**Republic of Maldives**
**Ministry of Housing, Transport**
**and Environment (MHTE)**
**Maldives Energy Authority (MEA)**
**State Electric Company Limited (STELCO)**

# FEASIBILITY STUDY

# FOR APPLICATION
# OF PHOTOVOLTAIC POWER
# ON MALE' AND HULHUMALE' ISLANDS
# IN
# THE REPUBLIC OF MALDIVES

## FINAL REPORT

**NOVEMBER 2009**


**JAPAN INTERNATIONAL COOPERATION AGENCY**

---

**YACHIYO ENGINEERING CO., LTD**

**SHIKOKU ELECTRIC POWER CO., INC.**

# PREFACE

In response to a request from the Republic of Maldives, the Government of Japan decided to conduct the Feasibility Study for Application of Photovoltaic Power on Male' and Hulhumale' Islands and entrusted to the study to the Japan International Cooperation Agency (JICA).

JICA selected and dispatched a study team headed by Mr. Tadayuki Ogawa of Yachiyo Engineering Co., LTD. (yec) and consists of yec and Shikoku Electric Power Co., INC. four times between February and November, 2009.

The team held discussions with the officials concerned of the Government of Maldives and conducted field surveys at the study area. Upon returning to Japan, the team conducted further studies and prepared this final report.

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

Finally, I wish to express my sincere appreciation to the officials concerned of the Government of Maldives for their close cooperation extended to the study.

November 2009

Atsuo Kuroda
Vice President
Japan International Cooperation Agency

Mr. Atsuo Kuroda
Vice President
Japan International Cooperation Agency

# LETTER OF TRANSMITTAL

November 2009

Dear Sir,
It is my great pleasure to submit herewith the Final Report of "The Feasibility Study for Application of Photovoltaic Power on Male' and Hulhumale' Islands in the Republic of Maldives".

The Study Team conducted field surveys in Maldives over the period between February and November, 2009 according to the contract with the Japan International Cooperation Agency (JICA).

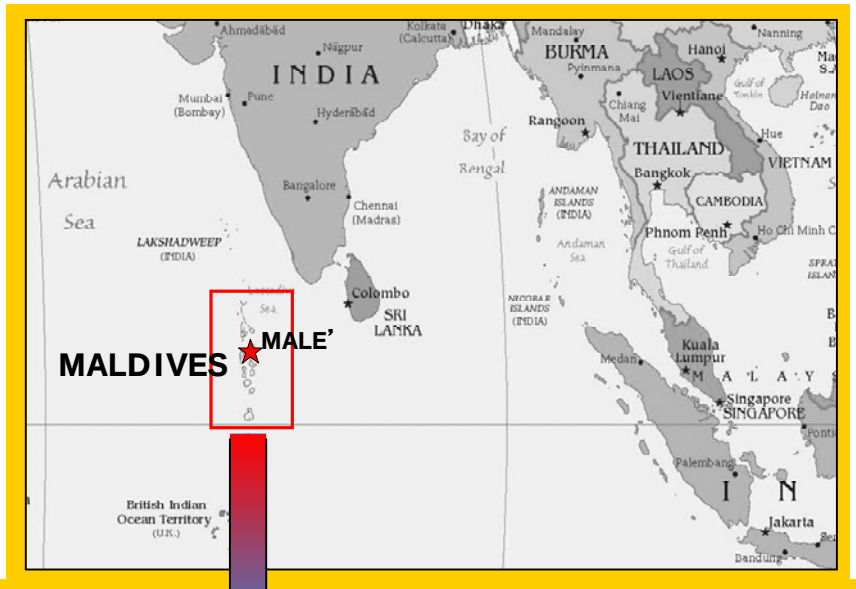
The Study Team compiled this report, which consists of the Technical, Economic and Financial Feasibility Study to introduce Grid-connected Photovoltaic (PV) System, Detail Design for Pilot Project, examination on Value-added Measures, and Long-term Action Plan, etc. through close consultations with officials concerned of the Government of the Republic of Maldives and other authorities concerned. In addition to compiling this report, technical transfer and human resource development have been conducted through collaboration work with counterpart engineers in Maldives, and counterpart training at concerned organizations in Japan for the capacity development in planning and designing of Grid-connected PV system.

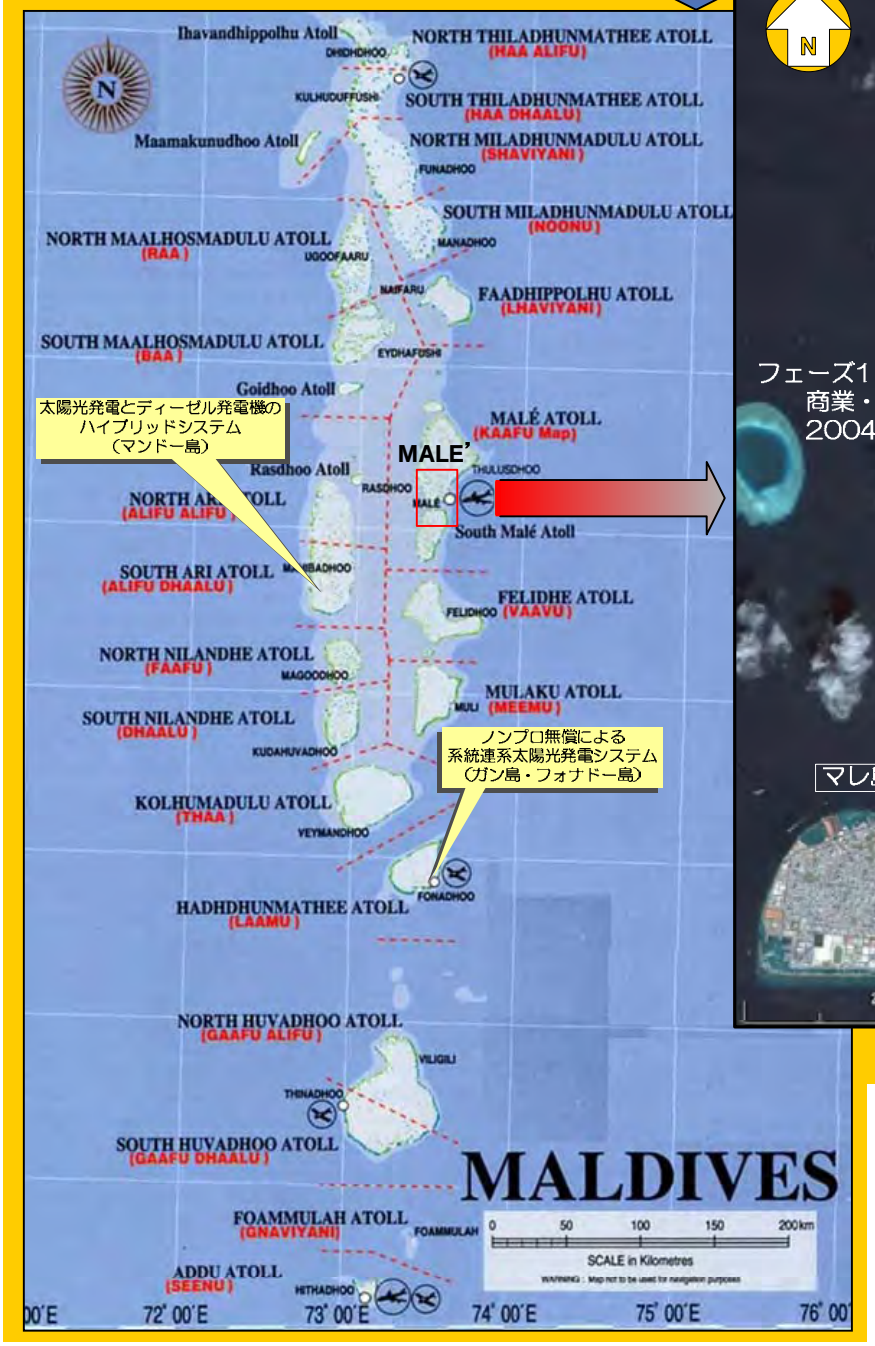
On behalf of the Study Team, I would like to express my sincere appreciation to officials concerned of the Government of Maldives and other authorities concerned for their cooperation, assistance, and heartfelt hospitality extended to the Study Team.

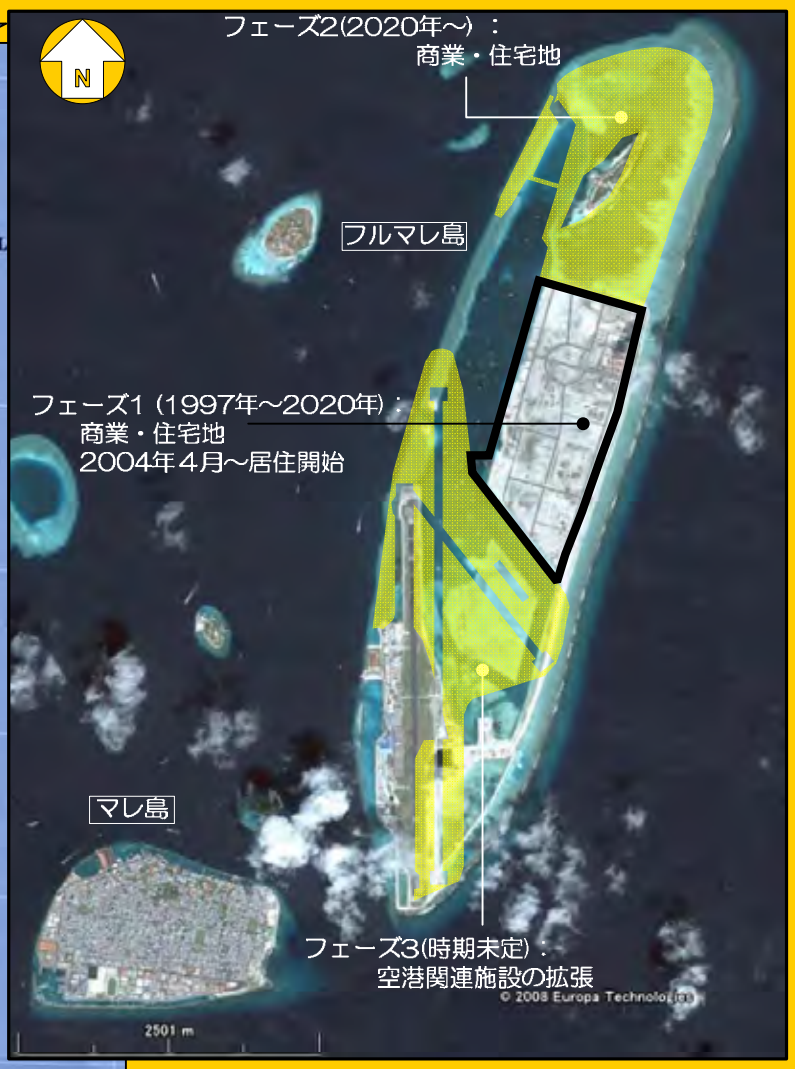
We are also deeply grateful to the Japan International Cooperation Agency, the Ministry of Foreign Affairs, the Ministry of Economy, Trade and Industry, and the Embassy of Japan in Sri Lanka for their valuable suggestions and assistance during the course of the Study.

