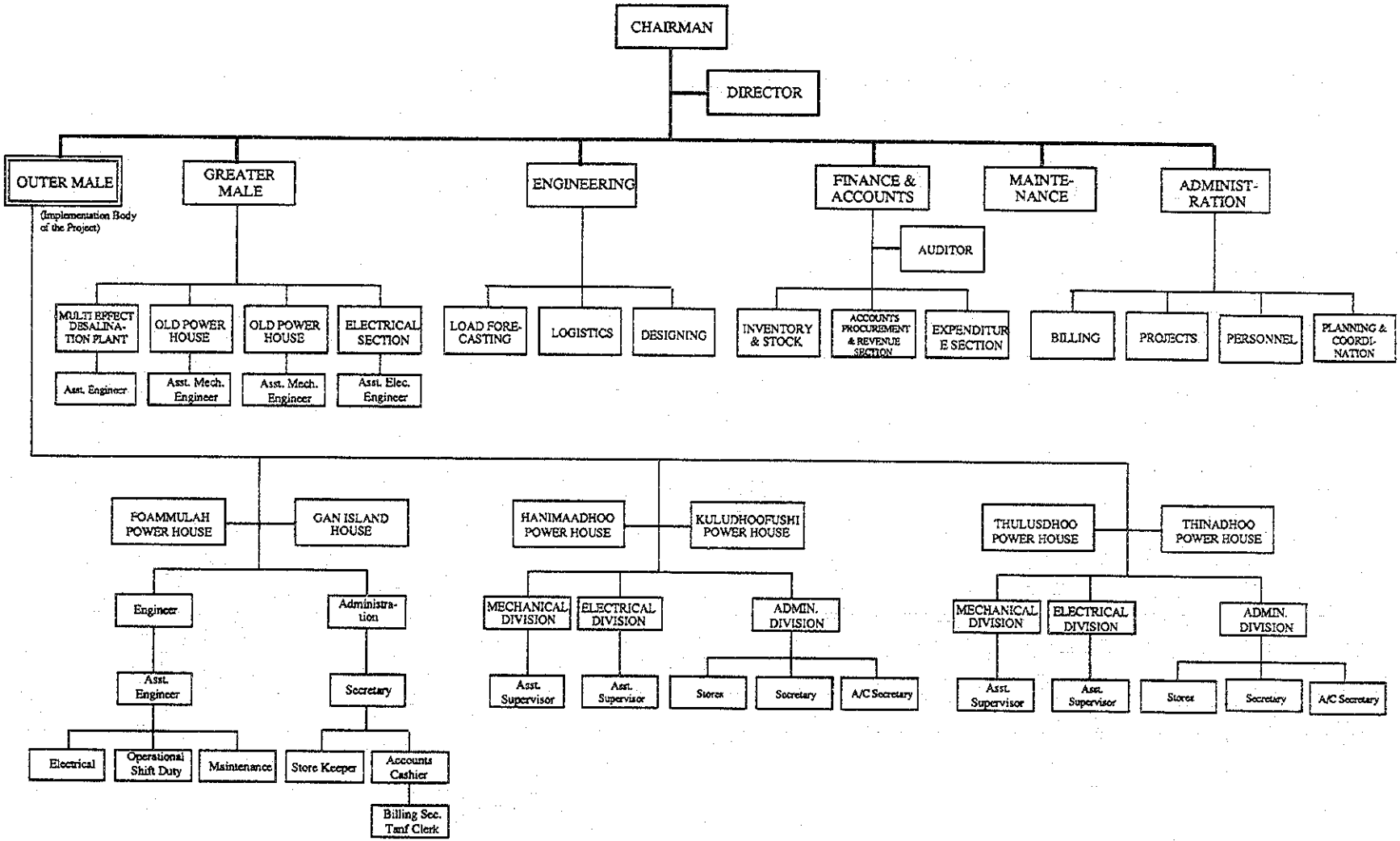

Fig. 2-2 Organization of MEB (as of September in 1993)

2.2.2 Financial Situation of MEB

The financial situation of the MEB is shown in Table 2-4. During 1988 to 1991, the revenue exceeded the operation cost (fuel and labour) indicating the MEB's healthy financial state of electricity supply operation. Further analysis of the MEB's financial situation reveals that rising operation costs in due to increases in the price of imported oil, wage hikes and the fluctuation in the foreign exchange rate has been met by a higher rate for domestic users on Male Island upon approval by the government as shown in Table 2-5.

Table 2-4 Financial Situation of MEB

(Unit: 1,000 Rufia)

Item		1988	1989	1990	1991
1.	Revenue				
1.1	Sale of Electricity	35,699	40,916	51,000	62,606
1.2	Others	1,764	496	498	806
	Sub-Total	37,433	41,412	51,498	63,412
2.	Operation Cost				
2.1	Fuel	18,035	18,836	26,435	36,482
2.2	Labor	4,170	4,529	5,984	9,576
2.3	Depreciation	3,328	4,228	4,272	4,196
2.4	Miscellaneous	8,667	7,770	11,367	10,572
	Sub-Total	34,200	35,363	48,058	60,826
3.	Profit	3,233	6,049	3,440	2,586

Source: MEB

The electricity rates charged by the MEB are shown in Table 2-6. There is a large gap between the rates for Male Island and the rates for outlying atoll islands, taking into account that some 80% of the operation cost is incurred on Male Island and that there is a large income gap between the residents of Male Island (average personal income of some 1,050 Rufia/month) and the residents of other outlying atoll islands (average personal income of some 700 Rufia/month).

At present, only the domestic electricity rate for Male Island is revised every year. However, there will be pressure to revise the rates for other types of users on Male Island as well as users on other outlying atoll islands in order to meet the ever increasing operation costs.

Table 2-5 (1) Changes of Civil Servant Wage

1985	1986	1987	1988	1989	1990	1991	1992	1993
100	114	122	171	207	258	351	483	562

Note: 1985 = 100

Table 2-5 (2) Changes of Fuel Oil Price

(Unit: Rufia/l)

1985	1986	1987	1988	1989	1990	1991
3.0	3.0	2.75	2.75	3.0	4.5	4.15

Note: Maximum price recorded in each year
Source: Statistical Year Book of Maldives

Table 2-6 Electricity Rates (1988 - 1991)

(Unit: Rufia/kWh)

Item	1988	1989	1990	1991
Male Island				
- Domestic	1.16	1.06	1.78	1.81
- Commercial	3.50	3.50	3.50	3.50
- Industrial	3.50	3.50	3.50	3.50
- Government	2.25	2.25	2.50	2.50
Thulusdhoo Island	1.50	1.50	1.50	1.50
Gan Island	1.50	1.50	1.50	1.50
Thinadhoo Island	1.50	1.50	1.50	1.50
Kulhudhuffushi Island	1.50	1.50	1.50	1.50
All User Average	2.20	2.28	2.30	2.42

2.2.3 National Power Supply Situations

(1) Generating Facilities for Commercial Power Supply by MEB and Independent Generating Facilities

In addition to the MEB, there are also several public institutions in the Maldives which have generating facilities. These include the State Trading Organization (STO), Maldives Air Services, Ltd. (MAA) and Addu Atoll Development Association (ADA). Moreover, some individuals and companies running tourist resorts have independent generating facilities. As the generating facilities owned by the STO, MAA, ADA, individuals and resort companies are designed for their own consumption, there are not any direct benefits to the public.

Of the some 1,200 islands which comprise the Maldives, 266 islands, including 64 resort islands, are inhabited. Of these, 177 have an electricity supply in one form or another, and the domestic electrification rate of 69% is fairly high (as of 1990). However, the reality of the electrification of outlying atoll islands is rather poor as a household with a diminutive 5W lamp is included in the calculation of the electrification rate.

The historical changes of the electrification rate are shown in Table 2-7, and institutions owning generating facilities and electrified islands as of August 1993 are shown in Table 2-8. Furthermore, details of the generating facilities owned by the MEB are given in Table 2-9. The current generating facilities in the Maldives are predominantly diesel oil-based with small solar generating devices (1 or 2 panels/device) used to operate radio station.

Table 2-7 Changes of Electrification Rate

(Unit: %)

	1977	1985	1990
National Average	9.8	55.5	69.0
- Male Island	59.3	NA	93.8
- Other Islands	2.3	47.7	63.3

Source: Population and Housing Census, 1977, 1980 and 1990 (provided by RTM).

Table 2-8 Owners of Generating Facilities and Electrified Islands (August, 1993)

Owner	Electrified Islands		Generator Capacity (kW)	Number of Electrified Islands
	Atoll	Island		
MEB	Kaafu	Male	12,671	
		Thulusdhoo	188	
	Seenu	Gan	2,700	
	Haa Dhall	Kulhudhuffushi	300	10
		Hanimaadhoo	350	
	Gaafu Dhaalu	Thinadhoo	300	
	Gnaviyani	Foammulah	350	
STO				44
MAA	Kaafu	Hulhule		
	Laamu	Kadhdhoo	118.5	4
	Haa Dhall	Hanimaadhoo	70	
	Alifu	Khaadidhoo		
ADA	Seenu	Gan		1
Individuals (Companies)		Resort Islands		64
		Individuals		57
Total				177

Table 2-9 Generating Facilities of MEB (August, 1993)

Electrified Islands		Unit No.	Date of Operation Commencement	Generator Capacity (kVA)	Voltage (V)	Revolution (rpm)
Atoll	Island					
Kaafu	Male	1	1978	186.25	400	750
		2	1978	186.25	400	750
		3	1962	298.00	400	600
		4	Out of Order			
		5	1978	625.00	400	1,000
		6	1978	625.00	400	1,000
		7	Out of Order			
		8	1972	291.50	400	750
		9	1972	291.50	400	750
		10	Out of Order			
		11	1984	625.00	400	750
		12	1986	625.00	400	1,000
		13	1987	1,487.00	11,000	1,000
		14	1989	1,000.00	400	1,500
		15	1989	1,000.00	400	1,500
		16	1991	2,700.00	11,000	750
		17	1991	2,700.00	11,000	750
		(Sub-Total)		12,671.50		
Seenu	Gan	1	Aug. 1985	675.00	3,300	428
		2	Aug. 1985	675.00	3,300	428
		3	Aug. 1985	675.00	3,300	428
		4	Aug. 1985	675.00	3,300	428
		(Sub-Total)		2,700		
Haa Dhall	Kulhudhuffushi	1	Apr. 1988	100.00	400	1,500
		2	Apr. 1988	100.00	400	1,500
		3	Apr. 1988	100.00	400	1,500
		(Sub-Total)		300.00		
Gaafu Dhaall	Thinadhoo	1	Apr. 1988	100.00	400	1,500
		2	Apr. 1988	100.00	400	1,500
		3	Apr. 1988	100.00	400	1,500
		(Sub-Total)		300.00		
Kaafu	Thulusdhoo	1	July 1984	94.00	400	1,500
		2	July 1984	94.00	400	1,500
		3	Out of Order			
		(Sub-Total)		188.00		
Haa Dhall	Hanimaadhoo	1	July 1992	37.50	400	1,500
		2	July 1992	37.50	400	1,500
		(Sub-Total)		75.00		
Gnaviyani	Foammulah	1	Oct. 1992	175.00	400	1,500
		2	Oct. 1992	175.00	400	1,500
		(Sub-Total)		350.00		
		Total		16,584.50		

2.3 Outline of Related Plans

2.3.1 National Development Plan

National development efforts in the Maldives have been based on the First National Development Plan (1985 - 1987), Second National Development Plan (1988 - 1990) and Third National Development Plan (1991 - 1993). The Ministry of Planning and Environment (the former Ministry of Planning and Development) has a central role in regard to planning and implementation. The current year, 1993, is the final year of the Third National Development Plan, and there are strenuous efforts being made to achieve social and economic development and to improve the welfare of the public. These plans had or have the following goals.

(1) First National Development Plan (1985 - 1987)

1) To improve the living standards of the population
2) To balance the economic and social progress between Male and the atolls
3) To attain greater self-reliance for future growth

(2) Second National Development Plan (1988 - 1990)

The three general goals of the First National Development Plan were inherited by the Second National Development Plan and the following priority areas were identified.

