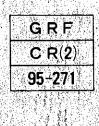
Ministry of Finance and Treasury Maldives Electricity Board The Republic of Maldives

BASIC DESIGN STUDY REPORT ON ATOLL ISLAND ELECTRIFICATION PROJECT (PHASE II) IN THE REPUBLIC OF MALDIVES

DECEMBER 1995



JAPAN INTERNATIONAL COOPERATION AGENCY (JICA) YACHIYO ENGINEERING CO., LTD.



No. 1

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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 (Phase II) and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Maldives a study team from July 31 to September 5, 1995.

The team held discussions with the officials concerned of the Government of 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 Maldives in order to discuss a draft basic design, and as this result, the present report was finalized.

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

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

December, 1995

Kimio Fujita President Japan International Cooperation Agency

December, 1995

Letter of Transmittal

We are pleased to submit to you the basic design study report on Atoll Island Electrification Project (Phase II) in the Republic of Maldives.

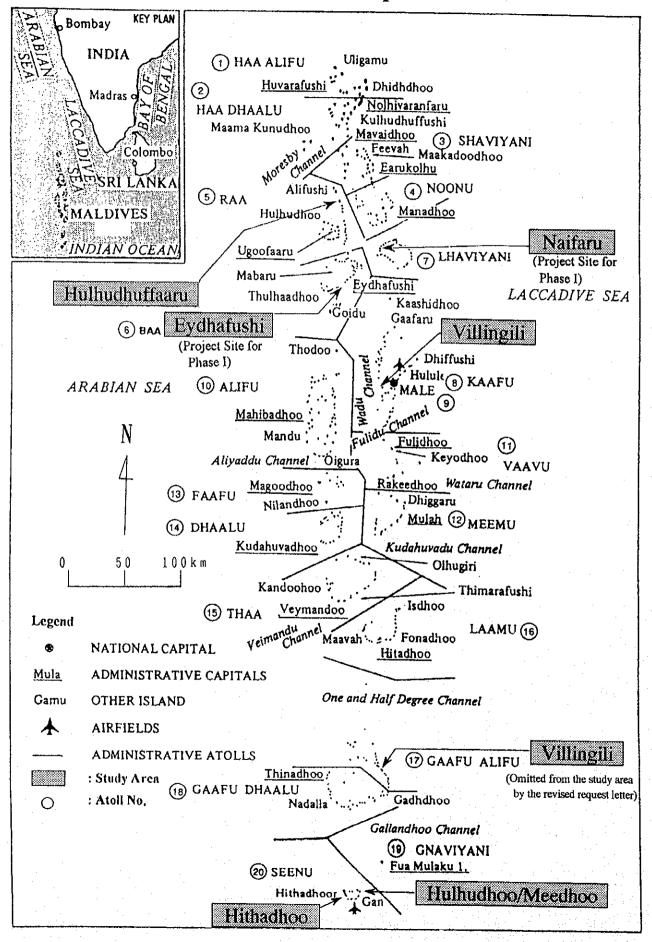
This study was conducted by Yachiyo Engineering Co., Ltd., under a contract to JICA, during the period from July 26, 1995 to January 22, 1996. In conducting the study, we have examined the feasibility and rational of the project with due consideration to the present situation of Maldives and formulated the most appropriate basic design for the project under Japan's grant aid scheme.