Yours faithfully,

Tadayuki Ogawa
Team Leader
The Feasibility Study for Application of
Photovoltaic Power on Male' and Hulhumale'
Islands in the Republic of Maldives




調査対象地域

# 「モ」国全図及び調査対象地域位置図
# Location Map of the Project Sites

# Male’ Island


Site name
① STELCO Building
② STELCO Power House
③ Dharubaaruge
④ Velaanaage (Govt. Office)
⑤ Giyaasudheen School
⑥ Kalaafaanu School
⑦ Maldives Center for Social Education
⑧ Thaajuddeen School
⑨ New Secondary School for Girls
⑩ Indhira Gandhi Memorial Hospital (IGMH)
⑪ Faculty of Engineering
⑫ National Stadium
⑬ Majeedhiya School
⑭ Dharumavantha School
⑮ Fen Building
⑯ Water Tank
⑰ Faculty Education
⑱ Sports Grounds
⑲ Male’ South West Harbour Parking
⑳ Grand Friday Mosque
㉑ Jumhooree Maidhan
㉒ President’s Office

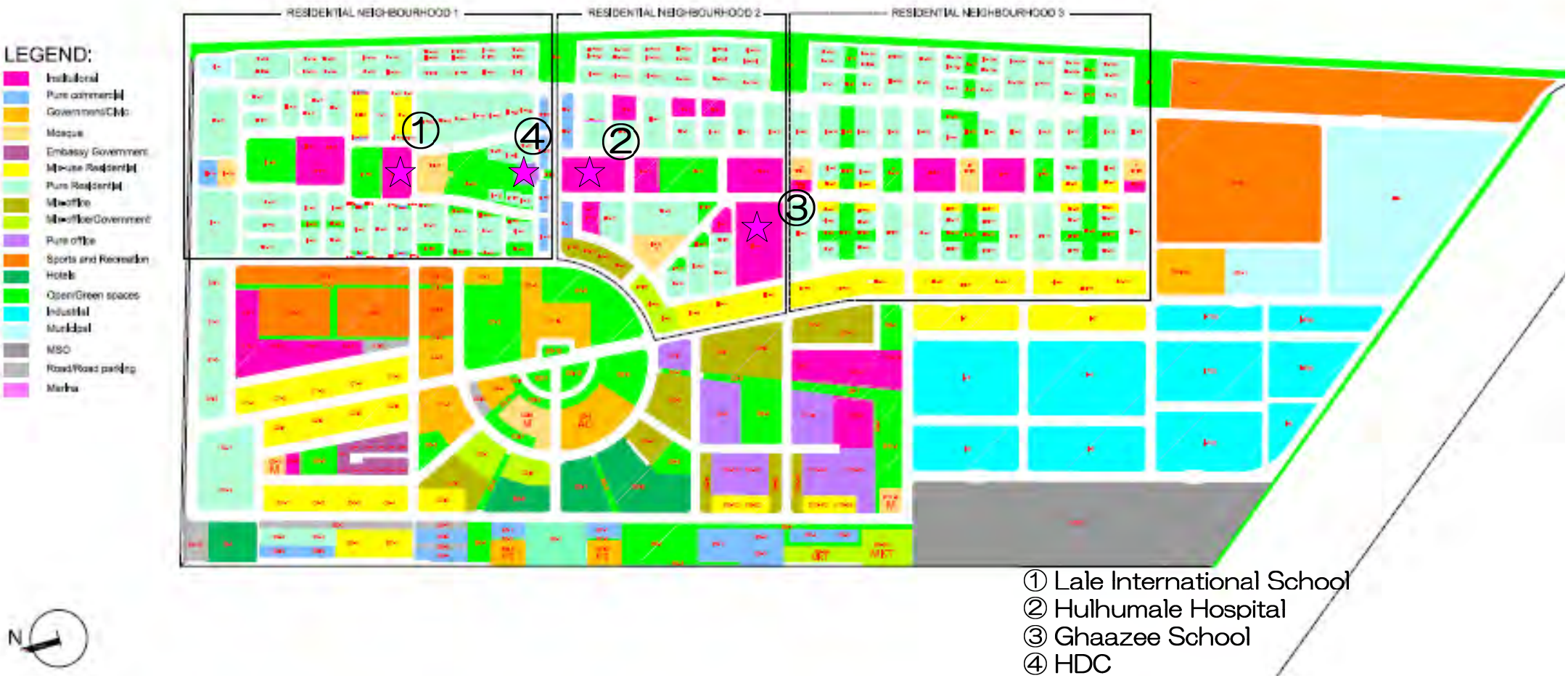
legend(凡例) ★ : Possible Location (ポテンシャルサイト)

▮ : Pilot Project Site (パイロットプロジェクトサイト)

## Possible Locations for PV Installations – “Male’”

マレ島　連系PVシステム導入サイト位置図

# Hulhumale’ Island




① Lale International School
② Hulhumale Hospital
③ Ghaazee School
④ HDC

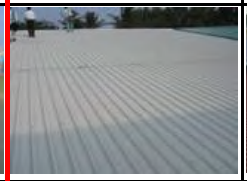
legend(凡例)

★：Possible Location (ポテンシャルサイト)

## Possible Locations for PV Installations – “Hulhumale’”

フルマレ島　連系PVシステム導入サイト位置図

# Evaluation of the potential sites in Male' and Hulhumale' Islands

| Island | Male' | | | | | | |
|---|---|---|---|---|---|---|---|
| No. | 1 | 3 | 5 | 6 | 7 | 8 | 9 |
| Site name | STELCO Building | Dharubaaruge (Public Works Building) | Giyaasudheen School | Kalaafaanu School | Maldives Center for Social Education | Thaajuddeen School | New Secondary School for Girls |
| Installation location | Rooftop | Building roof | Building roof, Rooftop | Building roof | Building roof | Building roof | Building roof |
| Available area [$m^2$] | 620 | 2,420 | 520 | 950 | 1,180 | 1,460 | 1,440 |
| PV capacity [kWp] | 45 | 85 | 40 | 85 | 100 | 130 | 100 |
| Annual power generation [kWh] | 45,739 | 100,382 | 48,378 | 117,069 | 120,945 | 157,228 | 90,778 |
| Shade condition | OK | OK | OK | OK | OK | OK | OK |
| Reinforcement of existing structure | Unnecessary | Need examination | Unnecessary | Unnecessary | Unnecessary | Unnecessary | Unnecessary |
| Space for Power Conditioner | Enough | Need to find an additional electric room | Enough | Need to find an additional electric room | Enough | Enough | Enough |
| Cable route | No problem | No problem | No problem | No problem | No problem | No problem | No problem |
| Interconnection feeder | FD9 | FD3 | FD6 | FD3 | FD6 | FD6 | FD6 |
| Transformer No. | 20B | 60 | 70 | 61 | 62 | 23 | 23 |
| Capacity [kVA] | 500 | 630 | 150 | 100 | 200 | 1000 | 1000 |
| Site owner | STELCO | MHTE | Ministry of Education | Ministry of Education | Ministry of Youth | Ministry of Education | Ministry of Education |
| Approval from owner | | | | | | | |
| O & M | Easy | General | General | General | General | General | General |
| Safety | No problem | No problem | No problem | No problem | No problem | No problem | No problem |
| Public Relations Impact | Middle | Middle | Middle | Middle | High | Middle | Middle |
| Cost | | | | | | | |
| Photo |  |  |  |  |  |  |  |
| Overall Comments | /The panel support structural is necessary /Construction of footing and water proof ing is necessary /O & M is easy because there are many staff | /Existing building is not permanent structure. /Large area of roof /As-build DWG not found /Detail investigation is necessary | /The exchange of the roof material is necessary /The space of the electric room is enough | /The exchange of the roof material is necessary | /The exchange of the roof material is necessary /There is enough space for equipments above the electric room | /Large area of roof /Coating improvement of the roof is necessary | /Large area of roof |
| Ranking | 6 | 7 | 9 | 4 | 3 | 1 | 2 |

Total of = 1605 kW

Total of top 6 = 480 kW

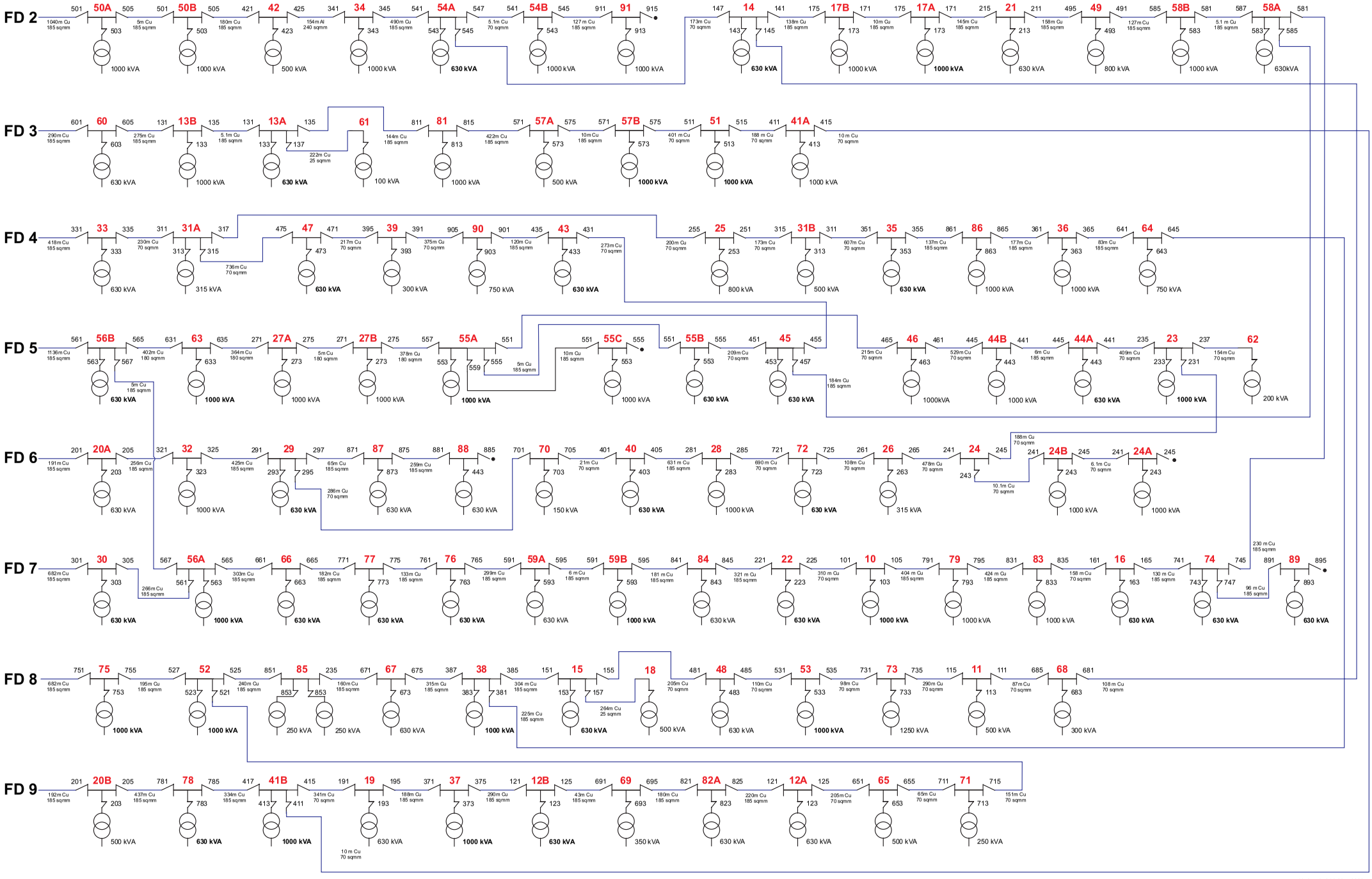
# Evaluation of the potential sites in Male' and Hulhumale' Islands