1) To increase the gross domestic product as well as national product
2) To increase the foreign exchange earnings
3) To increase the level of incomes especially in the atolls
4) To provide better and balanced health and educational facilities throughout the country
5) To emphasise human resources development as the basis for all development activities
6) To give more emphasis to atoll development
7) To accelerate the decentralization process
8) To relieve Male of its congestion
9) To accelerate the process of import substitution especially in food and agriculture products
10) To preserve and properly manage the environment

(3) Third National Development Plan (1991 - 1993)

The following development goals have been adopted for the Third National Development Plan. In essence, all the goals and targets of the First and Second Plans have been inherited.

1) Secure improvements in the living standards and quality of life of all Maldives
2) Ensure that the benefits of development are shared more equitably among the population
3) Achieve greater self-reliance which is essential for future growth

In order to achieve these goals, the following priority areas have been identified.

1) Economic management and development
2) Infrastructure development
3) Social development
4) Institutional development
5) Environment

Rectification of the development gap between Male Island and outlying atoll islands has been on the agenda throughout the three plans, and the electrification of outlying atoll islands has been promoted by the Government of the Maldives. The MEB is part of the overall effort to close this gap.

2.3.2 Development Projects in Electricity Sector

Since the launching of the First National Development Plan in 1985, a series of projects have been implemented, mainly using loans from the Asian Development Bank (ADB), to improve the electricity supply in the Maldives. The planned electrification projects and the projects actually implemented during the three national development plan periods are shown in Tables 2-10/12.

Table 2-10 Electrification Projects under First National Development Plan

	Project	Summary
1	Upgrading Male Electricity	1) Donor: ADB 2) Finance: Loan 3) Cost: US$535,500 4) Year of Completion: 1985 5) Project Outline: - Provision of diesel generating facility (1,000 kW x 1) and switchgear - Improvement of cooling system
2	Electrification of Atoll Islands (Phase 1)	1) Donor: ADB 2) Finance: Loan 3) Cost: US$461,200 4) Year of Completion: 1985 5) Project Outline: Electrification of Thinadhoo and Kulhudhuffushi Islands with the provision of three 80 kW diesel generators for each island
3	Male New Power Station	1) Donor: Not yet decided 2) Finance: Loan/grant 3) Cost: US$3,150,000 4) Year of Completion: 1985 5) Project Outline: Transfer of old power station to new site
4	Electricity Supply to Seenu Atoll	1) Donor: ADB/UK 2) Finance: Grant/loan 3) Cost: US$1,737,800 4) Year of Completion: 1986 5) Project Outline: Construction of transmission line from Gan Island to Hitadhoo, Maradhoo and Faydhoo Islands
5	Atoll Island Public Electricity Supply (Phase 2)	1) Donor: Not yet decided 2) Finance: Grant/loan 3) Cost: US$4,366,000 4) Year of Completion: 1997 (commenced in 1987) 5) Project Outline: Electrification of 20 islands based on priority order - 4 islands (1986 - 1987) - 12 islands (1988 - 1990)

Table 2-11 Electrification Projects Under Second National Development Plan

	Project	Summary
1	Institutional Improvement	1) Donor: ADB 2) Finance: Grant 3) Cost: US$350,000 4) Year of Completion: 1988 5) Project Outline: Provision of consulting services in following areas to improve functions of MEB - Accounting, finance and management - Coordination of electricity distribution between Male Island and Hulhule Island as well as Vilingili Island
2	Power System Development	1) Donor: ADB 2) Finance: Loan 3) Cost: US$7,503,200 4) Year of Completion: 1991 (commenced in 1988) 5) Project Outline: Expansion of generating capacity and improvement of distribution network to respond to increased demand on Male Island - Construction of new power station equipped with 2 MW diesel generator and other facilities
3	Atoll Island Electrification (Phase 2)	1) Donor: Not yet decided 2) Finance: Loan/grant 3) Cost: US$4,366,000 4) Year of Completion: 1998 (commenced in 1988) 5) Project Outline: Electrification of 20 islands based on priority order

Table 2-12 Electrification Projects Under Third National Development Plan

	Project	Summary
1	Power System Development Project	1) Donor: ADB 2) Cost: US$7,209,500 3) Period: Dec. 1989 - Nov. 1992 4) Project Outline: - Expansion of generating capacity of Male Power Station to 5.4 MVA - Construction of new substation on Male Island to improve distribution network
2	Second Power System Development Project	1) Donor: ADB 2) Cost: US$15,912,000 3) Period: 1992 - 1994 4) Project Outline: - New installation of one 2.7 MVA and two 6 MVA generators on Male Island - Construction of new substation on Male Island to improve distribution network
3	Electrification of Lhaviyani Atoll	1) Donor: Not yet decided 2) Cost: US$1,521,400 3) Period: 1992 - 1995 4) Project Outline: Electrification of 3 islands, i.e. Naifaru, Hinnararu and Maafilaafushi Islands, of Lhaviyani Atoll
4	Electrification of Kaafu Atoll	1) Donor: Not yet decided 2) Cost: US$2,317,000 3) Period: 1991 - 1993 4) Project Outline: Electrification of 2 islands, i.e. Vilingili and Meerufenfushi Islands, of Kaafu Atoll
5	Electrification of Laamu Atoll	1) Donor: Not yet decided 2) Cost: US$3,928,000 3) Period: 1992 - 1993 4) Project Outline: Electrification of 3 islands, i.e. Gan, Maandhoo and Kadhdhoo Islands, of Laamu Atoll
6	Electrification of Seenu Atoll	1) Donor: Not yet decided 2) Cost: US$3,673,000 3) Period: 1992 4) Project Outline: Electrification of 5 islands of Seenu Atoll, i.e. Maradu Fedu, Maradhoo, Hithadhoo, Huludhoo and Meedhoo Islands
7	Electrification of Haa Alifu Atoll	1) Donor: Not yet decided 2) Cost: US$486,000 3) Period: 1991 4) Project Outline: - Electrification of 2 islands, i.e. Kelaa and Hanimaadhoo Islands, of Haa Alifu Atoll
8	Energy Sector Master Plan	1) Donor: UNDP/IPF 2) Cost: US$165,000 3) Period: 1992 - 1993 4) Project Outline: - Preparation of master plan for electricity sector as requested by Ministry of Planning and Environment - Improvement forecasting system for electricity demand - Establishment of energy database - Procurement of microcomputers

2.4 Background and Content of the Request

2.4.1 Background of the Request

The Government of the Maldives has prepared a series of National Development Plans with the top priority given to alleviating the excessive unipolarisation of all the country's socioeconomic functions in the capital, Male, and the construction of socioeconomic infrastructure for the development of outlying atoll islands.

As part of the overall effort to achieve these priority targets, the Government of the Maldives and MEB have prepared the Atoll Island Electrification Project and have been making active implementation efforts. However, the progress of project implementation has been critically delayed due to the acute financial constraints faced by the Government of the Maldives, resulting in failure to much improve the above-mentioned unipolarisation.

In order to improve the deadlock situation, the Government of the Maldives has requested the Government of Japan's provision of grant aid for the electrification of six high priority outlying atoll islands.

2.4.2 Contents of the Request

Through discussions with the Maldive side that the priority for electrification was suggested as follows.

① Naifaru

② Hinnavaru

③ Eydhafushi

④ Gan

⑤ Kan'dholhudhoo

⑥ Kelaa

The following basic study issues and contents were confirmed by the Basic Design Study Team as a result of discussions with the Government of the Maldives.

(1) Provision of Equipment

1) Provision and installation of three diesel generators (including one reserve generator and auxiliary mechanical and electrical equipment) for each of Naifaru, Eydhafushi and Gan Islands.

2) Provision of distribution equipment and materials (including domestic meters and distribution boards) for Naifaru, Eydhafushi and Gan Islands.

3) Supply of spare parts for above items 1) and 2) (Approx. 2 years supply), and installation/maintenance tools.

4) Provision of maintenance manuals relating to above items 1), 2) and 3).

(2) Construction of Buildings

Construction of power station buildings, administrative office buildings and foundations to support generators, etc. on Naifaru, Eydhafushi and Gan Islands.

(3) OJT

Provision of OJT during the installation and test operation periods of the generating facilities.

It was noted that the Maldive side expressed a strong desire for the training of their technicians in Japan in addition to the above-mentioned OJT during the construction period. Primarily, the Maldive side favours additional training in Japan to help these technicians become completely competent with the operation and maintenance technologies/techniques for the new power stations to be constructed under the Project.

CHAPTER 3 OUTLINE OF THE PROJECT

CHAPTER 3 OUTLINE OF THE PROJECT

3.1 Location and Current Conditions of Subject Islands

3.1.1 Location of Subject Islands

The location of the three subject islands and the proposed power station sites are shown in Table 3-1.

Table 3-1 Location of Subject Islands

Item	Naifaru	Eydhafushi	Gan
Location of Island	Some 130 km north of Male as shown on the Location Map	Some 110 km northwest of Male as shown on the Location map	Some 230 km south of Male as shown on the Location Map
Location of Power Station	On the east coast as shown on the Location Map	To the north of the football ground on the north coast as shown on the Location Map	In the central village, Mathimaradhu, of the 3 villages on Gan Island as shown on the Location Map
Elevation of Power Station	1.5m	1.5m	1.5m

3.1.2 Current Conditions of Subject Islands

The current conditions of the subject islands at the time of the field survey conducted in August and September, 1993 are outlined in Table 3-2.

(1) Naifaru

Naifaru Island has a population of 3,985 with some 650 households and is the administrative seat of Lhaviyani Atoll. It has a population density of 25,000 persons/km^2. As the island has dense housing and public buildings, substantial sites for the future development of housing and public buildings appear to be unavailable. The islanders mainly rely on fisheries for their livelihood and some 300 (7.5% of the total population) commute daily to the tuna canning factory on neighbouring Felivaru Island.

While there is a health center on the island, the lack of a full-time doctor at either this health center or on Lhaviyani Atoll means that urgent cases must travel to Male by boat. There are several small factories, including a bakery, a fishing boat manufacture and repair workshop and a welding workshop. The Yammar Center (repair shop) on the east coast conducts the repair of diesel engines.

Some of the wealthy islanders own portable diesel generators for their personal use while some households receive electricity generated by the community-run diesel generator. At the time of the field survey, 347 households (just more than half of the total number of households on the island) are electrified. The communal supply of electricity is limited from 6 o'clock in the evening for 5 hours until 11 o'clock and is not available during the day at all. Despite this modest supply, the islanders are required to pay 1.0 Rf/W/month for lighting and 100 Rf/month for a small refrigerator and greatly hope that the MEB will provide a stable and adequate supply of electricity. A minimum required sized site has now been secured on the east coast for the new power station.

1) Purposes of Electrification

Domestic electrical appliances are restricted to lighting, ceiling fans and radios because of the currently limited communal supply of electricity. With the MEB's provision of a stable, adequate supply of electricity throughout the day, it will be possible for the islanders to use sewing machines, irons and refrigerators to improve their standard of living.

2) Current Conditions of Existing Generating Facilities

There is a communal power station (approximately 100 m^2) at the center of the island which is equipped with six diesel generators (2, 3, 7, 10, 12.5 and 40 kVA). These generators are not synchronously operated and the volume of spare parts in stock appears to be negligible.

(2) Eydhafushi

Eydhafushi Island has a population of 2,436 with some 420 households and is the administrative seat of Baa Atoll. It has a population density of 10,000 persons/km^2. While the island has dense housing and public buildings, some 26,000 m^2 of land (some 10% of the total land area) at the western end of the island has been earmarked for future housing development. It was decided that the present sports ground (40m x 60m) will be used as the site for the new power station.

The island's economy relies on fisheries. Some 500 islanders are engaged in deep-sea fishing and are absent from the island for a year once they sail from the island.

Some of the wealthy islanders own portable diesel generators for their personal use. While the procurement of generating and distribution facilities for the communal electricity service commenced seven years ago, only the generators (40 and 50 kVA) have so far been installed. As the laying of the underground distribution cable (35 mm^2) has not yet been completed, no communal supply of electricity is available. As the implementation of the remaining work for this communal electricity supply service must wait until sufficient funds are available, no firm date for operation commencement has been set. Even if the remaining work is completed, electricity will only be supplied for 5 hours/day, from 6 o'clock in the evening until 11 o'clock,. Moreover, both the generating and distribution capacities are suspected to be inadequate to meet the demand. As in the case of Naifaru Island, the islanders greatly hope for the MEB's provision of a stable and adequate supply of electricity.