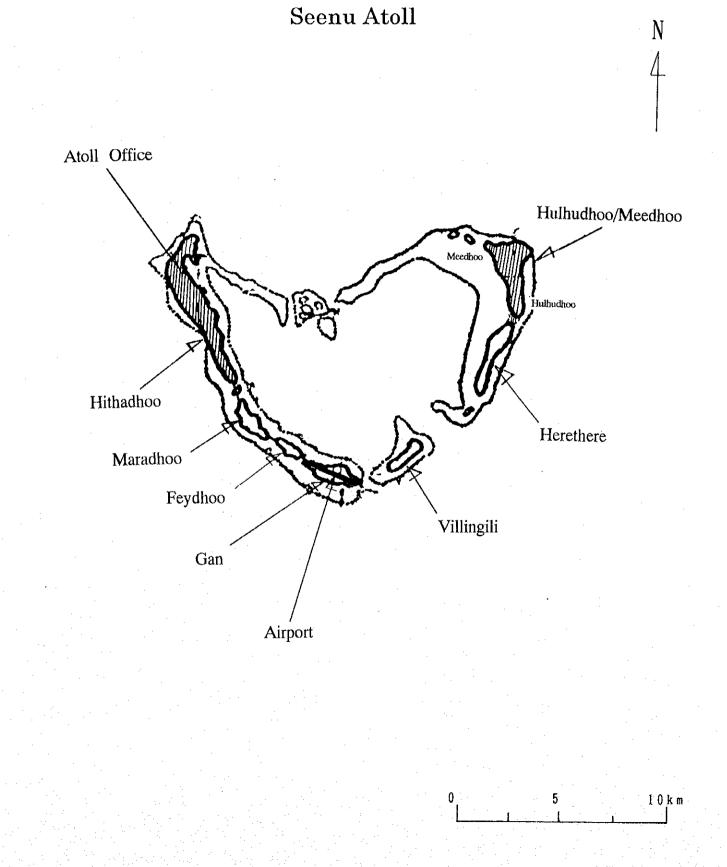
Finally, we hope that this report will contribute to further promotion of the project.

Very truly yours,

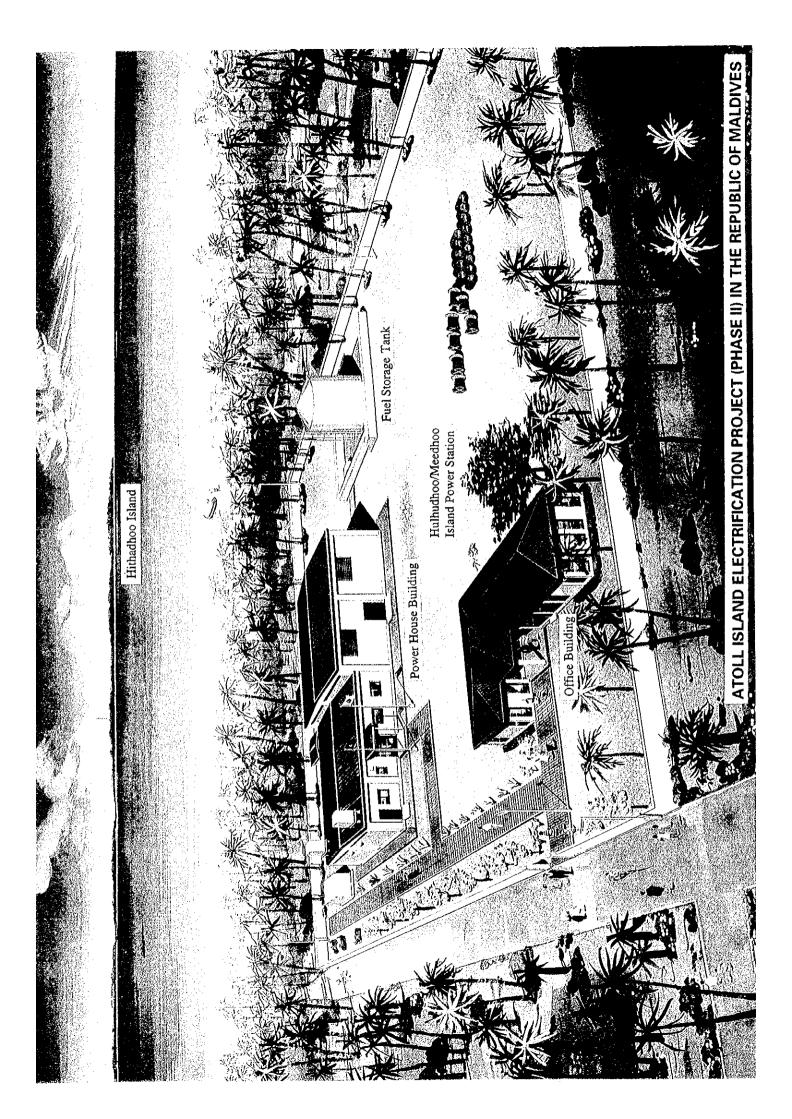
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Mitsuhisa Nishikawa Project manager, Basic design study team on Atoll Island Electrification Project (Phase II) Yachiyo Engineering Co., Ltd. Site Location map