| Island | Male' | | | | | | Hulhumale' |
|---|---|---|---|---|---|---|---|
| No. | 11 | 12 | 17 | 20 | 21 | 22 | 2 |
| Site name | Faculty of Engineering | National Stadium | Faculty of Education | Grand Friday Mosque | Jumhooree Maidhaan | President's Office | Hospital |
| Installation location | Building roof, Rooftop | Roof | Rooftop | Rooftop | Ground | Rooftop | Building roof |
| Available area [$m^2$] | 1,130 | 2,970 | 98 | 2,000 | 2,860 | 1,158 | 1,130 |
| PV capacity [kWp] | 80 | 400 | 10 | 30 | 60~160(depend on the arrangement of panels) | 20 | 60 |
| Annual power generation [kWh] | 96,756 | 483,780 | 12,094 | 36,283 | 196,986 | 24,189 | 72,567 |
| Shade condition | OK | Shade from surrounding buildings and stand lights must be considered. | Need confirmation of the construction plan for the new building | Shade from tower and the mosque top | OK | Shade on the west and east side roofs | OK |
| Reinforcement of existing structure | Need examination | Necessary | Need examination | Need examination | | Unnecessary | Need examination |
| Space for Power Conditioner | Enough | Enough | Enough | Enough | Need to find a location | Need to find a location | Enough |
| Cable route | No problem | No problem | No problem | No problem | No problem | No problem | No problem |
| Interconnection feeder | FD4 | FD9 | FD7 | FD2 | FD2 | FD8 | FD2 |
| Transformer No. | 25 | 41B | 30 | 14 | 14 | 73 | 11 |
| Capacity [kVA] | 800 | 1000 | 630 | 630 | 630 | 1250 | 315 |
| Site owner | Ministry of Education | Ministry of Youth | Ministry of Education | Ministry of Islamic Affairs | Male' Municipality or Ministry of Home | President Office | Ministry of Health |
| Approval from owner | | | | | Approval from many stakeholders including public are required. | | |
| O & M | Easy | General | General | General | General | General | General |
| Safety | No problem | No problem | No problem | No problem | No problem | No problem | No problem |
| Public Relations Impact | Middle | High | Middle | High | High but public consultation may be necessary | High | Middle |
| Cost | | Structural reinforcement cost is expensive | | | | | |
| Photo |  |  |  |  |  |  |  |
| Overall Comments | /Shape of roof is complicated therefore it might need special mounting structure | /Largest potential but structural reinforcement cost is expensive | /Available area is only RC rooftop | /Large area but most of locations are affected by the shadow from surrounding structures | /Publicity is quite high /Difficulty in getting approval from all stakeholders | /Publicity is high /Detail plan of construction schedule is necessary /Coating improvement of the roof is necessary | /Priority is lower than Male' Island because the power supply is enough at present |
| Ranking | 8 | 12 | 11 | 10 | | 5 | 13 |

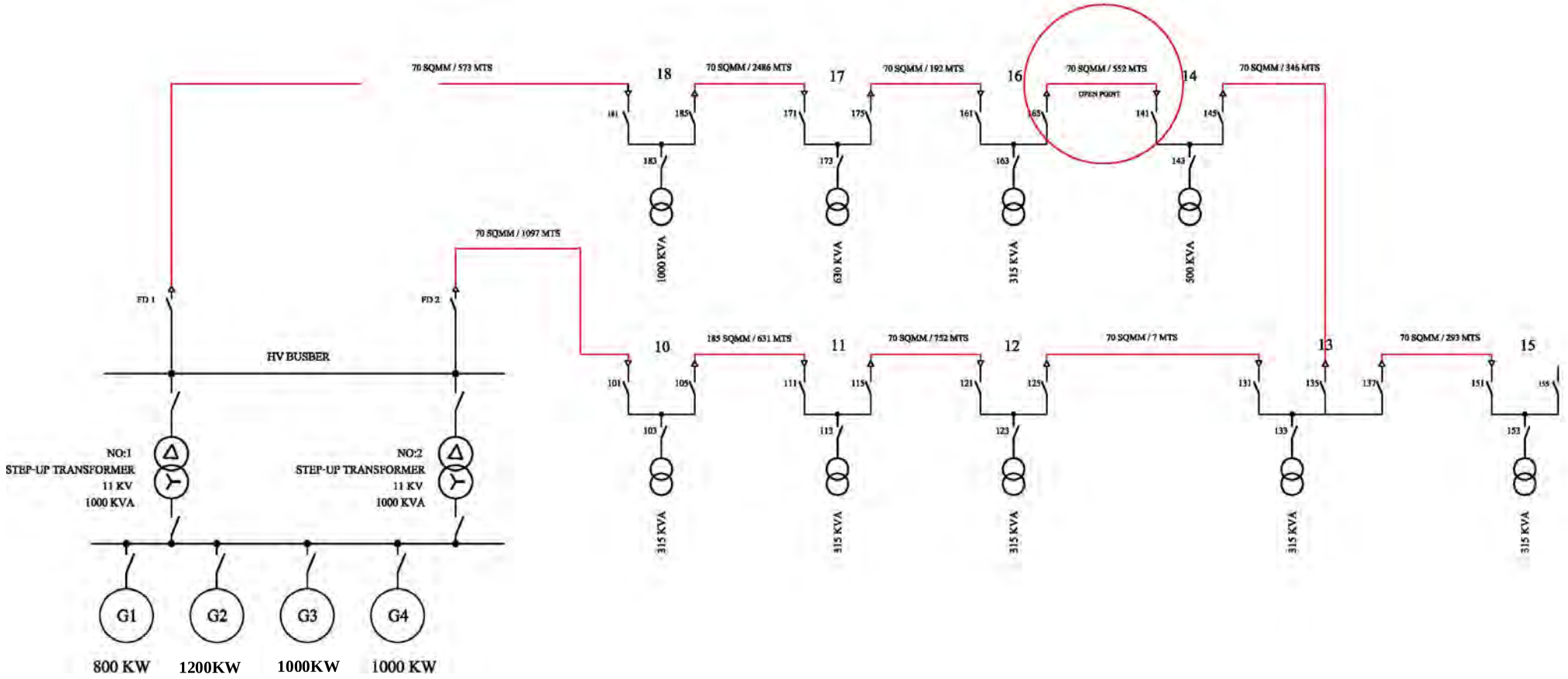
# MALE' MEDIUM VOLTAGE RINGMAIN DISTRIBUTION SYSTEM

# マレ島中圧（１１ｋV）配電系統図

**Power Distribution Department / State Electric Company Ltd**




Updated : 24th May 2009




Power Distribution system (Hulhumale')

# フルマレ島 中圧（１１kV）配電系統図

# CONTENTS

# LIST OF FIGURES AND TABLES

Chapter 5

Chapter 6

# ABBREVIATIONS

| | |
|---|---|
| ADB | Asian Development Bank |
| CER | Certified Emission Reduction |
| CDM | Clean Development Mechanism |
| DANIDA | Danish International Development Cooperation Agency |
| DNA | Designated National Authority |
| DRP | Dhivehi Rayyithunge Party |
| DSM | Demand Side Management |
| ECX | European Climate Exchange |
| US EIA | Energy Information Administration |
| EIA | Environmental Impact Assessment |
| EIRR | Economic Internal Rate of Return |
| EPA | Environmental Protection Agency |
| EUA | EU-Allowance |
| FIRR | Financial Internal Rate of Return |
| FIP | Feed-in Premium |
| FIT | Feed-in Tariff |
| GDP | Gross Domestic Product |
| GEF | Global Environment Facility |
| GHG | Green House Gas |
| HDC | Hulhumale' Development Corporation LTD |
| IEC | International Electrotechnical Commission |
| IEA | International Energy Agency |
| IEE | Initial Environmental Examination |
| JICA | Japan International Cooperation Agency |
| JIS | Japanese Industrial Standards |
| MATI | Maldives Association of Tourism Industry |
| MCPI | Ministry of Construction and Public Infrastructure |
| MCST | Ministry of Communications, Science and Technology |
| MDP | Maldivian Democratic Party |
| MEA | Maldives Energy Authority |
| MEB | Maldives Electricity Bureau |

| | |
|---|---|
| MEEW | Ministry of Environment, Energy and Water |
| MHTE | Ministry of Housing, Transportation and Environment |
| MMA | Maldivian Monetary Authority |
| MTAC | Ministry of Tourism, Arts and Culture |
| NEDO | New Energy and Industrial Technology Development Organization |
| NPC | National Planning Council |
| Off－JT | Off the Job Training |
| O&M | Operation and Maintenance |
| OJT | On the Job Training |
| PLC | Programmable Logic Controller |
| PPP | Public Private Partnership |
| PV | Photovoltaic |
| RETDAP | Renewable Energy Technology Development and Application Project |
| | RPS Renewables Portfolio Standard |
| SCADA | Supervisory Control and Data Acquisition System |
| SHS | Solar Home System |
| SSM | Supply Side Management |
| STELCO | State Electric Company Limited |
| STO | State Trading Organization |
| UNDP | United Nations Development Programme |
| UNFCCC | United Nations Framework Convention on Climate Change |

# CHAPTER 1 BACKGROUND AND BASIC CONCEPT OF THE STUDY

## 1.1 Background and Objectives of the Study

The Republic of Maldives (hereinafter referred to as Maldives) is an island nation situated southwest of India and Sri Lanka. It is composed of approximately 1,190 coral islands, of which 199 are inhabited. The national population is approximately 299,000 (2006 national census), of which 104,000 people or approximately 35% of the total population, live on Male' Island. Male' is home to the national capital functions and the most employment opportunities, however, problems of declining security and deteriorating living environment caused by this population concentration have become social problems on the island. The tourism industry of the Maldives was badly affected in the wake of the September 11-terrorist attacks in the United States, although the economy has displayed steady recovery since then. However, the Indian Ocean tsunami disaster of December 2004 caused 82 fatalities, 26 persons missing, destruction of around 2,000 homes and other massive damage especially in outer islands with little or no seawalls and other infrastructure. The financial cost of the tsunami damage amounted to approximately 62% of GDP and caused the GDP growth rate to plunge to minus 4.6% in 2005. Since then, however, the tourism and fisheries industries, which account for approximately 40% of GDP, have recovered and GDP growth rate of 19.1% and 6.6% was recorded in 2006 and 2007 respectively. As a result, there has been a construction boom in Male' and with more and more people who suffered damage on outer islands moving to Male' in search of employment and safer living conditions, which accelerated more population concentration.

Power supply on the 10 islands which including capital Male' is carried out by STELCO, which is 100% government financed electric utility, and power generation on Male' accounts for approximately 72% of generated power in inhabited islands (185,553 MWh) in 2006. Power demand in Male' is expected to grow rapidly at more than 11% per year, and it is forecasted that peak demand over the next five to seven years will reach more than double the capacity of generation facilities. Accordingly, STELCO is planning to procure new diesel generators, however, due to limited space any further expansion of power stations in Male' will be difficult. Moreover, with more than 80% of primary energy demand and almost all power generation depend on diesel fuel, the recent inflation in the price of diesel (22% in 2007) has badly affected the financial condition of STELCO and threatens the energy security of the country.