1) Purposes of Electrification

Small-scale generators for personal use is currently the only form of electricity supply on the island; common electricity supply is not available to ordinary islanders. Electrification of the island by the MEB means that, as in the case of Naifaru Island, all the islanders will be able to use not only lighting, ceiling fans and radios, which are currently enjoyed by those owning portable generators, but also sewing machines, irons and refrigerators, etc., throughout the day to improve their standard of living.

2) Current Conditions of Existing Generating Facilities

There is a deteriorated communal power station (approximately 100 m^2) at the center of the island which is equipped with two diesel generators (40 and 50 kVA). As neither of these generators have been operated in the five years since they were installed, however, measurement of the insulation resistance of the winding and its replacement if necessary is essential. In addition, a thorough inspection of the diesel engines is required.

The planned electrification of the island by the MEB includes the purchase of communal generators and underground cable by the MEB with a view to their use for the electrification of another island. The reason for this arrangement is that although the two generators have never been used, different generating capacities makes it inappropriate to run there simultaneously or to distribute the load evenly. Moreover, the total generating capacity is insufficient to meet the expected demand level. In the

case of the underground distribution cable, the size of cable is unsuitable for use for the Project.

(3) Gan

Gan Island is the largest island in the Maldives and is mostly covered by coconut and other trees. Three small villages, i.e. Thundi, Mathimaradhu and Mukuri Magu, are scattered in the northern, eastern and southern ends of the island, respectively. There is a plan to develop an industrial estate in the western end of the island, and there are two sewing factories with Indian capital currently operating. Gan Island is located immediately next to Maandhoo, Kadhdhoo and Fonadhoo Islands and a road link has been established between Gan Island and these islands to permit access by vehicle.

There are some individually owned portable generators and communal diesel generating facilities in each village and 234 households (some 80% of the total 291 households) are electrified in one form or another. The electricity supply is limited from 6 o'clock in the evening for 5 hours until 11 o'clock. Despite the restricted supply, the islanders receiving communal electricity are required to pay 1.5 Rf/W/month.

As in the case of the previous two islands, the inhabitants of Gan Island are hopeful of the MEB's provision of a stable and adequate supply of electricity. Given the fact that the Government of the Maldives hopes to implement a large-scale electrification project which covers Gan Island as well as its four neighbouring islands, an air field on Kadhdhoo Island and an industrial estate on Gan Island, it may be difficult to make the provision of domestic electricity supply on Gan Island alone fit into the overall development scheme.

1) Purposes of Electrification

As stated above, the supply of electricity should not be restricted to domestic use but should also cover the airfield and industrial estate.

2) Current Conditions of Existing Generating Facilities

Each village has a communally owned diesel generators.

Thundi	:	27 kVA
Mathimaradhu	:	25.7 kVA
Mukuri Magu	:	28 kVA

The generator specifications are single phase, 240V and 3,000 rpm and are judged unsuitable for long, continuous operation because of the high revolution rate.

Table 3-2 Current Conditions of Subject Islands

	Item	Naifaru	Eydhafushi	Gan
1	Land Area (m^2)	156,000	225,000	5,124,000
2	Population (July, 1993)	3,985	2,436	1,981
3	Number of Households (July, 1993)	650 (includes 86 developed lots)	420 (includes 50 developed lots)	291
4	Electricity Facilities			
4.1	Ownership	communal	communal	communal
4.2	Capacity (kVA)	74.5	90 (under construction)	80.7
4.3	Operating Hours	5 hours (18:00-23:00)	5 hours (18:00-23:00)	5 hours (18:00-23:00)
4.4	Distribution Voltage (V)	400/230	400/230	230
4.5	Rate (Rf/kWh)	1.0 Rf/W/month (for lighting)	undecided	1.5 Rf/W/month
4.6	Electrification Rate (%)	53	0	80
5	Public Facilities			
5.1	Atoll Office	yes	yes	no
5.2	Island Office	yes	yes	3
5.3	Court House	yes	no	3
5.4	Telephone Exchange Office	yes	no	1
5.5	Police Station	yes	no	no
5.6	Post Office	yes	no	no
5.7	School	3 (1 under construction)	yes	3
5.8	Health Center	yes	yes	1 (under construction)
5.9	Club House	yes	no	no
5.10	Library	no	no	no
5.11	Mosque	yes	no	4 (1 under construction)
5.12	Jetty	concrete	wood and concrete	concrete
5.13	Water Supply	rainwater	rainwater	no
6	Personal Facilities			
6.1	Diesel Generator (set)	25	33	10
6.2	Boat House	yes	28	11
6.3	Handicrafts	no	yes	no
6.4	Fishing Boat Repair Shop	yes	yes	no
6.5	Car	no	no	5
7	Average Income of Working Person (Rf/month)	700-800	800-900	700-800
8	Development Plan	no	no	industrial development

3.2 Natural Conditions

3.2.1 Climate

(1) Climatic Zone

The Maldives belong to the tropical monsoon zone and are subject to two prevailing strong winds characteristic of the Indian Ocean, i.e., north-east wind from November to April and a south-west wind from May to October, with much rain and thunder.

(2) Temperature

The average temperature is constant in the range of between 26°C and 29°C throughout the year. The highest and lowest recorded temperatures are 34.1°C and 17.2°C respectively.

(3) Relative Humidity

The day-time relative humidity is constant at around 80% throughout the year.

(4) Rainfall

The annual rainfall is approximately 2,000 mm, most of which is concentrated in the rainy season between May and October. A characteristic of the local rainfall is that the rain continues for a week unlike regions subject to tropical squalls. There are some 20 days of rainfall/month during the rainy season.

(5) Wind Velocity and Wind Direction

The prevailing wind direction is north-east from November to April and south-west from May to October. The average wind velocity is almost constant and gentle at 4 m/sec which can increase to 8 m/sec during the rainy season.

(6) Daylight Hours and Insulation

The average number of daylight hours is approximately 8 hours/day. According to the Energy Sector Volume of the Third National Development Plan, there is high potential for photovoltaic generation during the dry season. At present, only small photovoltaic generating devices are used to power for radio station.

(7) Earthquakes

No earthquakes have been recorded in the Maldives.

(8) Lightning

Thunder occurs some 30 times/year.

(9) Tsunami and Flood Tides

On April 10th, 1987, a flood tide assaulted Male and nearby islands for four days, causing extensive damage. A disaster prevention project is currently being implemented on Male Island with Japanese grant aid.

3.2.2 Cyclones

As the Maldives are not on the normal cyclone paths, serious damage has not been caused by cyclones. The strongest wind ever recorded was 31.9 m/sec on November 3rd, 1987.

3.3 Social Conditions

3.3.1 Port Facilities

None of the three subject islands have a jetty equipped with facilities to load/unload construction equipment and materials. Barges should, therefore, be used for the transportation of such heavy equipment as diesel engines (up to 3 tons) to be provided under the Project. Lighter materials, such as cement (approximately 50 kg/bag), can be transported by the conventional method of "Dhoni" for manual unloading at the jetty.

3.3.2 Roads

The roads on the subject islands are unpaved, but were judged to be capable of supporting the transportation of heavy items associated with the Project. The absence of such transportation as trucks, however, makes manual transportation, possibly using rollers, of such items necessary.

3.3.3 Telecommunications

There is a telephone/facsimile link between Male and hotels on the resort islands and major countries throughout the world. Between Male and any of the subject islands, VHF radio system is used because of the small number of telephone lines available.

3.3.4 Living Environment

Most of the islanders live in houses made of coral stones which are a specialty of the Maldives. Public transportation and cars are not available on Naifaru and Eydhafushi Islands. Domestic water is stored rainwater; salty ground water from wells is used to flush toilets.

The relatively wealthy islanders own portable diesel generators. The communally run diesel generators only provide electricity during certain hours, producing substantial desire of the islanders for the MEB's provision of a stable supply of electricity.

3.4 Outline of Electricity Sector

3.4.1 Electricity Supply on Subject Islands

(1) Islands with Power Station and its Operation

The MEB, the public electricity board in the Maldives, provides an electricity service on Male and on nine outlying atoll islands. There are two power stations in Male, the Old Power Station and the New Power Station. In the case of the outlying atoll islands, the MEB operates six power stations (on Gan Island of Seenu Atoll, Kulhudhuffushi Island of Haa Dhall Atoll, Hanimaadhoo Island of Haa Dhall Atoll and Foammulah Island of Gnaviyani Atoll). The operational conditions of the local power stations owned by the MEB are briefly described below, and are outlined in Table 3-3.

1) Gan

Four generators (including two reserve generators) became operational in 1985. The current total output capacity of 2,160 kVA far exceeds the maximum demand of 406 kW, presenting a favourable picture in terms of the supply and demand balance. The Government of the Maldives hopes

that Gan Island will become a key base for the country's industrial development.

2) Kulhudhuffushi

Three 100 kVA generators (including one reserve generator) became operational in 1988. The current total output capacity of 270 kVA exceeds the maximum demand of 152 kW and should be able to meet any demand increase in the immediate future. The fuel stock level is equivalent to approximately three months consumption. The power station appears to be well run by the MEB with well-stocked parts and a well-equipped workshop.

3) Thinadhoo

As in the case of Kulhudhuffushi, three 100 kVA generators (including one reserve generator) became operational in 1988. The current total output capacity of 270 kVA is well above the maximum demand of 82 kW.

4) Thulusdhoo

Three 75 kVA generators became operational in 1984, but one is currently out of order. As the current total output capacity of 150 kVA (excluding the capacity of the broken generator) is well above the maximum demand of 52 kW, there is not an immediate problem in regard to the electricity supply anticipated.

5) Hanimaadhoo

Two 37.5 kVA generators became operational in 1992. While there is not a reserve generator (space for an extra generator is provided in the power station building), the current total output capacity well satisfies the maximum demand of approximately 20 kW.

6) Foammulah

Three 175 kVA generators (including one reserve generator) became operational in 1992. The current total output capacity of 300 kVA is well above the total demand of 185 kW.

The MEB is currently constructing a new power station on four islands, i.e., Dhidhdhoo Island of Haa Alife Atoll, Gadhdhoo Island of Gaafu Dhaalu Atoll,

Vilingili Island of Gaafu Alifu Atoll and Hulhudhuffaaru Island of Raa Atoll, and the planning details of these power stations are given in Table 3-4.

On the subject islands (Naifaru, Eydhafushi and Gan), the available diesel generators are privately or communally owned and the MEB currently does not have any facilities on these islands.

Table 3-3 Operational Conditions of MEB's Power Stations on Atoll Islands (1992)

Island	Unit No.	Manufacturer		Year of Commencement	Installed Capacity (kVA)	Current Output (kVA)	Demand (kW)		Power Supply (MWh)			Utilization Rate (%)	Remarks
		Diesel Engine	Generator				Max.	Average	Generated	Demand	Loss		
Gan	1	Crosley	Brush	1985	675	540							2 operational
	2	"	"	"	"	"							2 reserves
	3	"	"	"	"	"							
	4				2,700	2,160							
	Sub-Total						406	189	2,170	1,660	510	9.2	
Kulhudhuffushi	1	Cummins	Markon	1988	100	90							2 operational
	2	"	"	"	"	"							1 reserve
	3	"	"	"	"	"							
	Sub-Total				300	270	152	48	510	420	90	19.4	
Thinadhoo	1	Cummins	Markon	1988	100	90							2 operational
	2	"	"	"	"	"							1 reserve
	3	"	"	"	"	"							
	Sub-Total				300	270	82	37	390	320	70	14.8	
Thulusdhoo	1	Guizho	unknown	1984	94	75							2 operational
	2	"	"	"	"	"							1 out of order
	Sub-Total				188	150	52	19	242	170	72	14.7	
Hanimaadhoo	1	Cummins	Markon	1992	37.5	33							2 operational
	2	"	"	"	"	"							
	Sub-Total				75	66	20	2	15	10	5	1.4	
Foammulah	1	Cummins	Leroy Somer	1992	175	150							2 operational
	2	"	"	"	"	"							
	Sub-Total				350	300	185	2	43	40	3	0.6	

Table 3-4 Installed Capacity of MEB's Power Stations Under Construction on Outlying atoll islands

Island	Unit No.	Planned Operation Commencement	Installed Capacity (kVA)	Remarks
Dhidhdhoo	1	Dec. 1993	100	One 100 kVA generator is a reserve
	2	"	100	
	3	"	75	
	Sub-Total		275	
Gadhdhoo	1	Dec. 1993	100	One 100 kVA generator is a reserve
	2	"	100	
	3	"	75	
	Sub-Total		275	
Vilingili		Dec. 1993		Currently at design stage
Hulhudhuffaaru	1	Dec. 1993	100	One 100 kVA generator is a reserve
	2	"	100	
	3	"	80	
	Sub-Total		280	

The Basic Design Study Team visited the power station on Dhidhdhoo Island in September, 1993 and found that the building's finishing work was in progress. As installation work had not been conducted, the commencement of actual operation at the end of 1993 as planned appears difficult.