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ABBREVIATIONS

ADB	Asian Development Bank	

DEG Diesel Engine Generator

E/N Exchange of Notes

GDP Gross Domestic Product

GNP Gross National Product

IEC International Electrotechnical Commission

ISO International Organization for Standardization

JEAC Japan Electric Association Code

JEC Japanese Electrotechnical Committee

JEM Standards of the Japan Electrical Manufacturer's Association

JICA Japan International Cooperation Agency

JIS Japanese Industrial Standards

MEB Maldives Electricity Board

O&M Operation and Maintenance

OJT On the Job Training

Rf Rufiyaa (1 US\$ = 11.72 Rf, as of August 1995)

STO State Trading Organization

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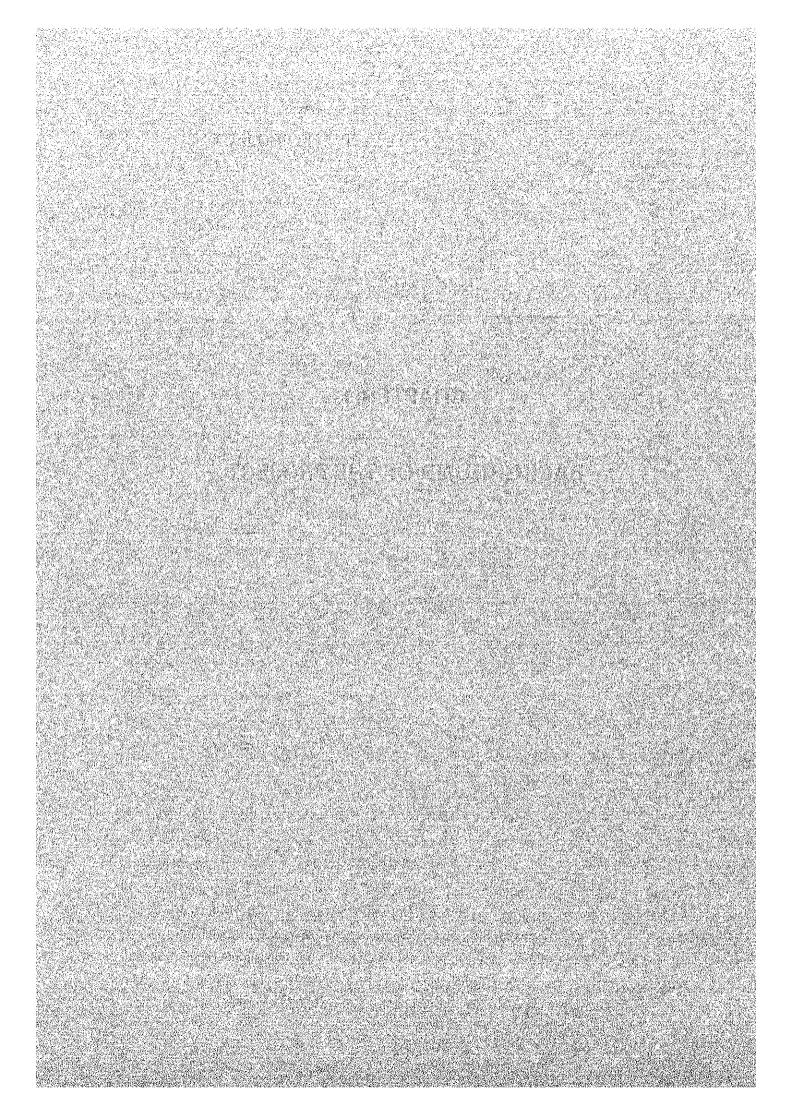
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CHAPTER 1

BACKGROUND OF THE PROJECT



CHAPTER 1 BACKGROUND OF THE PROJECT

The Republic of the Maldives (hereinafter referred to as the Maldives) is an archipelago country stretching 880km in the north-south direction and 140km in the east-west direction in the Indian Ocean and consists of some 1,200 coral islands of which only 266 islands are inhabited. These islands, in fact, form 20 atolls and each atoll constitutes an administrative unit. The economy of the Maldives depends on the two predominant industries of tourism and fisheries and the former has achieved conspicuous growth in recent years. Despite steady economic growth, however, the trade balance shows a chronic deficit due to the need to import food and most daily necessities. The GDP per capita is 703.4 US\$ (figure for 1993).