In response to these issues, the Government of Maldives (GOM) has reclaimed land (Hulhumale' Island: total area 7.85 square kilometers) off the coast of Male', and it is implementing a comprehensive development plan that includes the resettlement of residents in Male'. According to the plan, residential and commercial districts as well as cultural and education districts will be

constructed. In addition, tourism districts will be built by introducing foreign capital. Thus it is forecasted that the power demand in Hulhumale' will grow rapidly from now on.

Furthermore, since Maldives is an island nation with an average altitude of just 1 m above sea level, it is one of the countries most prone to the effects of rising sea level caused by climate change. For this reason, in the Manifesto 2008~2013 and Strategic Action Plan, the current government aims to achieve the carbon neutral within 10 years time. GOM aims to reduce greenhouse gas emissions from diesel power station and to ensure energy security.

Under these circumstances, GOM issued a request to Government of Japan for implementation of a development study for the introduction of grid-connected photovoltaic (PV) system, as a way to improve energy efficiency and mitigate climate change for the purpose of realizing stable power supply in the medium to long term.

The objectives of the Study are as follows: (1) To conduct technical and economic/financial feasibility study (F/S) and confirm the conditions required in order to introduce the grid-connected PV system in Male' and Hulhumale' Islands; and (2) To examine the required legislation, systems, regulations and human resources development plan, etc. and finalize long-term plan and action plan for the introduction and proper operation of the grid-connected PV system. At the same time, detailed design for the introduction of grid-connected PV system will be conducted on five or six potential sites, with a view to building the capacity of the organizations primarily responsible for introducing the system.

## 1.2 Basic Concept of the Study

(1) In the Study, it is necessary to select potential sites for the grid-connected PV system and to complete detailed design for potential sites during a short period. Accordingly, the Study Team has already commenced the preliminary planning and design of PV systems based on available data. Detailed design will be commenced immediately after potential sites are finalized in the joint work with the counterparts.

(2) As a result of the final round of voting in the presidential election held in October 2008, President Maumoon Abdul Gayoom, who had held office for the previous 30 years, was defeated, and Mohamed Nasheed, the leader of the opposition Democratic Party of the Maldives, became the new president. In line with this, the Ministry of Environment, Energy and Water (MEEW), which was expected to be the counterpart Ministry, was reorganized and combined with the Ministry of Construction and Public Infrastructure (MCPI), Ministry of Environment, Energy and Water (MEEW), Ministry of Transport and Communication (MTC) and Ministry of Housing and Urban Development (MHUD) to make the new Ministry of Housing, Transport and Environment

(MHTE). Accordingly, in the first field survey, full explanations will be given to the counterpart agency concerning background of the Study, the Study concept, methodology and schedule, etc. in order to facilitate the smooth introduction of the Study.

(3) On the densely populated island of Male', where buildings are already crowded, potential sites for the grid-connected PV system will be selected from the wide variety of candidate sites such as buildings, public facilities, stadium, pedestrian walks and bus stops while taking the impact on existing 11 kV distribution grid into account. Meanwhile, on Hulhumale' Island, potential sites will be selected utilizing vacant spaces on the roof of public and commercial facilities which are under planning phase, in consideration of economic advantage and operation after commissioning.

# CHAPTER 2 SOCIOECONOMIC CONDITIONS AND DEVELOPMENT PLANS

## 2.1 Socio-economic Conditions

In the aftermath of the Indian Ocean tsunami disaster in December 2004, tourism, which is the primary industry of the Maldives, was depressed and the economy recorded negative growth. From 2006 onwards, however, tourism recovered from a recession and the economy return to positive growth due to growth of secondary industries and tertiary industries excluding tourism (see Table 2.1-1). In the years up to 2004, fisheries and tourism in outlying resort islands formed the backbone of the economy, accounting for approximately 40% of real GDP, however, this ratio fell to 30% from 2005 onwards. Tertiary industries including tourism have constantly accounted for around 80% of GDP, while the share of primary industries fell from 12.2% in 1995 (when it was almost equivalent to the share of secondary industries) to 7% in 2008. In contrast, the share of secondary industries increased from 12.8% to 17.6% over the same period. This trend shows that the industrial structure has shifted. Looking at performance by sector, tourism has remained the key industry over this period, while the secondary sectors of electric power, public water supply and construction, and tertiary sectors of transport, communications and government services have made remarkable growth.

Table 2.1-1 Transitions in GDP

Unit: Million MRf

| | 1995 | 2000 | 2004 | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|---|---|---|
| Primary sector | 521 | 595 | 760 | 850 | 846 | 719 | 761 |
| Agriculture | 155 | 175 | 205 | 204 | 204 | 205 | 207 |
| Fisheries | 335 | 381 | 507 | 596 | 590 | 460 | 499 |
| Coral and sand mining | 31 | 39 | 48 | 50 | 52 | 54 | 55 |
| Secondary sector | 659 | 1,047 | 1,539 | 1,621 | 1,891 | 2,071 | 2,215 |
| Manufacturing | 336 | 505 | 660 | 594 | 680 | 706 | 730 |
| Fisheries processing | 112 | 132 | 204 | 247 | 299 | 300 | 300 |
| Electricity and water supply | 78 | 204 | 313 | 363 | 409 | 447 | 486 |
| Construction | 133 | 206 | 362 | 417 | 503 | 618 | 699 |
| Tertiary sector | 3,205 | 4,836 | 6,217 | 5,703 | 6,917 | 7,574 | 8,226 |
| Wholesaling and retail trade | 234 | 288 | 326 | 336 | 357 | 386 | 412 |
| Tourism (resorts, etc.) | 1,474 | 2,094 | 2,689 | 1,798 | 2,560 | 2,800 | 2,991 |
| Transport and communications | 478 | 919 | 1,263 | 1,456 | 1,729 | 1,893 | 1,993 |
| Financial services | 151 | 215 | 269 | 262 | 287 | 300 | 310 |
| Real estate | 390 | 497 | 571 | 575 | 595 | 611 | 628 |
| Business services | 129 | 184 | 223 | 222 | 233 | 239 | 245 |
| Government administration | 400 | 751 | 1,062 | 1,213 | 1,380 | 1,592 | 1,917 |
| Education, health and social services | 124 | 137 | 146 | 149 | 152 | 155 | 157 |
| Financial services indirectly measured (FISIM) | -175 | -249 | -332 | -308 | -376 | -402 | -427 |
| Total | 4,385 | 6,478 | 8,516 | 8,174 | 9,654 | 10,364 | 11,202 |

Source： Statistical Yearbook of Maldives 2008

Note: Figures are 1995-base prices and estimate values for 2008.

The international balance of payments shows a current account deficit, arising from excess imports over exports, is offset by foreign currency revenues derived from tourism. The current account deficit has increased steadily since 2005. The exchange rate has been pegged to the U.S. dollar at a rate of 12.80 MRf to the dollar since 2002.

Table 2.1-2 shows the fiscal balance of the Maldives government. Tax revenues declined in 2005 due to the impact of the Indian Ocean tsunami disaster on the tourism industry, however, they have recorded major increases again from 2006 onwards. Concerning revenue, non-tax revenue has recorded faster growth than tax revenue, and this is largely derived from rental of government assets (including rental of government-owned resorts). Expenditure is increasing every year as revenue increases; in particular, the increase in current expenditure from 2005 onwards has been conspicuous, and the fiscal deficit is growing year by year. Looking at expenditure by sector, spending on social services such as social security and community programs, etc. accounted for a major share in 2007, however, spending on economic services such as agriculture, fisheries, transport and electric power almost doubled in 2008.

The public sector comprises the government and state-owned enterprises and has traditionally played an important role in the economy. The state-owned enterprises have been active in numerous sectors such as banking, aviation, marine transport, international freight, telecommunications, electric power, fishing ports and importing, however, in recent years there has been a growing trend of privatization and shrinking of services supplied by the state-owned enterprises.

Table 2.1-2 Fiscal Balance of the Government of the Maldives

Unit: Million MRf (Maldives rufiyaa)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|---|---|---|
| Revenue and donations | | | | | | | |
| Tax revenue | 1,091.7 | 1,268.7 | 1,647.2 | 1,722.8 | 2,370.3 | 2,855.5 | 3,291.5 |
| Nontax revenue | 1,490.7 | 1,695.6 | 1,704.6 | 2,065.5 | 2,916.3 | 3,813.9 | 5,653.0 |
| Grants | 132.5 | 123.6 | 72.9 | 824.6 | 867.4 | 1,183.2 | 812.5 |
| Total revenue | 2,714.9 | 3,087.9 | 3,424.7 | 4,612.9 | 6,154.0 | 7,852.6 | 9,757.0 |
| Expenditure and net lending | | | | | | | |
| Current expenditure | 2,109.4 | 2,345.7 | 2,788.1 | 4,643.3 | 5,607.8 | 7,083.7 | 8,755.7 |
| Capital expenditure | 1,026.1 | 1,206.2 | 991.0 | 1,132.1 | 1,458.4 | 1,952.6 | 2,760.7 |
| Net lending | -18.2 | -163.7 | -196.5 | -117.8 | -118.1 | -122.0 | -194.8 |
| Total expenditure | 3,117.3 | 3,388.2 | 3,582.6 | 5,657.6 | 6,948.1 | 8,914.3 | 11,321.6 |
| Balance | -402.4 | -300.3 | -157.9 | -1,044.7 | -794.1 | -1,061.7 | -1,564.6 |
| GDP per capita（US$) | 1,482 | 1,986 | 2,439 | 2,293 | 2,649 | 2,804 | 2,992 |
| GDP growth rate (%) | - | 4.8 | 9.5 | -4.6 | 18.0 | 7.6 | 8.3 |

Source： Statistical Yearbook of Maldives 2007 and 2008

Note ： Figures for 2007 are provisional values, while those for 2008 are budget estimate values.

Table 2.1-3 shows the population of Male' Island and Hulhumale' Island according to the census of 2006. Compared with the findings of the 2000 census, the population of Male' Island grew by 5.8% per year, far faster than the national average of 1.7% per year, highlighting the trend of population concentration into Male's Island. Furthermore, when foreign workers and residents registered outside of Male's Island are also taken into account, the island population is approximately two times greater than the number of residents registered in Male'.

Table 2.1-3 Population in the Study Area

| | 2000 | 2006 | Growth Rate | Registered residents in 2005 |
|---|---|---|---|---|
| Male' Island | 72,230 | 102,377 | 5.8 | 46,647 |
| Hulhumale' Island | - | 2,866 | NA | 189 |
| National | 270,101 | 298,968 | 1.7 | 302,726 |

Source : Statistical Yearbook of Maldives 2007 and 2008

According to Population Division, Department of Economic and Social Affairs, the United Nations Secretariat, it is forecasted that the population of the Maldives overall will increase to 383,000 by 2020 and that the urban population will grow to 200,000.