3.4.2 Future Development Plan and Estimated Electricity Demand of Subject Islands

(1) Future Plan

As already stated, the Government of the Maldives and MEB have been earnestly promoting the electrification of outlying atoll islands in accordance with the Atoll Island Electrification Project as part of the Third National Development Plan. While Naifaru Island and Eydhafushi Island are the district seats of Lhaviyani Atoll and Baa Atoll respectively, the degree of electrification is still only partial and unstable. Consequently, these two islands are given high priority in the Project and the islanders strongly hope for the provision of a stable supply of electricity by the MEB. In the case of Gan Island, apart from a similar strong desire for electrification on the part of the islanders, electrification of the island has an extra dimension in terms of its link with the industrial estate development project. And the simultaneous electrification with to implementation of to industrial estate development is planned for.

(2) Demand Forecast

The subject islands of the Project are partially electrified with the use of privately and/or communally owned generators. While many electrified households have lighting and ceiling fans, only some public buildings have refrigerators and air-conditioning equipment.

To forecast the likely demand following the completion of electrification under the Project, it has been decided that, given the small size of all three subject islands which have a similar environment, a detailed survey will be conducted for Naifaru Island in view of adding all the loads to determine the present potential demand, in turn to be used to calculate the likely demand in 5 years time. The likely demand in 5 years time for the remaining two islands will be calculated based on the same conditions applied for Naifaru Island.

1) Potential Demand

The total potential demand on Naifaru Island was calculated in the following manner. Firstly, the total domestic power load (185 kW from Table 3-5) was added to the total power load of public facilities (60 kW from Table 3-6). Using a general demand rate of 0.46 which takes the likelihood of a simultaneous load and different life patterns between households, etc. into consideration, the potential demand on Naifaru Island was calculated to be 113 kW.

(185 kW + 60 kW) x 0.46 = 113 kW

The general demand rate of 0.46 was adopted as this is the rate used in Japan for a group of more than 100 households. The average electricity demand per household was given by dividing the island's total demand of 113 kW by the number of households (564). However, the demand per household of 200 W was adopted in view of extra load required to run the above-mentioned public facilities.

Table 3-5 Potential Electricity Demand on Naifaru Island (Domestic)

No.	Load Item	Load (W)	Possession Ratio (%)	Number of Households	Total Load (kW)
1	Lighting	200	100.0 (*1)	564	113
2	Ceiling Fan	80	100.0 (*1)	564	46
3	Radio	140	3.5 (*2)	20	3
4	Television	140	0.9 (*2)	5	1
5	Refrigerator	140	1.0 (*2)	6	1
6	Washing Machine	200	2.7 (*2)	16	4
7	Sewing Machine	100	3.4 (*2)	20	2
8	Iron	750	3.5 (*1)	20	15
	Total	-	-	-	185

Notes
(1) Estimate
(2) Statistical Year Book of Maldives, 1993 (Table II-27).

Table 3-6 Potential Electricity Demand on Naifaru Island (Public Facilities)

No.	Load Item	Load (W)	Possession Ratio (%)	Number of Households	Total Load (kW)	Remarkes
1	Lighting	800	100	17.0	14	
2	Ceiling Fan	320	100	17.0	6	
3	Radio	140	100	17.0	3	
4	Television	140	100	17.0	3	
5	Refrigerator	140	50	8.5	2	
6	Electric Heater	500	50	8.5	5	
7	Air-Conditioner	1,000	50	8.5	9	
8	Rainwater Pump	200	50	8.5	2	
9	Street Lighting	40	100	50.0	5	
10	Others	5,500	100	2	11	Dhoni Workshop or Port Facilities
	Total	-	-	-	60	

Notes
(1) Breakdown of public facilities: banks - 2, mosques - 4, atoll offices - 2, health center - 1, warehouses - 2, workshops - 1, social centres - 1, schools - 4.

2) Future Demand Forecast

The total demand on Naifaru Island for 1994 was forecast by multiplying the estimated average demand of 200 W/household, inclusive of public facilities, by the number of households. For the demand forecast for 1995 onwards, an annual rate of demand increase of 10% was used to allow for increases of populatoin, the number of households and the number of public facilities and also for the wider use of electrical appliances. As in the case

of Naifaru Island, the livelihoods of the inhabitants of both Eydhafushi Island and Gan Island mainly depend on fisheries. Coupled with a similar standard of living on all three islands with populations ranging from some 2,000 to 4,000, the average demand per household on Eydhafushi Island and Gan Island has also been set at 200W. The resulting medium-term electricity demand forecast up to 1998 for the three subject islands is given in Table 3-7.

Table 3-7 Forecast of Electricity Demand for Subject Islands

(Unit: kW)

Island	Number of Households in 1994	1994	1995	1996	1997	1998
Naifaru	564	113	125	138	152	168
Eydhafushi	370	74	82	91	101	112
Gan	291	59	65	72	80	88

CHAPTER 4 CONTENTS OF THE PROJECT

CHAPTER 4 CONTENTS OF THE PROJECT

4.1 Objectives

The Government of the Maldives has prepared a series of National Development Plans with the highest priority given to improving the national standard of living and eradicating regional gaps through the development of socioeconomic infrastructure on outlying atoll islands and has been promoting the electrification project to achieve these goals.

As of 1990, the national average electrification rate is as high as 69%. While the rate in Male is 93.8%, however, the rate for outlying atoll islands, including electricity supply for special facilities, of 63.3% is much lower. Given the fact that only nine outlying atoll islands in addition to Male receive electricity from the MEB, the electrification rate for outlying atoll islands is still generally low, implying that promotion of the electrification of non-electrified outlying atoll islands will be extremely useful in solving a number of problems currently faced by the Maldives.

Against this background, the Project intends to promote the electrification of certain islands to urgently improve the electricity supply in the Maldives in view of achieving stable life and the efficient operation of public welfare facilities on the subject islands.

4.2 Examination of Contents of the Request

4.2.1 Viability and Necessity of the Project

While some of the subject islands have electricity generated by personal and communal generators, the limited operation in terms of the supply hours greatly constrains local life, the running of public welfare facilities and industrial activities.

The present situation is that medical and educational services, which are essential aspects of social life, may stagnate unless appropriate improvement of the electricity supply is conducted through the implementation of urgent measures. The urgent implementation of the Project is, therefore, deemed necessary to provide an appropriate electricity supply in order to prevent the stagnation of social life in general and medical/educational activities in particular. Moreover, the electrification of outlying atoll islands will help to close the gap in the living standard between Male, the capital of the Maldives, and these islands, significantly contributing to the

stabilisation and development of the Maldives. Because of these positive effects, the Project is deemed highly suitable for implementation as a Japanese grant aid project.

4.2.2 Project Implementation and Management Plans

(1) Personnel Plan

The operation and maintenance of the new generators and distribution networks following the completion of the Project will be conducted by staff of the Naifaru Power Station and Eydhafushi Power Station, both of which will be newly created in the Outer Male Electricity Generation and Management Bureau. This arrangement will copy the current practice vis-a-vis those outlying atoll islands which have already been electrified by the MEB (nine islands with six power stations). The organizational set-up is illustrated in Fig. 4-1. As in the case of the MEB's existing power stations on outlying atoll islands, each new power station will require a staff of some 25 as shown in Fig. 4-2.

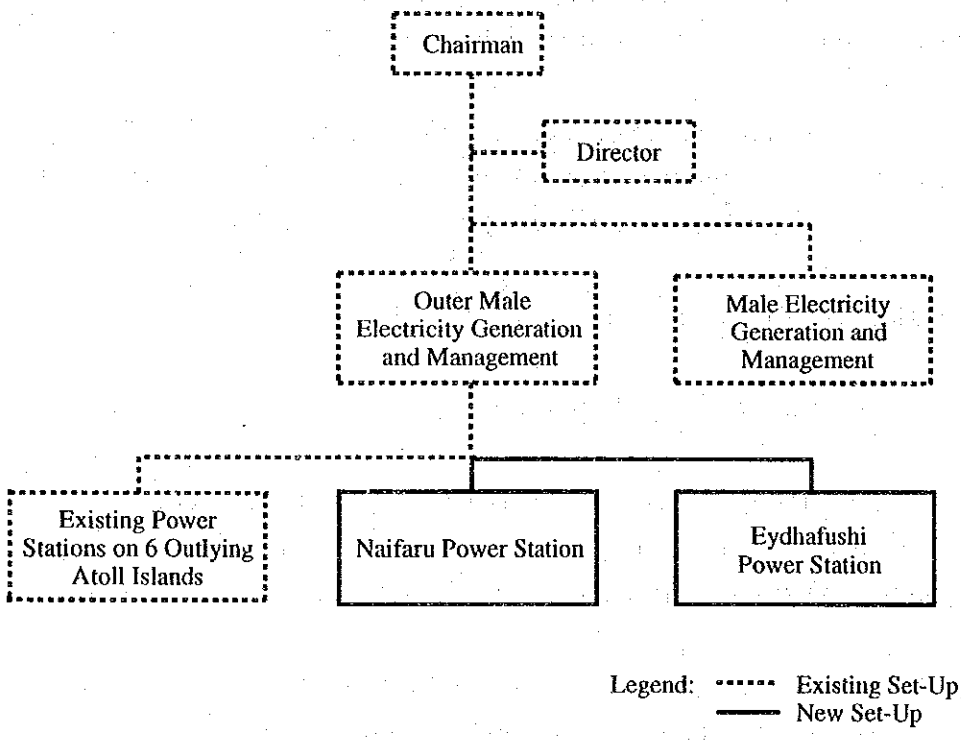

Fig. 4-1 Organizational Set-Up of New Power Stations

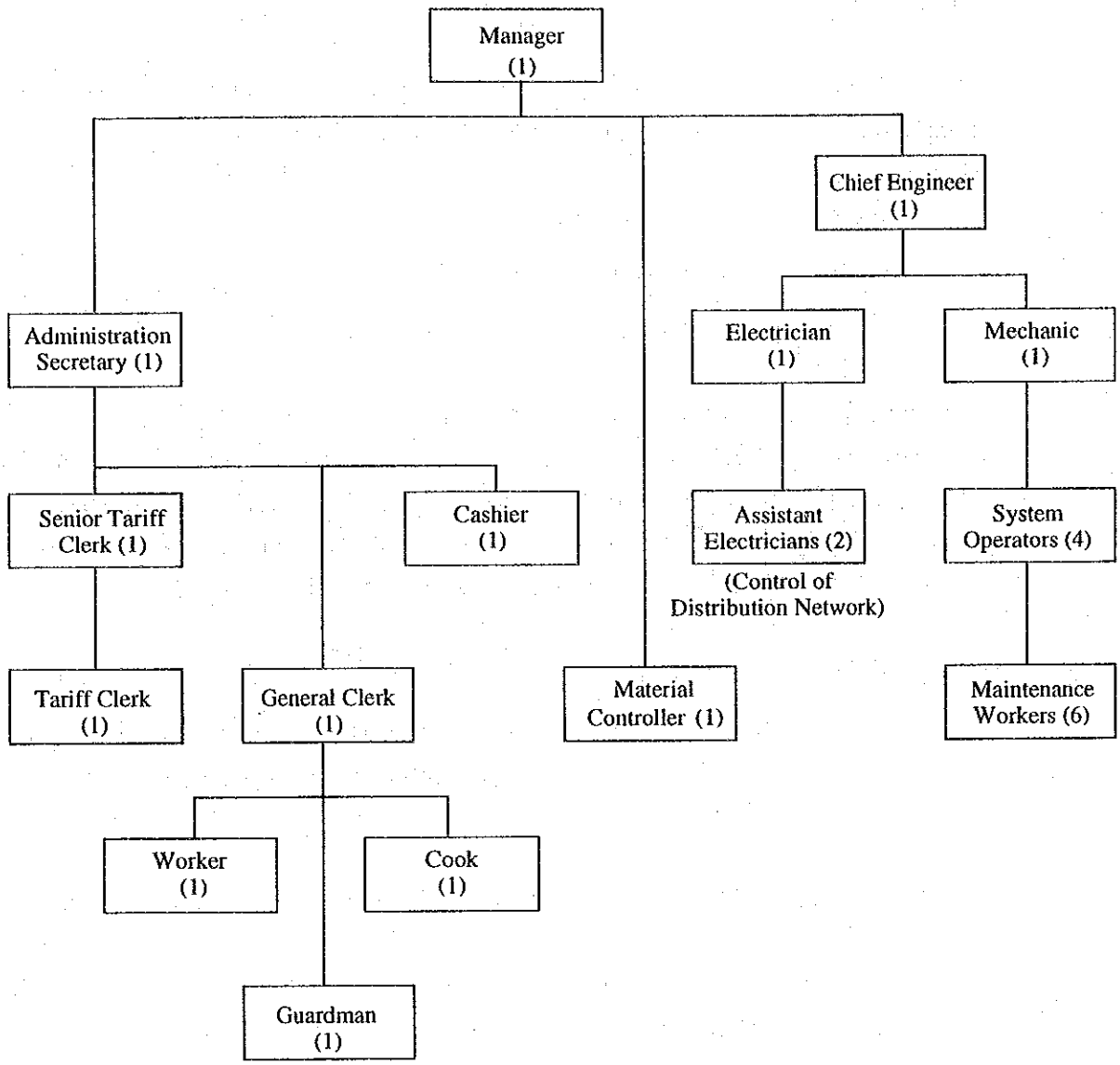

Figure in brackets is the number of staff for each job.