Of the total population of some 246,000 (1994), some 64,000 live on Male Island (1994 estimate) where the capital of the Maldives is located. This unipolarisation of the population is one of the country's biggest problems together with the rising sea level which is assumed to be caused by global warming. The Government of the Maldives has taken the mitigation of the population concentration through balanced development throughout the country as a major theme for national development and particularly emphasises the development of basic infrastructure in local areas.

While the Maldives Electricity Board (MEB), a public organization, is responsible for the supply of domestic electricity, it only supplies electricity to households on 13 islands (as of August, 1995), including Male Island. In addition, such government organizations as the STO supply electricity to specific facilities while resort facilities and some wealthy individuals have their own electricity generating units. The low level of electrification is particularly noticeable on local atoll islands and the lack of electricity supply is a stumbling block to improving the local standard of living and promoting local development. Improvement of the electricity supply in local areas has, therefore, been a leading issue throughout a series of national development plans.

Under these circumstances, the Government of the Maldives prepared the Atoll Island Electrification Project and made a request to the Government of Japan for the provision of grant aid for the Project, consisting of the construction of power generation buildings and installation of the relevant equipment. In response to this request, the Government of Japan provided grant aid (totalling 588 million yen in fiscal 1993 and hereinafter referred to as the Phase I Project) to construct a power station equipped with the necessary machinery and to provide materials and equipment for the distribution network for two islands (Naifaru Island of the Lhaviyani Atoll and Eydhafushi Island of the Baa Atoll). This grant aid for the Phase I Project was highly evaluated by the Government of the Maldives as the Phase I Project

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to consolidate the social infrastructure, particularly the development of power generation facilities of which the construction required hard currency, on local atoll islands. Such development has indeed been given priority in the national development plans to halt the population concentration on Male Island. Following the successful completion of the Phase I Project, the Government of the Maldives made a new request (Original Request) to the Government of Japan for the provision of further grant aid for the Atoll Island Electrification Project (Phase II) (hereinafter referred to as the Project) which aims at electrifying another 5 atoll islands.

Contents of the Original Request

Provision of the materials and equipment required by the electrification programme for 5 atoll islands.

- 1) Construction : those required for the construction of a power house building, an office Materials building and incidental facilities for each island
- 2) Equipment : diesel engine generator (DEG), associated electrical equipment and such auxiliary items as distribution cable, panelboards, workshop equipment and others

Requested Project Sites of the Original Request

- 1) Hithadhoo Island (Seenu Atoll)
- 2) Hulhudhoo/Meedhoo Island (Seenu Atoll)
- 3) Villingili Island (Gaafu Alifu Atoll)
- 4) Hulhudhuffaaru Island (Raa Atoli)
- 5) Villingili Island (Kaafu Atoll)

Through enquiries made to the Ministry of Finance and Treasury and the MEB, the Study Team confirmed that the contents of the Revised Request (dated July 19, 1995 and describing 4 islands as the subject islands for electrification) but not those of the Original Request (dated July 2, 1994 and describing 5 islands as the subject islands for electrification) comprised the latest request of the Government of the Maldives. Table 1-1 shows the differences between the Original Request and the Revised Request.

Main revised item on the Revised Request are as follows:

- Villingili Island (Gaafu Alifu Atoll) is omitted from the subject island for electrification. This island was electrified by the Maldivian government's own budget.

- All the work for building construction are done by Maldivian Side.
- Construction supervision services by the Consultant is deleted from the scope of Japanese side.

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Table 1-1 Comparison Between Original Request and Revised Request