Table 2.1-4 Population Forecast in the Maldives and Urban Areas

| | 1995 | 2000 | 2005 | 2010 | 2015 | 2020 |
|---|---|---|---|---|---|---|
| National population (1000) | 248 | 273 | 295 | 323 | 353 | 383 |
| National growth rate (%) | 1.93 | 1.57 | 1.76 | 1.80 | 1.65 | 1.37 |
| Urban population (1000) | 64 | 76 | 100 | 131 | 165 | 200 |
| Urban growth rate (%) | 3.49 | 5.62 | 5.29 | 4.63 | 3.88 | 3.11 |
| Urban share (%) | 25.6 | 27.7 | 33.9 | 40.5 | 46.6 | 52.1 |

Source : World Urbanization Prospects: The 2007 Revision Population Database, Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat

Concerning the political situation in the Maldives, the autocratic rule of President Gayoom continued for 30 years from 1978, however, the new Constitution enunciating for the first time basic human rights, freedom of speech and multiple political parties was enacted on August 7, 2008. On October 8 that year, presidential elections were held for the first time under the new Constitution, resulting in a runoff election victory for Mohamed Nasheed, the leader of the Maldivian Democratic Party (MDP). Parliamentary elections were held on May 11, 2009, the Maldivian People's Party (DRP) won a majority of seats.

## 2.2 Development Plans

### 2.2.1 National Development Plan

The superior development plans in the Maldives are Vision 2020 and the Millennium Development Goals. Vision 2020 envisages the attainment of middle income nation status and realization of the following targets by 2020: diversification of production activities, formation of an equitable society, provision of good quality health services and 10 years of public education to all citizens, application of environmentally friendly lifestyles and so on. Meanwhile, under the Millennium Development Goals, the following measures are proposed to combat extreme poverty: environmental sustainability, gender equality, mitigation of infant mortality and so forth. The 7$^{th}$ National Development Plan indicates the policies and strategies required in order to realize these superior plans. Specifically, it raises 12 goals in the following four fields.

(1) Economic development

Goal 1 : Create an environment conducive for growth and generate employment
Goal 2 : Enhance trade and support business and build competitive industries

(2) Spatial development

Goal 3 : Investment in strategic and state of the art infrastructure to enable ease of movement, enhanced access to services and build competitive advantage
Goal 4 : Creat a sustainable built environment that ensures preservation of cultural heritage, and provides opportunities for equitable access to recreational and other infrastructure
Goal 5 : Protect the natural environment and make people property safer

(3) Social development

Goal 6 : Invest in people through providing equal opportunities for education, lifelong learning, skills training and talent development
Goal 7 : Improve access to housing and health care and enhance well-being
Goal 8 : Empower women and advance protection for children, elderly, people with disabilities, poor and other vulnerable groups

(4) Governance

Goal 9 : Safeguards the values, rights and freedoms necessary to allow all to live a life of dignity

Goal 10 : Promote access to justice, rule of law and maximize public safety

Goal 11 : Strengthen local governance and public administration

Goal 12 : Protect sovereignty, enhance security and strengthen international relations

The energy sector is included in Goal 3 under spatial development. Conventional power generation, which depended on imports of fossil fuels, was extremely vulnerable to price rises in international markets and constituted a potentially major drawback to future growth. Accordingly, the 7th National Development Plan proposes a strategy reducing power generation based on fuel imports, promoting use of alternative energy sources, and concerning renewable energy in particular, introducing sustainable photovoltaic energy, and utilizing home appliances and industrial instruments that use renewable energy. As a concrete achievement goal, the Development Plan proposes that renewable energies account for 10% of energy use.

With respect to demand management, the 7th National Development Plan proposes a strategy comprising the promotion of demand management by major users including government agencies and implementation of enlightenment campaigns to encourage the use of products with good energy efficiency.

However, following the inauguration of President Mohamed Nasheed, the leader of the Maldivian Democratic Party (MDP), as a result of the presidential election in October 2008, the National Planning Council was established as the decision-making agency for national development policy in February 2009, and this Council approved the MDP manifesto as the new agenda for development in place of Vision 2020. This manifesto, which targets the period from 2008 to 2013, primarily aims to realize construction of a nationwide transport system, realization of affordable living costs, supply of attainable housing, affordable and quality health care for all, and prevention of narcotics abuse and trafficking, and it also includes policies related to good governance, social justice and economic development. The following measures are cited with respect to the energy field, which is included in economic development policy:

- Open up the fuel markets for competition
- Increase the capacity to generate electricity
- Provide electricity to all citizens without discrimination
- Open up the generation and supply of electricity to private entrepreneurs through a competitive market at the island level
- Eliminate import taxes and duties on renewable energy products

- Implement programs to create awareness on energy efficiency and minimize waste of electricity
- Increase energy security through the use of renewable sources of energy
- Encourage the use of alternative fuels such as bio gases and reduce the use of natural gases
- Formulate a Hydrocarbon Exploration Act
- Conduct all necessary surveys to determine the possibility of finding oil in the country

Most notably, short-term goals over the coming three years are given as: opening of the domestic oil market, implementation of bidding for the supply of oil and fuel products, promotion of reliable energy supply, public information on the use of renewable energy, and elimination of import tax on oil and fuel products.

Moreover, on March 15, 2009, President Nasheed announced a plan for the Maldives to become the world's first carbon-neutral state within 10 years through conversion to renewable energies. According to Wiki News, This plan envisages the installation of 0.5 square kilometers of photovoltaic panels and 155 wind turbines each generating 1.5 MW. It also includes construction of a biomass plant that combusts coconut husks, transition to electric cars and electric ships, and laying of undersea power transmission cables, and its execution will require funding of US$1.1 billion (US$110 million every year for 10 years).

### 2.2.2 Hulhumale' Island Development Plans

In the Hulhumale' Island development, for which Phase 1 is currently in implementation, public facilities such as hospitals and schools, etc. are already in operation, and 5,000 people are living in the island as of February 2009. Since it is planned to relocate 60,000 people to the island by the end of Phase 1 in 2020, if the relocation advances according to plan, it is expected that 4,600 people on average will move to the island every year from now on.

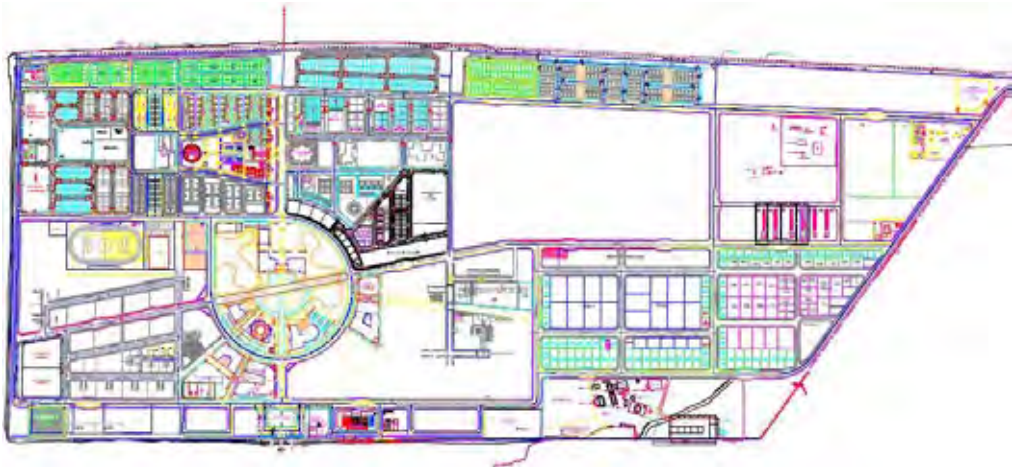
Figure 2.2.2-1 shows the area already developed as of February 2009. Housing development is taking place on the east side of the island. Building collective housing units has started in Residential Neighborhood 2 in the central area of the east side, and the tender for sections in the industrial area was implemented in the beginning of March 2009. Since height controls are enforced with respect to housing development, collective housing units can only be constructed up to four stories. Incidentally, hotel construction is expected to be completed by 2010.

Under the decentralization and privatization policies of the Government of the Maldives, the Hulhumale' Development Corporation LTD (HDC) will be changed to the Housing Corporation by

2010, while the public services that were so far provided by the HDC will be transferred to Male' Municipality.

a. Land use plan

b. Current condition (Feb 2009)



Source : Hulhumale' Development Corporation

Figure 2.2.2-1 Hulhumale' Island Development Plan and Current Condition

## 2.3 Aid by Other Donors

The Asian Development Bank (ADB) and United Nations Development Programme (UNDP) have provided active support to the energy sector of the Maldives. Since technical cooperation and F/S similar to the Study have been conducted in the past, close exchange and sharing of information have been conducted with other donors during field surveys.

(1) Asian Development Bank (ADB)

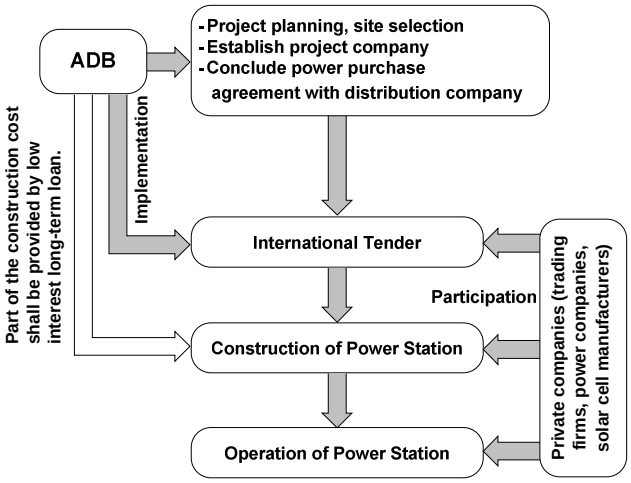
Through its ongoing implementation of the electrification program on Male' Island and outer atoll islands since 1985, the ADB has been deeply involved in developing the electricity sector in Maldives. In 2004, it completed work on the Third Power System Development Project for reinforcing power generation and distribution facilities on Male' Island. Currently, it is advancing work on procuring and installing diesel generating equipment and power distribution facilities on 19 outer islands that have been targeted under the Outer Islands Electrification Project (total project cost: US$10.6 million). As is shown in Table 2.3-1, tenders for three lots in this project were completed in 2005, 2007 and 2008 respectively, and the loan term is scheduled to end in December 2009.

Table 2.3-1 State of Progress in the Outer Islands Electrification Project (June 2009)

| No. | Lot 1: Target Islands | Start of Operation | No. | Lot 2: Target Islands | Start of Operation | No. | Lot 3: Target Islands | Start of Operation |
|---|---|---|---|---|---|---|---|---|
| 1 | Ha. Kelaa | 2007/3 | 1 | Ha. Baarah | 2008/6 | 1 | R. Ungoofaaru | 80% Completed |
| 2 | Ha. Ihavandhoo | 2007/4 | 2 | H. Dh. Neykurendhoo | 2008/6 | 2 | N. Manadhoo | 80% Completed |
| 3 | H.Dh.Makuudhoo | 2008/5 | 3 | Sh. Kanditheem | 2008/8 | | | |
| 4 | N.Kendhikulhudhoo | 50% Completed | 4 | B. Kendhoo | 2008/10 | | | |
| 5 | M.Muli | 2009/6 | 5 | M. Mulah | 2009/9 | | | |
| 6 | F. Nilandhoo | 2007/11 | 6 | Th. Guraidhoo | 60% Completed | | | |
| 7 | Th. Thimarafushi | 2008/9 | 7 | Ga. Kolamaafushi | 2009/11 | | | |
| 8 | Th. Veymandhoo | 45% Completed | 8 | Ga. Maamendhoo | 2009/10 | | | |
| 9 | L. Fonadhoo | 2007/11 | | | | | | |

Source : MHTE

Furthermore, ADB Headquarters is planning to establish a new support framework (see Figure 2.3-1) to utilize the Climate Investment Funds established with the World Bank, and disseminate PV power throughout Asia. In this scheme, ADB and developing countries will establish a project company to identify power stations and find customers for generated power. Also, the project company will be sold to private trading firms and power companies through international tender in order to contract out construction and management of the power stations. However, the Team confirmed that there is no active plan to utilize the same scheme in Maldives as of September 2009.