Fig. 4-2 Personnel Plan for New Power Stations

(2) Rate and Collection System

As in the operation of the existing power stations on outlying atoll islands, the meters will be read by a member of the new power station staff and users will be requested to pay the rate directly to the cashier at the power station.

4.2.3 Relationship and Overlapping with Other Aid Projects

No aid projects are currently being implemented by other countries or organizations which relate to or overlap with the Project.

4.2.4 Decision on Subject Islands for Electrification

The priority order of electrification of outlying atoll islands under the Project in the final request of the Government of the Maldives is as follows.

① Naifaru Island of Lhaviyani Atoll

② Eydhafushi Island of Baa Atoll

③ Gan Island of Laamu Atoll

Details of these islands are summarised in Table 3-2. In deciding the subject islands for the Project, it is necessary to establish the viability and urgency of the Project to be implemented on such islands with Japanese grant aid. Moreover, the benefits of the Project's implementation must be ascertained. The current conditions of the subject islands are described here together with their evaluation results.

(1) Naifaru

- Naifaru Island is the administrative seat of Lhaviyani Atoll and is located in a key position of the maritime transportation link between atolls in the north and Male Island.

- Naifaru Island has well established social welfare and other public facilities.

- Although the electrification rate of 53% is fairly high, the system is somewhat unreliable and electricity supply is limited to 5 hours in the evening.

- Naifaru Island is one of those islands which are given the highest priority for electrification in the National Development Plan

The electrification of Naifaru Island under the Project will provide a stable and reliable public electricity supply for not only domestic users but also for social welfare and other public facilities, leading to the vitalisation of the socioeconomy and an improved standard of living. In addition, the island's status as the administrative seat of Lhaviyani Atoll and key location in the northern maritime transport network of the Maldives, will be enhanced. Implementation of the Project on Naifaru Island has a high degree of conformity with the National Development Plan, further emphasising the importance of the island's electrification. (Some 4,000 people living on the island as of July, 1993 will immediately benefit from the implementation of the Project.)

(2) Eydhafushi

- Eydhafushi Island is the administrative seat of Baa Atoll.

- Although the provision of social welfare and other public facilities is still inadequate, expansion in the future is planned.

- The island's communal organization has been trying to provide an electricity supply on the island. However, it is uncertain whether or not these efforts will be successful given the poor finance and technical level of the organization. There is a very strong requirement for electrification on the part of the islanders.

- Electricity supply is currently not provided.

- Eydhafushi Island is one of those islands which are given the highest priority for electrification in the National Development Plan.

The electrification of Eydhafushi Island will meet the significant requirement of islanders and also promises a stable and reliable public supply of electricity to houses as well as social welfare and other public facilities, leading to the development of the island as the capital of Baa Atoll. Concrete results of electrification will include improved socioeconomic conditions and an improved standard of living. Given the high degree of conformity with the National Development Plan, as in the case of Naifaru Island, the Project's implementation is judged highly desirable and important. (Some 2,500 people living on the island as of July 1993 will immediately benefit from the implementation of the Project.)

(3) Gan

- Gan Island has important road links with Funadhoo Island, the administrative seat of Laamu Atoll, Kadhdhoo Island which has an airfield and Maandhoo Island where a fishing base is under construction with Japanese grant aid and funding by Kuwait.

- The atoll administration points out the importance of the coordinated development of the above four islands. At present, there is only one concrete social infrastructure development plan for the area, i.e., the road development

plan prepared with ADB assistance (implementation schedule has been finalised).

- There are independent generating facilities at the atoll office, airfield and fishing base, etc. A concrete electrification plan or relevant investment plan involving the four islands does not exist.

- The Government of the Maldives and the Laamu Atoll administration jointly plan to encourage migration from other outlying atoll islands to the four islands to alleviate over-crowding on Male Island. However, such efforts have so far proved less successful.

- There are three villages on Gan Island and an industrial estate development plan exists.

- Only two sewing factories established with Indian capital have so far commenced operation in the industrial estate. More than 90% of the industrial estate site is still empty and a firm commitment has not been made by possible investors.

- The electrification rate of the three villages is as high as 80%, but the system is unreliable.

The electrification of Gan Island under the Project means the electrification of Gan Island's three villages but not the industrial estate. Some 2,000 islanders (as of July, 1993) will immediately benefit from the implementation of the Project. The local socioeconomy will be vitalised and the standard of village life will be improved. In principle, however, a comprehensive socioeconomic infrastructure development plan involving all four islands should firstly be prepared and a concrete electrification project for these islands should then be prepared as part of such a comprehensive plan. In fact, the atoll administration hopes for the coordinated, simultaneous development of the four islands. The blanket electrification of the islands will assist the alleviation of the uni-polarisation of socioeconomic activities on Male Island which the Government of the Maldives has been trying to achieve. From a technical point of view, the system to provide electricity to the three villages should not be isolated and must eventually be linked to the system for the four islands, creating a possibility of repetitive investment. Moreover, given the slow progress of the industrial estate development plan, estimation of the industrial estate's likely electricity demand

is extremely difficult. Furthermore, there is uncertainty in regard to the number of people (families) who will migrate from other outlying atoll islands with a view to working at the industrial estate and fishing base, etc., making estimation of the future domestic electricity demand also difficult. The lack of a concrete plan to construct public welfare facilities makes such estimates even more difficult. In conclusion, the preparation of an adequate electrification plan is extremely difficult.

Even if estimation of the future electricity demand was possible, the blanket electrification of the four islands, including the industrial estate, would exceed the scope of Japan's grant aid cooperation. As the electrification rate of the three villages on Gan Island is as high as 80% despite the system's unreliability, there appears not to be any urgency to warrant the Project's implementation on Gan Island. As a result, Gan Island was dropped from the list of islands to be electrified under the Project.

The finalised subject islands for electrification under the Project are, therefore, Naifaru Island of Lhaviyani Atoll and Eydhafushi Island of Baa Atoll.

4.2.5 Project Components

The Project, which intends the electrification of outlying atoll islands, consists of the following three components.

(1) Construction of a power station on each subject island

(2) Construction of a distribution network on each subject island

(3) Provision of spare parts, tools, VHF radio station and repair tools for each power station and distribution network.

These three components are essential for electrification of the islands, and proper and coordinated implementation will ensure the Project's benefits. The stable operation of the power stations and distribution networks will guarantee a stable supply of electricity while the availability of spare parts and tools, etc. will ensure the stable operation and maintenance of the power stations and distribution networks. As outlined the project, the construction of the new power stations will be conducted by the Japanese side while the construction of the distribution networks, storage of spare parts and tools, and installation of VHF radio station will be

conducted by the Maldive side using equipment and materials to be provided by the Japanese side. These arrangements make it crucial for the Maldive side to establish a reliable project implementation system in addition to a maintenance system to be introduced following the completion of the Project.

4.2.6 Proposed Generating Facilities and Distribution Network

The objective of the Project is the improvement of the standard of living on outlying atoll islands and the establishment of stable operation and maintenance of such public welfare facilities as health centre and schools by means of urgent implementation of electrification. In examining the optimal scale of the generating facilities and distribution networks, it must accordingly be assumed that the users of the electricity to be generated will be all households, public facilities and factories on Naifaru Island and Eydhafushi Island. The installation capacity should also take into consideration the estimated electricity demand at the time of the service's commencement.

(1) Electricity Demand Increase Rate

Fishing is the predominant industry on Naifaru Island and Eydhafushi Island. Given the size of these islands, it is highly unlikely that an industrial complex will be developed in the near future. In fact, there is hardly any remaining space on the islands for further residential expansion. Consequently, there is little prospect of large electricity users emerging in the future and any increase of the electricity demand will come from the domestic and public welfare sectors in terms of physical expansion and wider use of electrical appliances. The electricity demand annual increase rate for both Naifaru Island and Eydhafushi Island is assumed to be 10% (see 3.4.2).

Gan Island has been omitted from the scope of the Project because of the necessity to create a large generating and distribution system to meet the likely demand of the proposed network which will supply electricity not only to the industrial estate on Gan Island but also to users on the neighbouring three islands (see 4.2.4).

(2) Required Installed Generating Capacity to Meet Project Objective

The electricity demand in 1998, five years after the completion of the Project, will be 168 kW for Naifaru Island and 112 kW for Eydhafushi Island (see 3.4.2). Consequently, it was decided that the required generating capacity is 200

kW (three 100 kW generators, including one reserve) for Naifaru Island and 150 kW (three 75 kW generators including one reserve) for Eydhafushi Island.

For reference purposes only, the required installed generating capacity for Gan Island to meet the domestic demand is placed at 100 kW (three 50 kW generators including one reserve) to meet the estimated demand of 88 kW.

(3) Required Size of Distribution Network

The distribution network to be established on Naifaru Island and Eydhafushi Island will cover all user points, such as households and public buildings. As of July 1993, the number of households is 650 for Naifaru Island and 420 for Eydhafushi Island. The underground cable system will be adopted to avoid salt damage and to ensure the same specifications as those networks already in operation on other islands. Cable will be provided by the Japanese side and the actual laying work will be conducted by the Maldive side.

4.2.7 Necessity for Technical Cooperation

The MEB is fully aware of the necessity for its engineers engaged in the Project to possess appropriate maintenance skills for generating facilities. Based on this awareness, the MEB strongly hopes for the transfer of a wide range of technologies, from basic skills relating to the assembly and installation of generating facilities, to operation and maintenance skills, in view of the effective utilisation of the new power stations to be constructed with Japanese grant aid over a long period of time to improve the electricity supply in the Maldives. The concrete agenda is the provision of technical cooperation by the Government of Japan for the training of engineers following the implementation of the Project as a grant aid project of the Government of Japan.

- Training of engineers in Japan in regard to the operation and maintenance of generating facilities (one electrical engineer and two mechanical engineers) in association with the factory inspection of generators which is planned to be conducted from August to September, 1994.

The provision of the above training in Japan is deemed highly necessary to foster MEB engineers which are capable of operating the new generating facilities.

4.2.8 Basic Aid Principles for the Project

The implementation of the Project as a grant aid project of the Government of Japan is deemed suitable on the grounds that the project is feasible, its benefits, the implementation capability of the Maldive side which has been confirmed, and that these effects meet the criteria for Japanese grant aid cooperation. Consequently, the following basic design contents are based on the assumption that the Project will be implemented with Japanese grant aid cooperation. Table 4-1 compares the original contents of the request made by the Government of the Maldives with the finalised contents of the Project.