Item	Original Request	Revised Request
. Date Request Issued	July 2, 1994	July 19, 1995
2. Subject Islands for Electrification		
(Oshows priority No.)		
(1) Hithadhoo (Seenu Atoll)	0	1
(1) Hithadhoo (Seenu Atoli) (2) Hulhudhoo/Meedhoo (Seenu Atoli)	ø	Ø
(3) Villingili (Gaafu Alifu Atoll)	3	-
(4) Hulhudhuffaaru (Raa Atoll)	- (4)	٩
(4) Humunununaaru (Raa Aton) (5) Villingili (Kaafu Atoll)	\$	3
3. Contents of Request		
3.1 Construction		
(1) Power House Building	Materials, etc. supplied by	All work, including material
(2) Office Building	Japanese side (site work	procurement, is conducted by
(3) Foundation Work for Incidental Facilities (Fuel Tank, etc.)	conducted by the Maldives side)	the Maldives side
3.2 Equipment	Procurement and installation	Procurement and installation
(1)Generating Facilities		
1) DEG		0
2) Mechanical Items for Power Generation	· O	0
(Tanks and Piping, etc.)		0
3) Electrical Equipment for Power Generation	0	
(Panelboards and Distribution Boards,		
etc.) (2) Power Distribution Equipment and Materials	Broguromont and supply	Procurement and supply
	Floculement and suppry	Trocurement and suppry
1) Power Distribution	0	0
a) Main Distribution Cable		i o
b) Branch Distribution Cable	. 0	-
c) Local Distribution Panel	0	· 0
d) Household Panel	0	0
2) Street Lighting	0	0
3) VHF Radio Unit	0	0
4) Spare Parts and Maintenance Tools	0	0
	0	0
5) OJT Manuals	0	0
(3)OJT		Ŭ
3.3 Consulting Service		
(1)Construction		
1) Detailed Design	0	0
2) Site Supervision		-
(2) Equipment		
1) Detailed Design	0	• O
2) Site Supervision	0	0
3.4 Miscellaneous		• The Maldives side is
		responsible for domestic
		transportation of equipment
		and materials
		• To be utilized the 11kV cat
		donated by the Australia
		Government from the powe
Let the second state of the second		house on Gan Island to

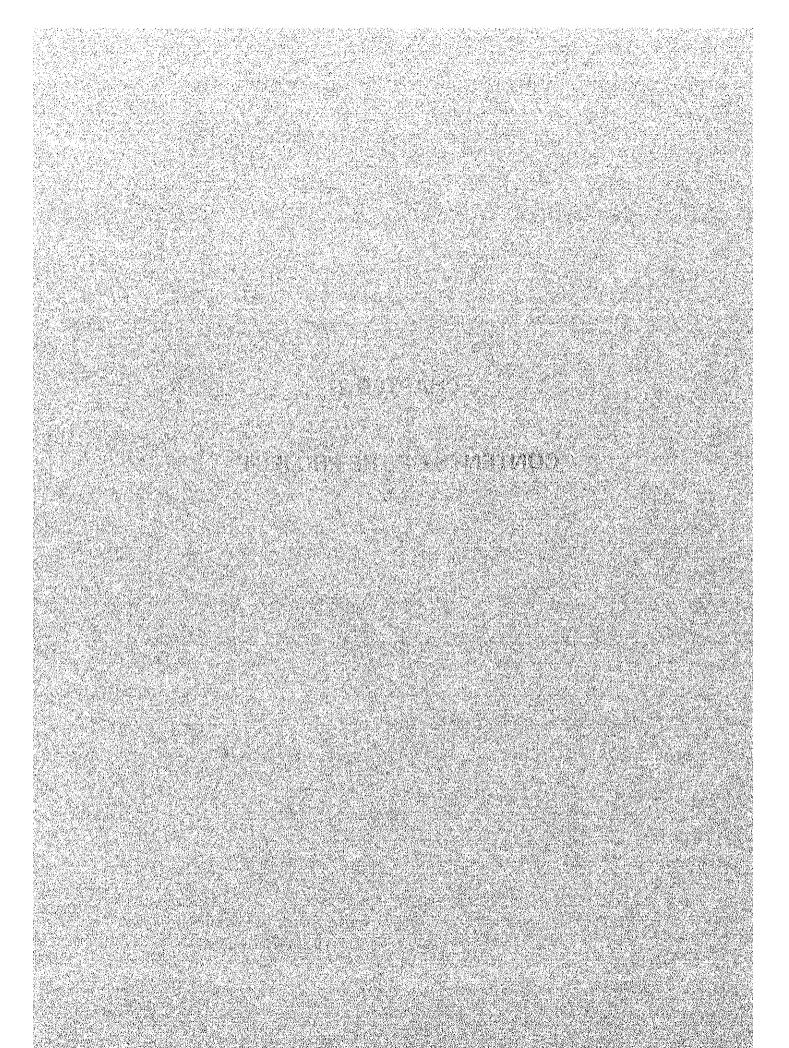
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CHAPTER 2

CONTENTS OF THE PROJECT



CHAPTER 2 CONTENTS OF THE PROJECT

2-1 Objectives of the Project

The Government of the Maldives has set the rectification of the socioeconomic unipolarisation to Male Island as the main objective of its Fourth National Development Plan in order to allow more balanced development between the capital and the rest of the country.