Source： Nikkei Shimbun (October 22, 2008, evening edition)

Figure 2.3-1 Support Framework for Photovoltaic Power by ADB

(2) United Nations Development Programme (UNDP)

UNDP has been implementing the Renewable Energy Technology Development and Application Project (RETDAP) utilizing funds from the Global Environment Facility (GEF) since 2005. Under the project, basic data on PV and other renewable energies are collected and examined. In addition, a hybrid system combining PV and diesel engine generators (DEGs) has been introduced as a pilot project in Mandhoo Island in South Ari Atoll. This project focuses on improving the maintenance skills and building the capacity of site engineers. Accordingly, training has been provided for engineers of the former MEEW, STELCO and private companies. 7 engineers have participated in the three weeks training from November 2007.

One of the components of this project is the Fund for RE System Applications (FRESA) currently in operation. The FRESA loan scheme derives from a total fund of US$250,000 and is operated by the Bank of the Maldives. Under this scheme, loans to support the introduction of renewable energy are provided to individuals up to a limit of MRf 50,000 (approximately US$3,900) and businesses up to a limit of MRf 80,000 (approximately US$ 6,250). Interest rates 20% below the market rate are applied to the first two years of loans under this scheme, while preferential interest rates are reviewed from the third year onwards. There were six applications to this scheme as of May 2009, however, none of these has so far been approved. Among the reasons cited for refusal, lack of technical or financial feasibility and insufficient financial capacity of applicants to repay loans have been given.

Since January 2008, UNDP has been implementing the new country program in the environmental sector with a view to ensuring sustainable technical transfer and mitigating climate change.

(3) Danish International Development Cooperation Agency (DANIDA)

The Fourth Power System Development Project was commenced under support from DANIDA in 2009. With a total project cost of 24 million Euros, this is a joint venture also involving the German consulting company OLP Co. and, on the execution side, the Denmark power company SEMCO and the German company MAN Co. This project aims to procure and install two diesel generator units (8 MW) (but foundations for three units) in response to the rapidly increasing demand for power on Male' Island.

# CHAPTER 3 CURRENT ENERGY AND ELECTRIC POWER DEMAND AND SUPPLY

## 3.1 Energy and Electric Power Policies and Legal Systems

### 3.1.1 Related Policy on the Energy and Electric Power Sector

The former Ministry of Communications, Science and Technology (MCST) in 2005 took the initiative in compiling the National Energy Policy-Maldives 2005 based on a nationwide survey of energy supply and demand implemented in 2002. The policy is undergoing revision in 2009, however, according to the draft document, the vision, main energy policy goal and energy policy objectives of the new policy are as follows.

**The Vision**

To achieve socioeconomic development of the Maldives based on sustainable energy supply and demand

**Main Energy Policy Goal**

To enhance energy utilization potential, reliability and accessibility through sustainable and environmentally friendly methods, and thereby promote domestic socioeconomic development.

**Energy Policy Objectives**

① To secure stable, economically sustainable and diverse energy supply in order to support socioeconomic development.
② To guarantee appropriately priced and reliable energy supply to all citizens.
③ To promote the introduction of renewable energy through removing domestic obstacles and providing incentives, and thereby enhance national energy security, create new occupations and solidify the economic base.
④ To protect the environment and health of citizens through securing an environmentally friendly energy demand and supply structure.
⑤ To achieve the optimum economic utilization of renewable and non-renewable energies and conserve energy consumption without lowering the level of services through implementing energy saving and efficient energy utilization programs and policies.
⑥ To attract domestic and foreign investment through enhancing the transparency of planning and operation in the energy sector.

Source： ”The Need and Urgency for a National Energy Policy”

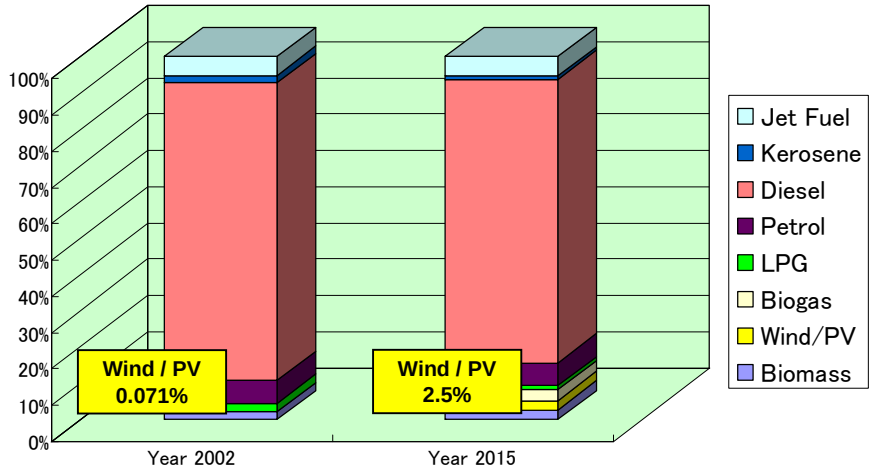
Figure 3.1.1-1 Main Points of National Energy Policy (revised version draft)

According to the results of the energy demand and supply survey of 2002, renewable energy use accounts for approximately 2% of primary energy supply, while PV power accounts for just 0.1% and is limited to supplying power to nighttime navigation lights for shipping and telecommunications

equipment on outer islands. Concerning the solar heat utilization field, solar water heaters are used on Male' Island and resort islands. In the National Energy Policy too, the high initial investment cost of PV utilization is considered an issue, however, it is expected that the price of PV modules will come down and wider use will be encouraged by the following methods:

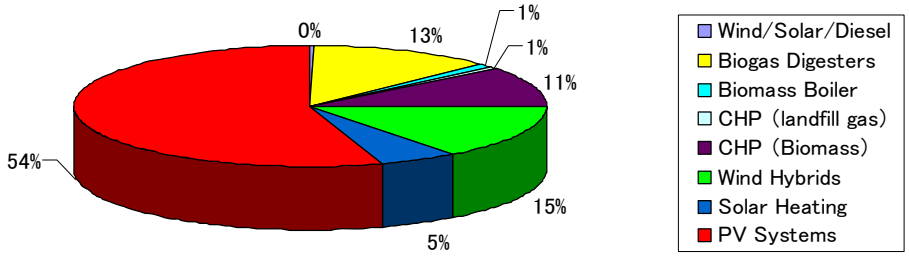
- Independent solar home systems (SHS)
- Grid-connected PV systems (interconnected PV systems)
- PV street lights
- Introduction of PV on resort islands

In the previous National Energy Policy-Maldives 2005, the plan was to raise the share of PV power use to 2.5% by 2015 through introducing a vigorous policy of dissemination as shown in Figure 3.1.1-2. The MHTE Energy Section is currently in the process of revising this policy, and in its draft it has specified a goal of raising the share of renewable energy in primary energy supply to at least 12% by 2020. However, individual target values for each resource which were specified in the National Energy Policy-Maldives 2005 have not yet been set, and the baseline survey needed to determine the target values has not yet been implemented. The draft revised policy suggests the possibility of introducing the RPS system and subsidies (described later) as methods for encouraging the introduction of renewable energies in order to achieve the above target (12%).




Source： National Energy Policy – Maldives 2005

Figure 3.1.1-2　Breakdown of Primary Energy Supply in Maldives (Actual and Forecast)

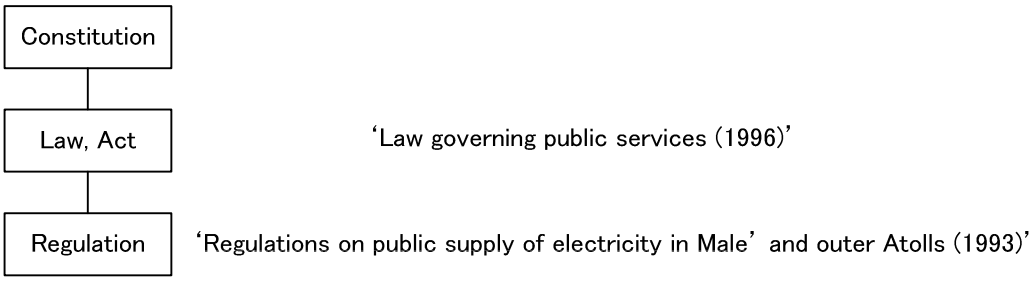



Source： National Energy Policy – Maldives 2005

Figure 3.1.1-3 Energy Resources Investment Plan up to 2015

### 3.1.2 Legal Systems

Under the Maldivian legal system, policies and institutions are specified in different levels starting with the Constitution and moving down through Laws or Acts and Regulations. Concerning the energy and power sector, Article 2 of the "Law governing public services" (Law No. 4, 1996) defines public services as electric power, telephones, public water supply and sanitary treatment (sewerage), and the entities (government agencies, government-run enterprises, private operators) that operate these public services must, according to Article 3 of the same law, register with government regulatory agencies and adhere to the rules laid down by those agencies.




Source: Study Team

Figure 3.1.2-1 Legal Systems related to Energy

The specific contents of regulations pertaining to the electricity utility are prescribed in the "Regulations on public supply of electricity in Male' and outer Atolls" established by the Maldives Energy Authority (MEA), which is the regulatory agency for the electric power industry. As is indicated below, these regulations stipulate the basic technical items to be adhered to concerning applications for permission to supply electricity as well as generating equipment and distribution equipment of electricity utility operators.

Table 3.1.2-1 Outline of the Regulations on Public Supply of Electricity in Male' and Outer Atolls