Table 4-1 Comparison of Requested Contents and Finalised Project Contents

Item	Original Request	Finalised Project
1. Procurement and installation of diesel generating facilities (including all necessary auxiliary equipment and electrical installation)	O	O
2. Test operation, adjustment and delivery inspection of above generating facilities	O	O
3. Spare parts for above generating facilities	O	O
4. Buildings and foundations for above generating facilities	O	O
5. Procurement and installation of distribution networks	O	O
6. OJT relating to O & M skills for above generating facilities during project period	O	(procurement only) O
7. Training of engineers at generating facilities in Japan	O	(to request separately)

Note: The Maldives side expressed confidence in installing the distribution networks without outside assistance to the Basic Design Study Team, and their capability was confirmed by the latter. Consequently, the installation work for the distribution networks has been dropped from the scope of the grant aid cooperation.

4.3 Outline of the Project

4.3.1 Project Implementation Body and Operation and Maintenance System

The project implementation body on the Maldive side is the MEB and the Outer Male Electricity Generation and Management Bureau will be in charge of the management of the Project (see 2.2.1). Upon completion of the Project, the operation and maintenance of the newly constructed generating facilities and distribution networks will be conducted by the management of each new power station on the islands (see 4.2.2).

4.3.2 Work Plan

(1) Planning Principles

The Government of the Maldives strongly hopes for (1) the urgent improvement of the country's electricity supply through the implementation of the Project, and (2) the establishment and consolidation of the operation and maintenance system following the commencement of the electricity supply service. In view of these hopes, the following points are specially noted in the formulation of the work plan.

1) Building Plan

① The power station building will be constructed using local construction methods where possible to ensure the effective and efficient operation and maintenance of the generating facilities.

② An administrative office building will be constructed to proceed with the daily control of the power station and the general affairs relating to operation and billing, etc.

③ The foundations for the generating facilities, a main fuel tank and auxiliary equipment, etc., will be constructed.

④ A rainwater storage tank and well, will be constructed.

2) Equipment Plan

① Diesel generating facilities will be provided and installed to ensure a stable and continuous supply of electricity.

② Procurement priority will be given to equipment currently produced by manufacturers to ensure long life and easy maintenance. The procurement of currently available equipment will keep the project cost low.

③ VHF radio station and repair tools for maintenance purposes will be provided as requested by the Government of the Maldives to facilitate the operation and maintenance of the procured equipment.

④ Adequate provisions will be taken to prevent environmental pollution following the implementation of the Project.

⑤ Spare parts and tools will be provided to ensure the smooth operation of the generating facilities after the completion of the Project.

⑥ Textbooks and other learning materials will be provided in order to review the skills taught by means of OJT.

3) OJT Programme

① The workers are expected to learn from OJT the elements and relationships of the operation and maintenance system and the status of maintenance work in the overall maintenance scheme of the power station.

② Practical training will be provided by Japanese engineers sent to the Maldives to assist and supervise the construction work.

4) Operation Plan for New Power Stations

The new power stations are expected to provide the base for electricity supply on the respective islands. Therefore, adoption of the following operation conditions appears appropriate.

- annual rate of operation : 100%

- annual operation hours : 8,760 hours

The required regular inspection items to ensure the proper operation of the power stations are described later in 4.3.5 - Operation and Maintenance Plan.

4.3.3 Locations and Conditions of Sites

Some 3,000 m^2 of land (50m x 60m) is required to permit the adequate layout of the power station building and administrative office building. As shown on the Location Map at the beginning of this report, the field survey found a possible site in the northern part of Naifaru Island. Because of the necessity for land preparation and retaining wall erection to make this site usable as a power station site, however,

alternative land of some 1,000 m^2 was found on the east coast. It was decided through consultations with the MEB that some of the existing warehouses will be removed to increase the project site as the present size will not accommodate an access road. (The removal work will be conducted by the Maldive side.)

In the case of Eydhafushi Island, the present sports ground of some 3,500 m^2 located in the northern part will be used as the power station site.

As both sites are flat, land preparation work is unnecessary. Both sites are located in convenient positions on the respective islands for the development of the distribution network.

4.3.4 Outline of Proposed Facilities and Equipment

The building and procurement plans for the proposed facilities and equipment are outlined in this section.

(1) Building Construction Plan

Construction work for the following items will be conducted.

1) Power station building

2) Administrative office building

3) Foundations for generators and auxiliary equipment

4) Rainwater storage tank and well

(2) Equipment Procurement Plan

1) Provision and installation of indoor-type diesel generators

2) Provision and installation of the following mechanical equipment/systems for operation of the power station

① Fuel supply system

② Ventilation System

③ Pipings

3) Provision and installation of the following electrical equipment/systems for operation of the power station

① Main panel board

② Local Control panel mounted on generator

③ Remote control panel

④ Exciter mounted on generator

⑤ DC power system

⑥ Earthing

4) Test operation, adjustment and delivery inspection of all above-mentioned equipment

5) Provision of equipment and materials for the distribution network

6) Provision of spare parts equivalent to approx. two years supply

7) Provision of tools required for maintenance of the generating facilities

8) Provision of radio equipment and repair tools for maintenance purposes

9) Provision of OJT materials

(3) OJT Programme

The following education and training will be provided for the MEB engineers. OJT will be provided for MEB engineers on operation and maintenance techniques by engineers dispatched by the Japanese contractor during the construction period (approximately three months).

4.3.5 Operation and Maintenance Plan

(1) Basic Principles

A proper operation and maintenance system for facilities and the maintenance of appropriate operation conditions are essential in the running of a power station to ensure a stable supply of electricity which can flexibly respond to demand fluctuations.

As described earlier (see 3.1.2), both Naifaru Island and Eydhafushi Island currently have an unstable electricity supply which is provided by personal or communally owned generators. Preventive and other types of maintenance work

aiming at improved reliability, safety and the efficiency of the new generating facilities must be introduced to provide a stable and increased electricity supply and to fully utilise the capabilities and functions of the generating facilities. The basic maintenance framework is shown in Fig. 4-3.

In relation to the Project, the MEB will be required to conduct the maintenance of the new generating facilities following the completion of the Project, within the above basic framework, in accordance with the operation and maintenance manuals using the relevant technologies/techniques to be transferred through the OJT provided by the Japanese contractor during the construction period.

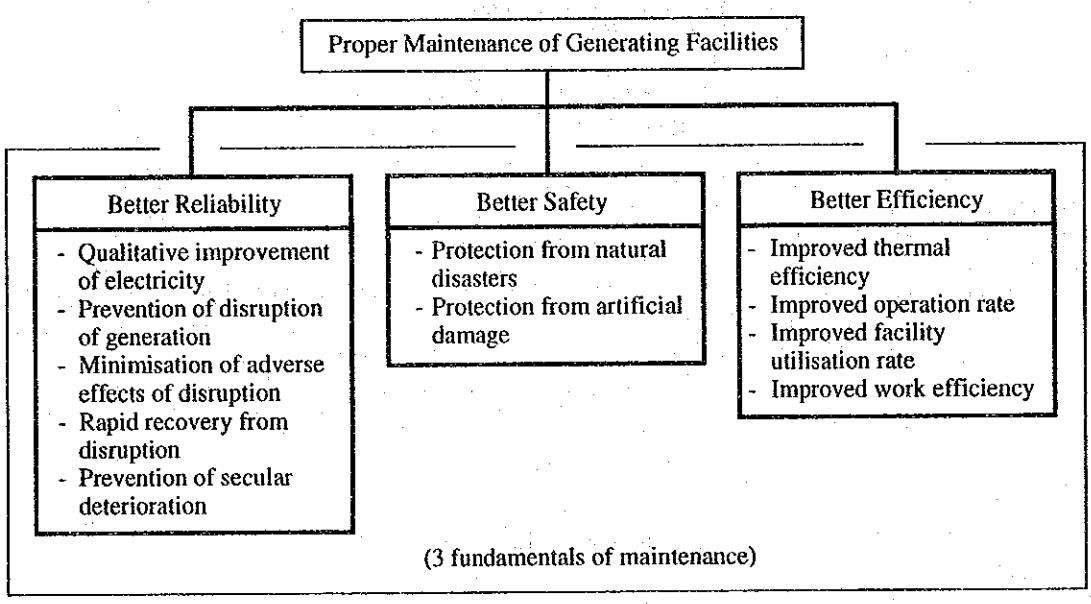

Fig. 4-3 Basic Maintenance Framework for Generating Facilities

(2) Regular Inspection Items

The standard subject items of regular inspection of the proposed generating facilities are listed in Table 4-2.

Table 4-2 Standard Subject Items of Regular Inspection

	Type of Inspection	Main Inspection Items/Work
Diesel Engine	daily (when in use)	- Visual external check; abnormal sound or temperature
	every 10 hours	- Engine oil level - Cooling water level - Fuel level
	every 50 hours	- Valve clearance (only first 50 hours for a new engine) - External nuts and bolts (tightening) (as above) - Engine oil (replacement) (as above) - Oil filter element (replacement) (as above) - Leakage of water or fuel to engine oil - Dewatering from fuel filter
	every 250 hours	- Engine oil (replacement) - Oil filter element (replacement) - Tension of fan and dynamo driving belts - Radiator fins (cleaning) - Fan drive (greasing) - Air cleaner element (cleaning) - Cooling water (replacement twice yearly together with anti-rusting agent)
	every 500 hours	- Oil filter element of governor (replacement) - Fuel injection nozzle (readjustment)
	every 1,000 hours	- Valve clearance - External nuts and bolts (tightening) - Fuel filter (replacement) - Fuel injection timing - Air cleaner element (replacement)
	every 2,000 hours	- Air suction cooler (cleaning) - Turbocharger
Generator	daily (when in use)	- Visual external check; abnormal sound or temperature
	every month	- Abnormal vibration - Lubricant oil flow; oil leakage at bearings - Simple cleaning
	every year	- Insulation resistance; lead wire connectors - Auxiliary items, including space heater - Visual check and cleaning of bearings

(3) Fuel Procurement Plan

The estimated annual fuel consumption (diesel oil) to operate the proposed generating facilities is shown in Table 4-3 for Naifaru Island, and Table 4-4 for Eydhafushi Island. The MEB will be required to prepare an appropriate fuel procurement plan to secure the supply of the necessary amount of fuel shown in these tables in view of the operation of the new generating facilities without any disruption.

Table 4-3 Estimated Annual Fuel Consumption of Naifaru Power Station

Item	1994	1995	1996	1997	1998
Electricity Demand (kW)	113	125	138	152	168
Installed Capacity (kW)	200	200	200	200	200
Operation Rate (%)	56.5	62.5	69	76	84
Hourly Consumption (litres/hour)	28	30	32	34.4	38
Annual Consumption (litres/year)	245,280	262,800	280,320	301,344	332,880

Table 4-4 Estimated Annual Fuel Consumption of Eydhafushi Power Station

Item	1994	1995	1996	1997	1998
Electricity Demand (kW)	74	82	91	101	112
Installed Capacity (kW)	150	150	150	150	150
Operation Rate(%)	49.3	54.7	60.7	67.3	74.7
Hourly Consumption (litres/hour)	22	23	24.4	26	28
Annual Consumption (litres/year)	192,720	201,480	213,744	227,760	245,280

Note: The recommended fuel for the proposed generating facilities is ASTMD-975 diesel oil No. 2-D, and the fuel consumption rate shown in Fig. 4-4 was used as the reference to estimate the annual consumption.