The Project is understood to constitute part of the Plan and aims at developing infrastructure which is essential for an improved standard of living, the stable operation of social welfare and public facilities and the fostering of industries on atoll islands. The principal objective of the Project is the construction of a power house and the provision of power distribution equipment and materials on those atoll islands which command priority in the government's atoll island development programme.

2-2 Basic Concepts of the Project

The selection of the subject islands for electrification under the Atoll Island Electrification Project of the Government of the Maldives depending on the results of a comprehensive evaluation, the subjects of which include the size of the benefiting population, the existence of administrative offices and the existence of public facilities and industrial workplaces, etc. Those 4 islands which are included in the Revised Request for the Project, i.e. Phase II Project; see Chapter 1, have excellent future development potential and are regarded as occupying an important position in the local development policies of the country. Notwithstanding such importance, the following 2 islands have been removed from the scope of the Project because of the provision of an adequate power supply and/or the need to observe the progress of the transmigration program from Male Island.

Hulhudhuffaaru Island (Raa Atoll)

Electrification has been completed by the Government of the Maldives' own budget for the island's total population which has swelled due to the urgent migration programme. The progress of the migration programme must be carefully observed before increasing the capacity to meet a future population increase.

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Villingili Island (Kaafu Atoll)

The immediate electricity demand can be met by the existing facilities of the MEB. The progress of migration from Male Island must be carefully observed before increasing the capacity.

Accordingly, the subject islands for electrification under the Atoll Island Electrification Project of the Government of Maldives (as of August, 1995) are the following 2 islands, both of which have a large population and command the highest priority in the Atoll Island Development Plan which is designed to rectify the trend of unipolarisation to Male Island and which is assisted by the ADB.

Hulhudhoo/Meedhoo Island (Seenu Atoll)

The existing generating facilities of this island with a population of some 5,300 are old and the inadequate capacity means a limited and unreliable power supply of 3 - 12 hours/day, necessitating the urgent upgrading of the power supply to stabilise life on the island. The distribution facilities provisionally use second-hand materials from Male Island and suffer from ageing and an inadequate capacity. The overhead distribution lines have been unprofessionally installed in that it is wound around trees or simply fixed to the underside of roofs, etc., inviting earth fault accidents.

Hithadhoo Island (Seenu Atoll)

Hithadhoo Island is the seat of the Seenu Atoll's administrative office and its population of some 12,000 is the second largest among the islands of the Maldives after Male Island. The capacity of the generating facilities currently operated by private companies is sufficient to meet the present demand and the planned transfer of these facilities to the MEB has been confirmed as a reality in progressing. Meanwhile, the power distribution facilities using second-hand overhead cables which were formerly used on Male Island are old with an inadequate capacity, resulting in voltage drops of more than 25% of the rated voltage. As a result, many electrical goods fail to operate or a prone to break-downs, causing undesirable disruptions in the lives of the people and the operation of public facilities, etc. This situation calls for the urgent improvement of the power distribution network.

Based on the above examination results, the scope of the Project has been set at constructing a diesel power house (only for Hulhudhoo/Meedhoo Island) to meet the power demand upto the year 2000 and the supply of power distribution equipment and

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materials for both islands of the Seenu Atoll to help rectify the socioeconomic unipolarisation to Male Island.

2-3 Basic Design

2-3-1 Design Concept

- (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-à-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.

As the humidity is fairly high throughout the year, it will be necessary to install a space heater for outdoor equipment and to employ other precautions.

2) Weather Conditions

The rainfall is significant from May to October and accompanies the seasonal southwest wind. The monthly rainfall can reach as much as 400 mm from May to July, and the tall waves at this time make maritime transportation outside the atolls hazardous. Consequently, the Project implementation schedule should avoid maritime transportation to the subject atoll islands during the above period if possible. If such transportation is unavoidable, the utmost care must be taken, including the preferential navigation inside an atoll where possible.

3) Salt Damage

As the proposed site for the new power house is located on the coast, it will be necessary to install the generating unit within the building to protect it from salt damage. The fuel oil tank and oil pipeline will be installed outdoors but will be protected by an anti-salt coating. As the distribution panel will be installed outdoors, it should be made of materials with an excellent anti-corrosion performance, such as FRP. No special care vis-à-vis salt damage will be required for the distribution cable as the distribution line will be laid underground.