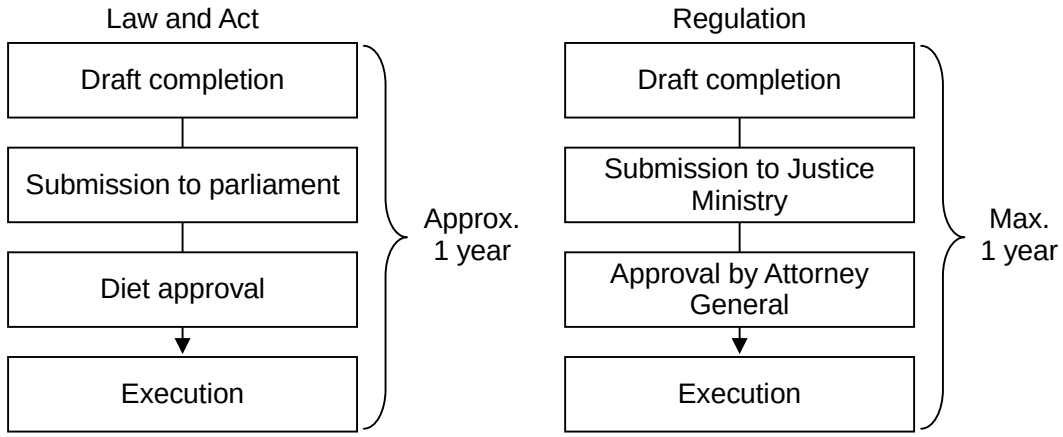
| Article | Outline |
|---|---|
| Article 1<br>Supply of electric power services | Operators providing electricity supply services to ordinary consumers need to register with the MEA and obtain the necessary authorization. |
| Article 2<br>Statement of agreement | Electricity suppliers need to obtain written agreement from consumers that services are being provided in accordance with the technical regulations established herein. |
| Article 3<br>Provision of services by third parties | When electricity suppliers registered with the MEA transfer all or part of electricity supply services to other parties, it is necessary to obtain a separate authorization from the MEA. |
| Article 4<br>Contract infringements | In cases where consumers are found to not conform with responsibilities specified in the statement of agreement and to be in violation of contract, they may be notified to the MEA and have their supply suspended. |
| Article 5<br>Provisional suspension of services | In cases where it becomes necessary to suspend supply, this may be done upon first notifying the reasons to the MEA in writing and obtaining permission from the MEA. |
| Article 6<br>Electricity tariffs | In order to apply for the establishment or revision of electricity tariffs, it is necessary to submit a supply plan and price structure based on a demand projection of at least 10 years to the MEA and obtain permission. |
| Article 7<br>Contract articles | In cases where regulations between electricity operators and consumers include third parties, this shall become a valid contract article upon securing permission from the MEA. |
| Article 8<br>Specifications relating to power plants | Outline specifications pertaining to the construction site, foundation height and materials, etc. of power plants |
| Article 9<br>Specifications relating to control stations, distribution panels and feeders | When constructing control stations, distribution panels and feeders, it is necessary to submit the necessary drawings to the MEA and to obtain permission. |
| Article 10<br>Specifications relating to distribution lines | When constructing overhead distribution lines, it is necessary to submit the necessary drawings to the MEA and to obtain permission. Regulations are also prescribed concerning voltage drop, building column positions and cable laying depth, etc. |
| Article 11<br>Lead-ins to consumers | Consumers need to install main switches, overload protection (cutout fuses, MCB, MCCB) and grounding protection (ELCB, ELR). |
| Article 12<br>Indoor wiring | When implementing indoor wiring works, it is necessary to submit the necessary drawings to the MEA and to obtain permission. Regulations are also prescribed concerning the phase color identification of wires, phase balance and installation of protective devices, etc. |
| Article 13<br>Employees of electric power suppliers | Employees of power plants need to receive the necessary training. Moreover, persons responsible for power plants need to acquire qualifications that have been approved by the MEA. |
| Article 14<br>Regulations concerning distribution lines | All operators who conduct wiring works need to adhere to MEA regulations. |
| Article 15<br>Compliance with regulations | Decisions whether consumers who started receiving electricity supply prior to January 1, 2007 need to implement additional works according to these regulations shall be made by the supervisory agency (MHTE). |
| Article 16<br>Violations of regulations | In the event where violation of these regulations is confirmed, the party concerned shall be ordered to pay a fine of 100～5,000 Rf. |

Source： Prepared by the Study Team from the "Regulations on public supply of electricity in Male' and outer atolls"

Article 8 of the regulations stipulates requirements and outline specifications relating to the construction of power plants assuming construction of diesel power plants; however, regulations pertaining to the introduction of PV generating facilities including grid-connected PV systems will need to be examined from now on.

The Maldives National Building Code which the former Ministry of Construction and Public Works established in August 2008 stipulates safety standards for indoor wirings and other electric facilities in buildings as well as energy conservation. However, the Building Code is just a performance standard and has no legal binding force. Specific measures to realize the prescribed performance are chosen by building owners. In order to give the Building Code legal force, it is expected that the Building Act will be enacted.

Figure 3.1.2-2 shows the usual procedure and time required between the drafting and execution of an Act. If the time needed to prepare the draft is also taken into account, it will take an even longer time up to execution.




Source： Study Team

Figure 3.1.2-2 Necessary Procedures and Times for Each Legal System

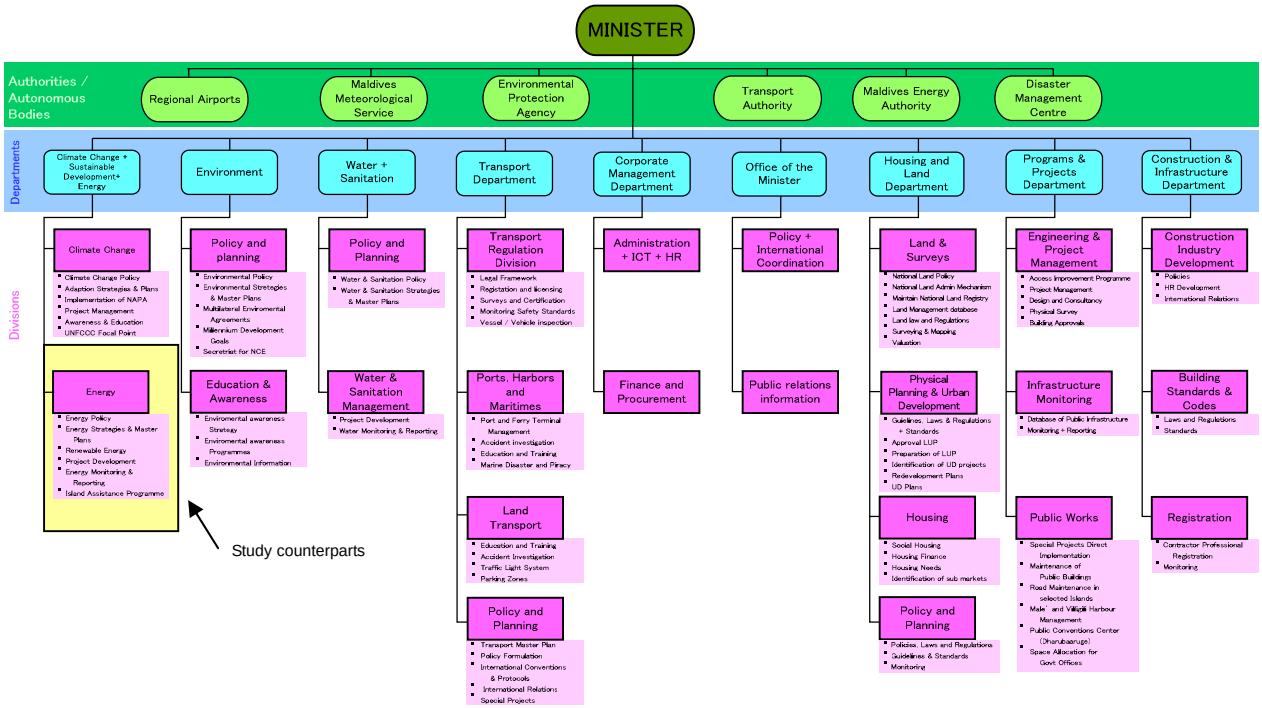
Concerning grid connections of dispersed power sources including renewable energy, consumers are confronted with a choice between either power supply from STELCO or supply from only private generating equipment. This system was introduced out of concern that the spread of small generators will lead to environmental pollution, however, in the event where grid-connected PV systems become more widespread and available to not only STELCO but also general consumers in future, it will be necessary to revise this regulation.

## 3.2 Organizations in the Energy and Electric Power Utility

### 3.2.1 Ministry of Housing, Transport and Environment (MHTE)

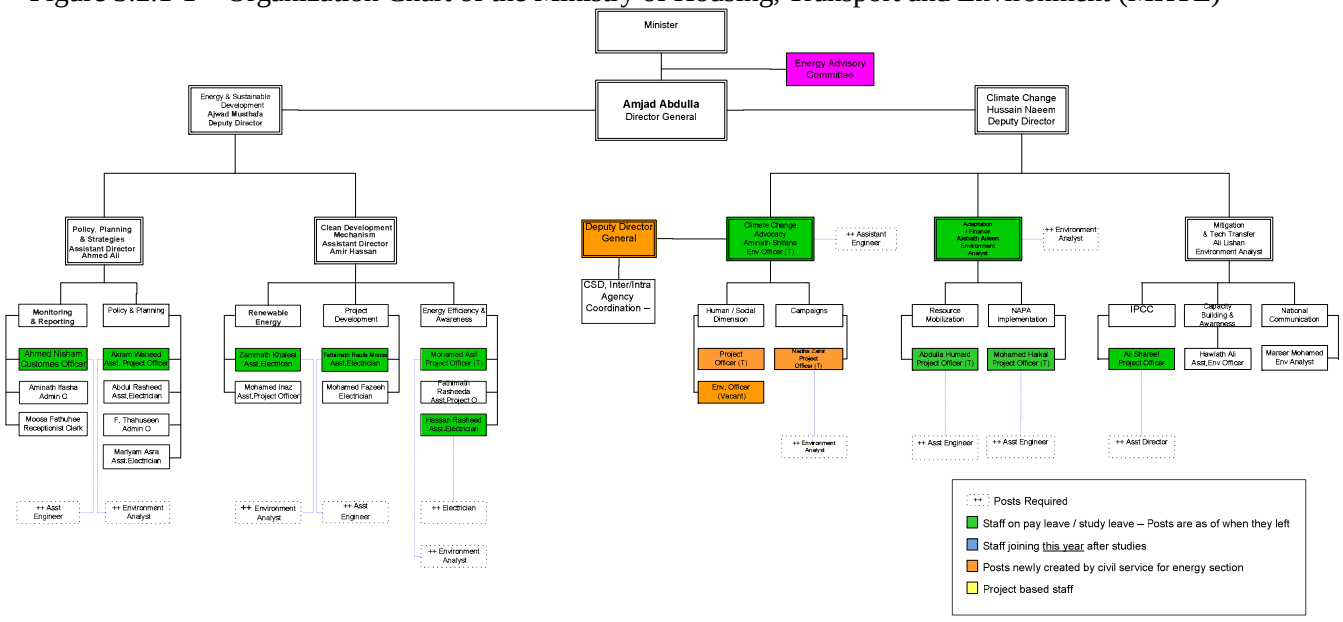
The Ministry of Housing, Transport and Environment (MHTE), which succeeded the Ministry of Environment, Energy and Water (MEEW), is in charge of policies on energy including renewable energies. Formed through combining the former MEEW, Ministry of Construction and Public Infrastructure, Ministry of Transport and Ministry of Housing and Urban Development, the MHTE has 1,351 employees as of June 2009 and its organization is divided into nine departments (residential land development, construction and infrastructure, environment and so forth). The Study counterpart, i.e. the Energy & Sustainable Development Division of the Climate Change and Energy Department, is responsible for formulating policy and development plans in the energy and electric power sector. The Division is composed of two sections, namely Policy, Planning & Strategies Section, and Clean Development Mechanism Section. Policy, Planning & Strategies Section is responsible for Monitoring & Reporting, Policy and Planning. Clean Development Mechanism Section is in charge of Renewable Energy, Project Development, and Energy Efficiency & Awareness. However, those two sections are working hand in hand to be directed and managed by Mr. Ahmed Ali. Figures 3.2.1-1 and 3.2.1-2 show the organization charts of the MHTE (overall ministry) and Climate Change and Energy Department respectively.

As was mentioned above, the MHTE is involved not only with conventional energy supply but also utilization and dissemination of renewable energies, however, since the Energy & Sustainable Development Division has only ten employees, it may be realistic to consign technical maintenance work to electricity operators (STELCO, etc.) and allow the MHTE to focus on policy formulation and planning in order to ensure the operation and maintenance of grid-connected PV systems.