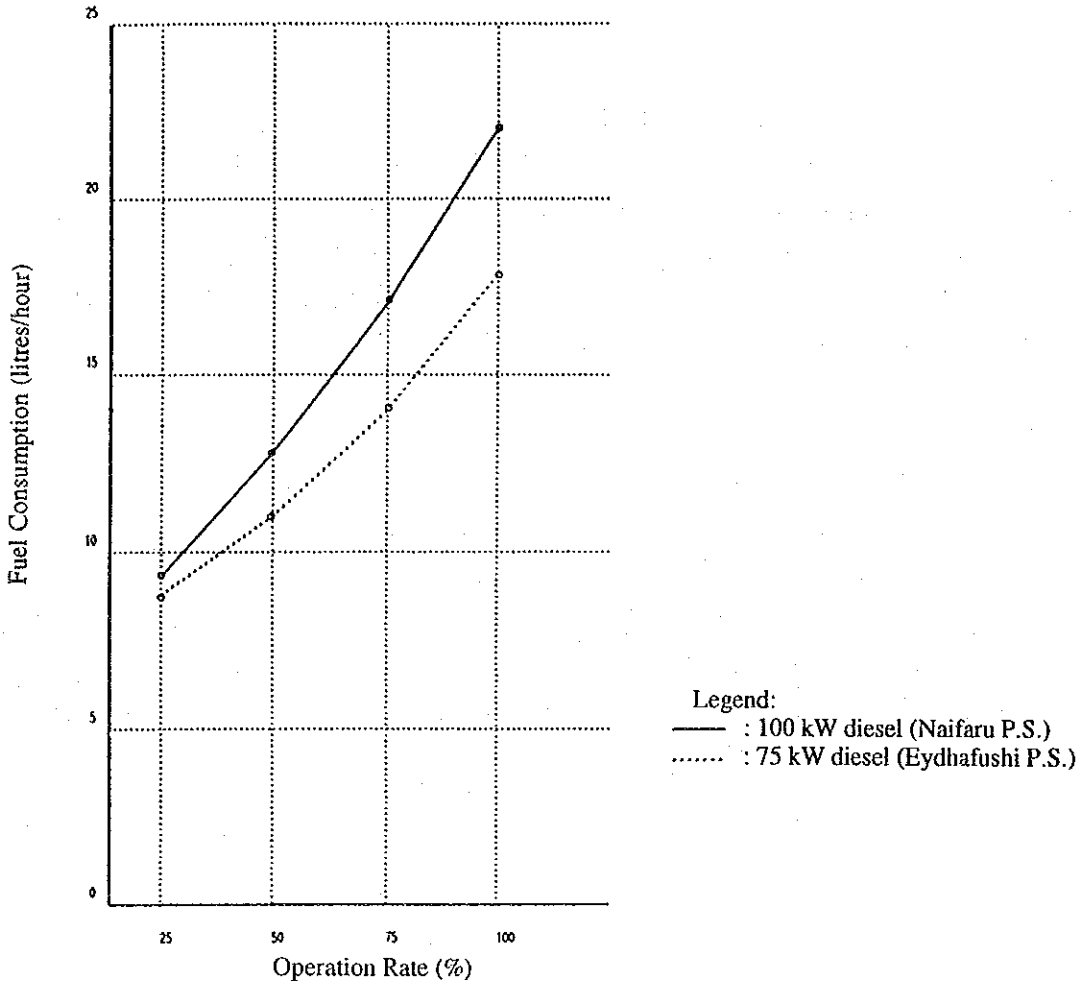

Fig. 4-4 Fuel Consumption Rate

4.4 Technical Cooperation

The argument for the provision of technical cooperation has already been discussed in 4.2.7. The provision of such technical cooperation by the Government of Japan to transfer operation and maintenance technologies/techniques is deemed essential for the proper functioning and maintenance of the generating facilities to be provided under the Project. The required technical cooperation is outlined in Table 4-5.

Table 4-5 Required Technical Cooperation

Item	Objective	Remarks
Training in Japan	Learning of basic technical skills and knowledge relating to the running of diesel generators	2 mechanical engineers and 1 electrical engineer

CHAPTER 5 BASIC DESIGN

CHAPTER 5 BASIC DESIGN

5.1 Design Principles

5.1.1 Principles Concerning Natural Conditions

(1) Temperature and Relative Humidity

Temperature records for the last 25 years indicate that the region is dominated by a tropical climate with maximum, minimum and annual average temperatures of 34.1°C, 17.2°C and 28°C, respectively.

As the generating facilities to be provided under the Project will be installed indoors, no special measures vis-a-vis the outdoor air temperature will be required. In principle, the distribution cable will be buried underground and, therefore, will be little affected by the outdoor air temperature. However, careful attention should be paid to the maintenance of the equipment in view of the high relative humidity throughout the year.

(2) Rainfall

The rainfall is significant from May to October and accompanies the seasonal southwest wind. The monthly rainfall can reach as much as 200 mm from May to July, and the tall waves at this time make maritime transportation outside the atolls hazardous. Navigation within the great ring of atolls will, therefore, be necessary when transporting items to the outlying atoll islands.

(3) Salt Damage

As the project sites are located on the coast, the generating facilities must be installed indoors to prevent salt damage. The fuel storage tanks and unloading facilities will be constructed outdoors and given protective painting.

With regard to the distribution network, the distribution panels will be installed outdoors, necessitating protective painting or the use of highly salt-resistant materials. In contrast, the distribution cables will be buried underground and not require such care.

5.1.2 Principles Concerning Use of Local Construction Industry

The use of local equipment and materials (such as coral blocks) should be included where possible in the construction plan. However, such crucial structural materials as sand, gravel and cement are not available locally and will be imported from a third country.

While the level of skill required to install the planned generating facilities is not particularly significant, Japanese engineers will be sent to the Maldives to provide technical guidance and to supervise the process control to ensure completion of the work on time.

5.1.3 Principles Concerning Operation and Maintenance Capability of Project Implementation Body

At present, all generating facilities in the Maldives use diesel engine generators and, therefore, the MEB is believed to have the necessary expertise to operate and maintain the generators to be provided under the Project. However, the provision of OJT by Japanese engineers for the MEB engineers to be assigned to the new power stations is highly desirable in view of guaranteeing the more effective and efficient operation and maintenance of these power stations.

5.1.4 Principles Concerning Design Scope and Technical Levels of Proposed Facilities, Equipment and Materials

The design scope and technical levels to be adopted for the facilities to be constructed and equipment to be provided under the Project are determined based on the following principles.

(1) Design Scope

The configuration of the generating facilities, types and quantities of equipment and materials, and contents of OJT will be carefully decided to achieve the objective of the Project, i.e., a stable electricity supply for domestic and public use, (see 4.1) by means of (1) the construction of generating and distribution facilities, (2) the provision of equipment and materials, including spare parts, and (3) the provision of OJT.

(2) Technical Levels

The specifications for generating equipment must not exceed the technical levels of existing equipment, facilities, operation and maintenance of which MEB engineers are familiar. The OJT to be conducted under the Project should aim at fostering the technical capabilities of MEB engineers to a level where they can analyse operation and breakdown data of the new facilities based on improved operation and maintenance skills, and prepare and conduct appropriate preventive inspections.

5.1.5 Principles Concerning Construction of Facilities

The following basic design principles concerning construction of the facilities have been adopted taking into consideration the principles described thus far regarding common layouts of the buildings and of equipment inside the existing power stations, operating conditions of electrical and mechanical equipment in such power stations, and future plans in neighboring areas, etc.

(1) The selected sites for the new power stations must not interfere with future social welfare development and other similar public plans.

(2) The electricity generated by the new power stations will be supplied to households and public buildings, etc., via the 400V distribution network.

(3) The diesel engine to be used for generation should allow continuous operation. Given the small generating capacity required, a general-purpose diesel engine with a speed of 1,500 rpm or less will be selected.

(4) The fuel (diesel oil) to be used will be of the same quality as the fuel currently used by the existing power generating facilities.

(5) The fuel tank capacity will be sufficient enough to support the continuous operation of two generators for 30 days due to the anticipated difficulties in maritime transportation between May and July.

(6) As most of the equipment and materials for the Project will originate from Japan or a third country (see 5.4.4), either Japanese standards/codes or the British standards used in the Maldives will, in principle, be referred to in the manufacture/procurement of such equipment.

5.1.6 Principles Concerning Environmental Conservation

There are not any regulations on noise, emission gas and waste oil treatment in the Maldives. The relevant criteria adopted in Japan or countries neighboring the Maldives will be referred to in the basic design for the Project.

5.2 Examination of Design Conditions

Having examined the various conditions and principles for the basic design, it was decided to adopt the following design conditions.

5.2.1 Climatic and Site Conditions

(1)	Outdoor Air Temperature	:	maximum 34°C (the maximum design temperature for air-conditioning : 32°C)
(2)	Diesel Generator Room	:	maximum 40°C (indoor)
(3)	Relative Humidity	:	average 95%
(4)	Average Annual Rainfall	:	approximately 2,000 mm May - July: approximately 200 mm/month average monthly rainfall: approximately 160 mm/month
(5)	Wind Velocity	:	maximum 115 km/hour (31.9 m/s)
(6)	Earthquakes	:	not considered
(7)	Salt Damage Prevention	:	generators and other machinery to be installed indoors; distribution cables to be buried underground
(8)	Dust Prevention	:	not considered
(9)	Bearing Strength	:	10 tons/m^2

(10) Noise Prevention : - Special attention will be paid to the equipment layout so that the engine exhaust, which is the noisiest part, will be located on the seaward side as well as the leeward side.

- Sound insulation materials will be used for the internal walls of the generator room to minimise sound leakage from the room.

- The power station building will be located as far as possible from nearby houses and/or public facilities.

5.2.2 Generating Method

As in the case of existing similar facilities, the electrical generating facility is diesel engine generator.

5.2.3 Fuel

The composition of the diesel oil currently imported from Singapore and used by the Male Power Station is shown in Table 5-1. The same diesel oil will be used for the new power stations.

Table 5-1 Composition of Fuel (Diesel Oil) Used by Male Power Station

Item	Unit	Value
Specific Gravity (60°F)	-	0.82 - 0.89
Kinematic Viscosity (40°C)	Stokes (cSt)	1.80 - 5.00
Pour Point	°C	9
Flash Point	°C	60
Sulphur Content	wt%	1.0
Water Content	Vol.g	0.05
Ash Content	wt.g	0.01
Calorific Value	KJ/kg	42,700

5.2.4 Lubricant Oil

The use of lubricant oil of the API-class, service CD-class and SAE No. 30~40 is recommended.

5.2.5 Cooling Water

Since ground water from wells contains salt, rainwater will be used as in the case of the existing power stations.

5.2.6 Distribution Method

The trunk distribution will be star distribution of 3 phase, 4 wire, 400/230V and 50 Hz as in the case of the already electrified outlying atoll islands, while the distribution to housing from a local distribution panel will be single phase, 2 wire and 230V. The distribution to public facilities will be 3 phase, 4 wire and 400/230V because of the larger load involved than domestic use.

5.2.7 Applicable Codes and Standards

The following standards will be referred to in the design of the project contents.

(1) Japanese Industrial Standards

(2) Standards of the Japanese Electrotechnical Committee

(3) Standards of the Japan Electrical Manufacturers' Association

(4) Japanese Electrotechnical Codes

(5) Japanese Cable Makers Association Standards

(6) Technical Standards for Electrical Installations

(7) International Electrotechnical Commission

(8) International Organization for Standardization

(9) British Standards

5.3 Basic Plan

5.3.1 Layout Plan

The installation locations for the planned generating facilities were described in 4.3.3. The following points should be noted in the preparation of the layout plan.

(1) The diesel engines will be located as far as possible from existing stations and public buildings to minimise noise disturbance.

(2) A space to accommodate the diesel generator will be provided inside the power station building to facilitate expansion of the generating capacity in the future. A site for an additional fuel tank will similarly be secured.

(3) Sufficient space will be available inside the power station building to facilitate maintenance of the diesel generators.

5.3.2 Building Plan

(1) Plan Contents

The following buildings and facilities will be constructed at the Naifaru Power Station and Eydhafushi Power Station sites.

- Power station building (1): single storey with a total floor area of 184.0 m^2
- Administrative Office Building (1): single storey with a total floor area of 88.0 m^2
- Foundations: including those for generators and oil tank
- Rainwater Tanks for Drinking Water (2): 5.0 m^3 each (nominal capacity)
- Rainwater Tank for Miscellaneous use (1) : 10.0 m^3 (nominal capacity)
- Well (1): ground water for toilet
- Simple Septic Tank (1)

(2) The facilities to be provided should be sufficient to support the proper functioning of the power stations.

1) Power station building

	Room	Floor Area (m^2)	Installed Equipment Types
1	Generator Room	8.0 x 11.0 = 88.0	lighting, ventilation
2	Control Room	6.0 x 4.0 = 24.0	lighting, air-conditioning
3	Battery Room	2.0 x 4.0 = 8.0	lighting, ventilation
4	Engineer Room	5.0 x 4.0 = 20.0	lighting, air-conditioning
5	Entrance Hall	3.0 x 2.0 = 6.0	lighting
6	Toilet	1.5 x 2.0 = 3.0	lighting, ventilation, sanitation
7	Spare Parts Storage	4.0 x 4.0 = 16.0	lighting, ventilation
8	Workshop	4.0 x 4.0 = 16.0	lighting, ventilation
9	Kitchenette	1.5 x 2.0 = 3.0	lighting, ventilation, sanitation
	Total	184.0 m^2	

2) Administrative Office Building

	Room	Floor Area (m^2)	Installed Equipment Types
1	Entrance Hall	3.0 x 4.0 = 12.0	lighting
2	Office	7.5 x 4.0 = 30.0	lighting, air-conditioning
3	Director's Room	3.5 x 4.0 = 14.0	lighting, air-conditioning
4	Kitchenette	2.0 x 2.0 = 4.0	lighting, ventilation, sanitation
5	Toilet	1.0 x 0.5 + 3.0 x 2.0 = 6.5	lighting, ventilation, sanitation
6	Storage	2.5 x 2.5 = 6.25	lighting, ventilation
7	Radio Room	2.5 x 4.0 = 10.0	lighting, air-conditioning
8	Corridor	3.5 x 1.5 = 5.25	lighting
	Total	88.0 m^2	

3) Foundations

Foundations will be constructed to support the diesel engine generators, auxiliary equipment, electrical installations and oil tanks, etc.