(2) Social Conditions

The Maldives is principally an Islamic country with the one month long Ramadan every year which was in February in 1995. As Ramadan can have negative impacts on the construction schedule due to the decline of the labour productivity, etc., the construction schedule must take Ramadan into proper consideration.

(3) Principles Regarding Conditions of Local Construction Industry

In the preparation of the construction plan, the first priority of procurement should be given to local equipment and materials. However, the lack of such building materials as sand, gravel, cement, etc., means that these must be imported from a third country.

Installation of the generating unit in question, including its test operation and tuning, will require expert skill and it will be necessary to dispatch the relevant engineers from Japan for technical guidance and schedule control to ensure the quality and punctual completion of the work.

(4) Principles Regarding Use of Local Construction Companies and Materials

1) Use of Local Construction Companies/Workers

Construction companies in the Maldives are not readily available and the number of construction industry workers is only some 3,000 nationwide, making the recruitment of an adequate number of workers for the Project difficult. The recruitment of Sri Lankan engineers and workers with experience of the civil engineering, building and installation work planned under the Project, as in the case of the Phase I Project, and their employment as sub-contracted workers by the Japanese Contractor is, therefore, deemed necessary. This recruitment of Sri Lankan workers will be the key to the successful implementation of the Project although it will necessitate the provision of accommodation and an additional meal allowance.

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2) Use of Local Equipment and Materials

Such basic construction materials as sand and aggregate must be imported in the Maldives due to the lack of a local supply. Among the materials required for the construction work under the Project, the materials used to produce concrete, structural steel, timber, etc., will be procured from neighbouring countries while the power distribution equipment and materials will be procured from either the third country, i.e., Singapore (the main source of power distribution equipment and materials commonly used in the Maldives).

The decision on the diesel engine generators (DEGs) to be procured and installed under the Project will depend on the prevailing conditions of the relevant market in the Maldives. In general, Japanese products are currently popularly used and local engineers are familiar with the operation and maintenance of Japanese diesel engines. The local agents of Japanese diesel engine manufacturers provide a good after-sales service and have a good stock of spare parts. In contrast, the existing generating facilities of the MEB and private generators were originally manufactured in various countries, including Japan, US, UK, France, Italy, India, etc., depending on the financial procurement source, etc. The lack of local agents means that it is difficult to obtain spare parts and repair services. In certain cases, those units which have broken down are cannibalised for spare parts, suggesting difficulties in operating these facilities. Given the above observation, the selection of Japanese DEGs appears to be a rational choice to meet the requirements of the Project.

(5) Principles Regarding Management and Maintenance Capability of Project Implementation Body (MEB)

All the existing power generation facilities in the Maldives use DEGs. The largest DEG unit is the 2.7 MVA unit on Male Island. As the MEB operates and maintains this largest unit as well as smaller units, such as those on Naifaru Island and Eydhafushi Island installed under the Phase I Project, it clearly has sufficient technical strength to operate and maintain the new facilities to be installed under the Project. However, it will be necessary to dispatch Japanese engineers to the Maldives to provide OJT during the installation period in order to establish an efficient and effective operation and maintenance system as most of the technical staff assigned to the new power house will be newly recruited as in the case of the Phase I Project.

The MEB has already appropriated 19 million Rf (approximately 173 million yen) from the Government of the Maldives for the implementation of the Project and these funds should be used in a constructive manner.

(6) Principles Regarding Design Scope and Level of Facilities and Equipment

The following principles regarding the design scope and level of the facilities to be construction and equipment to be procured and installed under the Project are adopted based on the relevant conditions and principles described above.

1) Scope of Facilities and Equipment

The types, quantities and composition of the power generation facilities, distribution equipment and materials and spare parts to be constructed or procured under the Project must help to achieve the Project's objective of providing the households and social public facilities on the subject islands with a stable power supply.

In the case of Hithadhoo Island, the specifications of the equipment and materials to be procured and supplied under the Project must be designed to forestall the need to change them when Hithadhoo Island and Gan Island are linked with an 11 kV distribution line as planned by the MEB.

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.

(7) Principles Regarding Construction Period

In view of the current power supply conditions and the urgent need to provide a stable power supply on the 2 subject islands, the Project will be implemented in the following 2 phases.

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