4) Rainwater Tanks and Well

- Two tanks (5.0 m^3 each) will store rainwater on the roof of the administrative office building for use as drinking water and cooling water for the diesel engines.

- One tank (10 m^3) will store rainwater on the roof of the power station building for miscellaneous use.

- A well will be constructed to use ground water for the toilet.

5.3.3 Equipment Plan

(1) Plan Components

1) Engine Output and Generator Capacity

As the rated output of the generators to be provided under the Project is 100 kW for Naifaru Island and 75 kW for Eydhafushi Island, the required engine output and rated generator capacity are calculated as follows. The values indicated below should be used for rough guidance only as the equation slightly varies from one manufacturer to another.

① Engine Output

$$Pe \geqq \frac{P}{0.7355 \times \eta G}$$

Pe : engine output (PS: French horse-power)

P : generator output (kW)

ηG : generator efficiency (90%)

Item	Naifaru	Eydhafushi
P (kW)	100	75
Pe (PS)	150	115

② Generator Capacity

$$PG = \frac{P}{Pf}$$

PG : generator capacity (kVA)

P : generator output (kW)

Pf : generator power factor: 0.8

Item	Naifaru	Eydhafushi
P (kW)	100	75
PG (kVA)	125	93.75

2) Mechanical Systems

① Fuel Supply System

An outdoor diesel oil storage tank will be installed for each power station and the capacity is determined based on the following two conditions.

- Tank Capacity

The arrival of oil supply ships may not be regular due to the difficulties of maritime transportation caused by the prevailing strong seasonal southwest wind from May to July. The storage of at least one months (30 days) supply of fuel for the two continuously operating generators appears necessary.

- Consumption Rate

The following consumption rate is assumed based on a 100% operation rate of the two generators (see Fig. 4-4).

Item	Naifaru	Eydhafushi
Consumption Rate V1 (litres/hour)	44	35.4

The required tank capacity can be calculated using the following equation.

$$V = \frac{V1 \times 24 \times 30}{1,000}$$

V : capacity (kl)

V1 : consumption rate (litres/hour)

The resulting nominal capacity of the fuel tank is as follows.

Item	Naifaru	Eydhafushi
Nominal Capacity (kl)	32	26

A daily tank with a capacity of 0.6 kl will be installed indoors at both sites to store fuel oil equivalent to 12 hours consumption. Two fuel pumps (one as reserve) will be installed outdoors with a simple roof and with a capacity of 40 litres/min. so that the daily tank can be filled in 15 minutes. Fuel will be transported in drum cans (200 litres) to the site and pumped to the main storage tank. A de-oiler will be installed at the outlet of the fuel pump to remove water in the case of water penetrating the drum can.

② Lubricant Oil Supply System

This system is integral to the diesel engine body and oil will be manually replenished.

③ Water Cooling System

This system is also integral to the diesel engine body and rainwater will be used as the cooling water.

④ Ventilation System

A ventilation system will be installed in the power station building and exhaust gas from the engines will be discharged outside the building via the silencer.

⑤ Start-Up System

An electrical start-up system using a DC motor will be used. A DC power unit (24V) for this purpose will also be used for the operation of the power station and will be installed in the Battery Room.

⑥ Waste Oil Treatment System

In order to prevent the planned generating facilities from causing environmental pollution, a de-oiler will be installed to the diesel oil storage tank to separate oil from water for the manual scooping of oil. The collected sludge and waste oil must be properly treated by the MEB to avoid any environmental pollution caused by their disposal.

⑦ Piping

With regard to the fuel pipeline to supply fuel to the generators, the indoor section will be laid in a trench for easy maintenance while the outdoor section will be directly buried to make sure the maximum use of available land. All piping will be accompanied by the necessary support and protective measures, such as a jute sheath.

3) Electrical Systems

The main electrical systems of this network are designed as follows.

① 400V Main Distribution Board

The electricity generated by the generating facilities will be supplied directly to the 400V distribution feeder without involving a transformer facility. The 400V distribution feeder will be accompanied by a moulded-case circuit breaker (MCB), an earth fault relay and a number of instruments (a watt-hour meter, an ammeter and its change-over switch and a voltmeter and its change-over switch). The rated current for the buses will be the value to be achieved by 4 simultaneously operating generators. When the buss voltage is lost, the MCB will be automatically tripped by an under-voltage relay. Manual switching of

the MCB will be required to resume normal operation. The buses will have a structure which allows it expansion in the future.

② Local Control Panel

A local control panel will be installed above each generator to start, stop, control and measure the generating system as well as to start the warning system.

③ Remote Control Panel

All the generating facilities of the planned power stations will be centrally controlled by the remote control panel in the control room. The synchronous operation of the generators will be instructed from the control room.

④ Excitor

A brushless thyristor-type excitor will be installed.

⑤ DC Power Supply System

A DC power supply system will be installed to power the start-up motors for the diesel engine as well as the circuit breaker and other operation-related equipment.

⑥ Earthing

The following earths will be required for the planned power stations.

a) Earth to protect the electricity generating system (direct earth from the neutral point of the generator)

b) Earth to prevent electric shocks from metal surfaces or electrical equipment

c) Earth for the fuel tank (to be separated from a) and b) above)

⑦ VHF radio station for Maintenance Purposes

A VHF radio station will be provided for communication between each power station and the Male Power Station.

⑧ Laying of Cable

The main cable connecting the generators and 400V main distribution panel will be without armour and will be laid on a cable tray inside the trench.

4) Distribution Cable Laying Plan

The electricity generated by the planned power stations will be distributed to households and public buildings on the subject islands via the 400V main distribution panel. The main design features of distributing facilities are as follows.

① Trunk and Branch Cables

a) Load Capacity

The trunk and branch cables will be capable of meeting the load 5 years after the completion of the power stations in 1994. Assuming a load/user of 200W in 1994 (see 3.4.2) and an annual load increase of 10% up to 1998, the load/user in 1998 will be 293W as shown below. Using this 293W, the trunk and branch cable sizes will be calculated.

(Unit: W)

1994	1995	1996	1997	1998
200	220	242	266	293

b) Voltage Drop

The voltage drop between the main 400V distribution panel board to end users will be kept to 8% or less. According to the Japanese Standards (JEAC 8001), the maximum voltage drop for a wiring distance of more than 200m is 6% or less. A maximum voltage drop of 8% is adopted for the Project as the distribution line is a trunk line stretching over 400m.

c) Specifications

As the trunk line will be directly buried underground, cable with armour will be used. In the case of branch lines, cable without

armour will be used to permit easy bending despite being directly buried underground.

d) Laying Depth and Location

The laying depth of all underground cable will be approximately 75cm below the ground surface. Only one side of the roads will be used for the laying of cable as the other side will be required for communication cable. Underground warning tape made of vinyl will be laid in view of the easy recognition of the cable location for future expansion work.

② Local Distribution Panels

Local distribution panels will be used to distribute electricity from the trunk line to users and one panel will be equipped with 15 branch lines to serve houses and street lighting (single phase, 2 wire, 230V), one line for public buildings (3 phase, 4 wire, 400/230V) and space of 2 lines for future extensions. The location of each local distribution panel should ensure that the maximum length of the branch cable to users is not more than 80m. These free-standing panels will be installed at the side of roads.

③ Household Panel boards

The household panel board unit will be a wooden board mounted with a single phase, 230V -type WH meter, fuse, or moulded-case circuit breaker (MCB), earth leakage breaker and three receptacles with a pin-type switch.

The panel board at public buildings will also be a wooden board mounted with a 3 phase, 4 wire-type WH meter, fuse, or MCB and earth leakage breaker. The panel boards for public (at Dhoni and port) will have a box shape with a single-phase 230V-type WH meter, fuse or MCB and 3 receptacles with a pin-type switch mounted on the inside.

5) Building Services Plan

① Rainwater Collection and Transfer System

Rainwater will be used for two different services.

a) Rainwater collected from the roof of the administrative office building will be stored in water tanks (5 m^3 x 2) and will be supplied by an automatic water supply system through pipes to the administrative office building and power station building as drinking water. The water from these tanks will also be used as cooling water for the diesel engine and supply will be manually conducted.

b) Rainwater collected from the roof of the power station building will be stored in a different water tank (10 m^3) and will be supplied by an automatic water supply system to the administrative office building and power station building for miscellaneous use (sprinkling and cleaning of battery room).

② Well

Ground water will be pumped from the newly constructed well and supplied to the toilet on the premises by an automatic water supply system.

③ Fire-Fighting

An ABC fire extinguisher (3 kg type) will be provided in each room, except the toilet and corridors. One halogen fire extinguisher will be provided in the control room.

6) General Specifications of Main Equipment

The general specifications of the main equipment have been decided as shown in Table 5-4, taking all the design principles, conditions and past performance records of existing generating facilities similar to the scale of those planned under the Project into consideration.

Table 5-4 General Specifications of Main Equipment

Equipment	General Specifications
1. Diesel Engine	Standard Operation Mode: continuous Output: 150 PS (Naifaru), 115 PS (Eydhafushi) Revolutions: under 1,500 rpm Engine Type: 4 cycle diesel engine Cooling Method: radiator-type Fuel: diesel oil (with common base and anti-vibration rubber)
2. Generator	Standard Operation Mode: continuous Rated Output: 100 kW (Naifaru), 75 kW (Eydhafushi) Phase: 3 phase, 4 wire Rated Voltage: 415/240V Revolutions: under 1,500 rpm Power Factor: 0.8 (lag) Frequency: 50 Hz Coil Connection: Y connection, leader from neutral line Excitor: brushless thyrister-type
3. Electrical Systems 1) 400V Main Distribution Board 2) Local Control Panel 3) Remote Control Panel 4) DC Power Supply System 5) Radio Equipment	 400V with mould case circuit breaker control panel attached to generator independent with synchronization system lead battery, 24V VHF
4. Mechanical Systems Fuel Supply System 1) Fuel Tank 2) Daily Tank 3) Fuel Pump 4) Oil Water Separator	 Type: vertical type (Naifaru), horizontal cylinder (Eydhafushi) for outdoor installation Capacity: 32 kl (Naifaru), 26 kl (Eydhafushi) Quantity: one for each site Type: angular (with supporting bed) for indoor installation Capacity: 600 litres (for both Naifaru and Eydhafushi) Quantity: one for each site Type: gear pump for outdoor installation Capacity: 40 litres/min. (3 kg/cm^2) Quantity: 2 for each site (one as reserve) Type: filter element Capacity: 40 litres/min. Quantity: one for each site
5. Distribution System 1) Local Distribution Panel 2) Household Panel board 3) Cable (Trunk Line) 4) Cable (Branch Line)	 400V with mould case circuit breaker mounted with WH meter, earth leakage breaker and mould case circuit breaker 600V with armour 600V without armour
6. Building Services 1) Drinking Water ① Water Tank ② Water Supply System 2) Miscellaneous Use Water ① Water Tank ② Water Supply System 3) Well ① Water Supply System	 Type: for outdoor installation Capacity: 5 m^3 Quantity: 2 for each site Type: automatic water supply (centrifugal pump with pressure control) for outdoor installation Capacity: 18 litres/min. (14 mWG) Quantity: one system (2 pumps, pressure tank and control panel) Type: for outdoor installation Capacity: 10 m^3 Quantity: one Type: automatic water supply (centrifugal pump with pressure control) for outdoor installation Capacity: 18 litres/min. (14 mWG) Quantity: one system (2 pumps, pressure tank and control panel) Type: automatic water supply (centrifugal pump with pressure control) Capacity: 18 litres/min. (14m WG) Quantity: one system (1 pump, pressure tank and control panel)