Source ：MHTE

Figure 3.2.1-1 Organization Chart of the Ministry of Housing, Transport and Environment (MHTE)



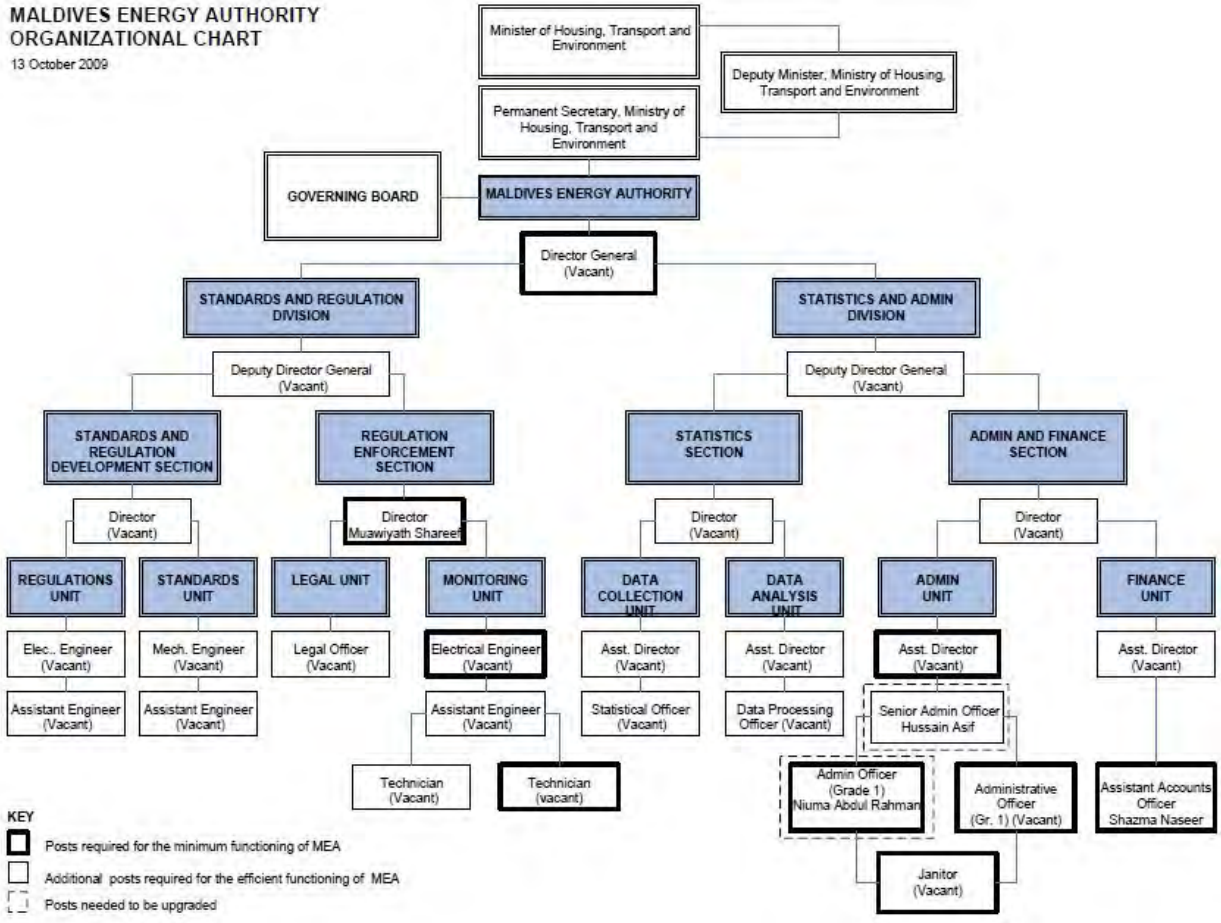

Source ：MHTE

Figure 3.2.1-2 Organization Chart of the MHTE Energy & Sustainable Development Division

### 3.2.2 Maldives Energy Authority (MEA)

The Maldives Energy Authority (MEA) was established in April 2006 as the regulatory and supervisory agency for the overall energy sector including electricity following a reorganization of the regulatory and supervisory functions of the Maldives Electricity Bureau (MEB). As a regulatory agency independent from the MHTE, the MEA is in charge of formulating technical criteria,

associated regulations and provisions and conducting supervisory administration. The energy division of the MEA is operated by four employees as of October 2009, and three out of four are not engineers. Therefore, in order to achieve the roles required of the organization as shown in Figure 3.2.2-1, in total nine staff is required. So further recruitment and capacity development of the staff is necessary to introduce and operate regulations for renewable energy including solar power system.



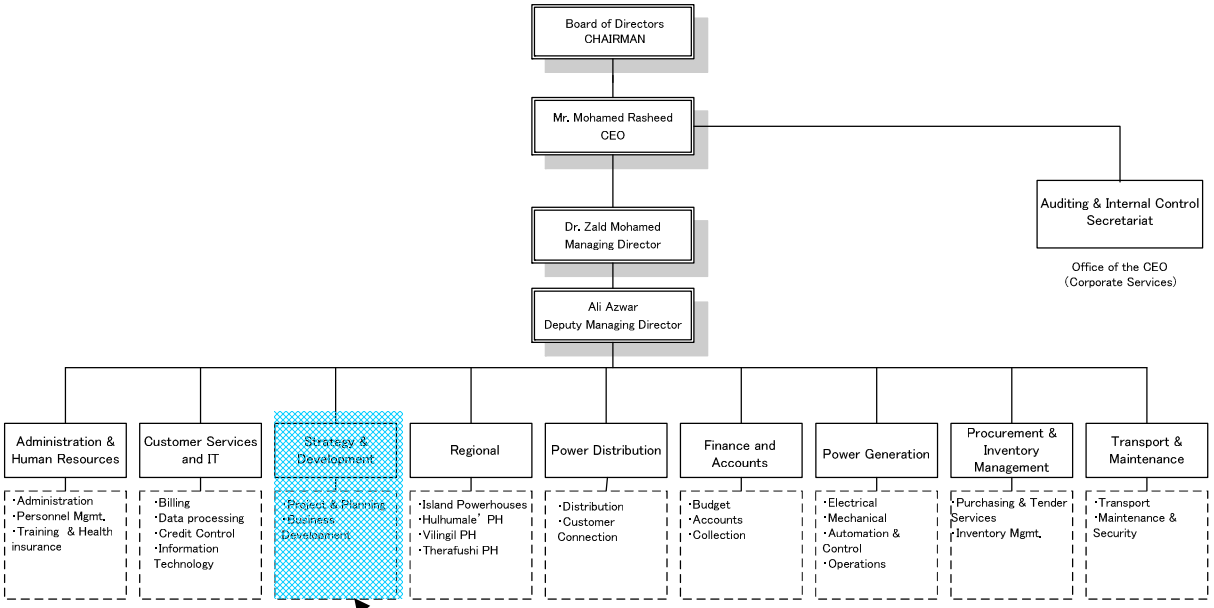

Source ：MEA

Figure 3.2.2-1 Organization Chart of Maldives Energy Authority (MEA)

### 3.2.3 State Electric Company Limited (STELCO）

In Maldives, the Electricity Department launched the electricity utility in 1949, and this was subsequently implemented by the former Maldives Electricity Board (MEB). In June 1997, in line with the government policy to make public corporations out of the public utilities, the State Electric Company Limited (STELCO) was established based on 100% government funding with the objective of achieving a self-supporting accounting system in the electricity utility. STELCO provides power generation and distribution business in total 10 islands including Male'. The organization of STELCO is divided into nine departments, namely Administration & Human Resources, Customer Services and IT, Strategy & Development, Regional, Power Generation, Power Distribution, Finance and Accounts,

Procurement & Inventory Management, and Transport & Maintenance Department. The total number of employees is 449 as of October 2009, of which 330 are employed in Male'. The Strategy and Development Department in the head office is the counterpart for the Study, however, this only possesses six staff including the director, it has no staff in charge of renewable energy and energy saving, and it simultaneously works on multiple projects. The Strategy and Development Department is the counterpart for the Study. Figure 3.2.3-1 shows the organization chart of STELCO.




Source : STELCO

Figure 3.2.3-1 Organization Chart of the State Electric Company Limited (STELCO)

### 3.2.4 Business Condition of the State Electric Company Limited (STELCO)

Table 3.2.4-1 shows the STELCO profit and loss statement for 2002 to 2008. The increase in revenue mainly derives from greater power sales, however, because sales costs are rising together with sales turnover, the gross profit on sales has been in decline since 2002 and a gross loss on sales was provisionally recorded in 2008. The decline in profits from 2004 onwards has been affected by reduced electricity tariffs and increase of diesel fuel price, and an increasingly large ordinary loss has been recorded since 2006. The loss was particularly large in 2008, when the diesel prices skyrocketed.

Table 3.2.4-1 Profit and Loss Statement of STELCO

(Unit: Thousand MRf)

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|---|---|---|
| Revenue | 346,433 | 391,428 | 411,535 | 480,907 | 566,643 | 665,190 | 753,905 |
| Cost of sales | 169,068 | 216,014 | 278,288 | 374,227 | 555,280 | 660,865 | 1,110,552 |
| Gross Profit | 177,365 | 175,414 | 133,247 | 106,680 | 11,364 | 4,324 | -356,647 |
| Other Income | 2,631 | 2,241 | 1,603 | 60,623 | 30,138 | 10,551 | 202,997 |
| Administrative Expenses | | 73,945 | 80,328 | 115,803 | 84,412 | 112,598 | 98,952 |
| Other Expenses | 77,630 | | 7,915 | | 57,816 | 26,633 | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Profit/Loss from Operating Activities | 102,366 | 103,710 | 46,607 | 51,500 | -100,727 | -124,355 | -252,602 |
| Finance Income | | | 751 | 82 | 413 | 45 | 4 |
| Finance Cost | 30,894 | 33,150 | 24,754 | 23,557 | 21,879 | 22,020 | 24,416 |
| Net Profit/Loss for the Year | 71,472 | 70,560 | 22,605 | 28,026 | -122,193 | -146,330 | -277,014 |

Source : STELCO

Note : Figures for 2008 are provisional values.

STELCO has received subsidies from the government since 2005, however, these are treated as other income and, as is indicated in Table 3.2.4-2, they are used to make repayments on loans and purchase diesel fuel from the STO. In addition to these subsidies, STELCO also receives capital donations from the government.

Table 3.2.4-2 Breakdown of Subsidies from the Government

Unit: 1000 MRf

| | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|
| 1. Subsidies | | | | |
| Loans | 42,725 | - | - | |
| Payments to STO | 11,957 | 16,462 | - | |
| Deficit makeup | - | - | 3,569 | 200,000 |
| Subtotal | 54,682 | 16,462 | 3,569 | 200,000 |
| 2. Capital donations | | | | |
| Generating equipment costs | - | 16,552 | 7,471 | 1,264 |
| Total | 54,682 | 33,013 | 11,040 | 201,264 |

Source : STELCO

Note : In the provisional profit and loss statement for 2008, capital donations are categorized as government subsidies under other income.

Table 3.2.4-3 shows financial performance indicators of STELCO for the period 2004 to 2007. It can be seen that the operating ratio has been increasing since 2004 and operating costs have exceeded operating revenue since 2006. The liquidity ratio is declining every year, and in 2007, current liabilities exceeded current assets. The amount of current liabilities has been increasing twofold every year since 2005: in 2007, short-term loans were two times greater than the previous year, accounts payable were 1.5 times greater, and bank overdrafts were 11 times greater. The capital-to-asset ratio temporarily increased in 2005 but has subsequently showed a downward trend; particularly in 2007, the drop in accumulated earnings was significant and the capital-to-asset ratio showed a major decline. Since the business performance in 2008 has deteriorated even more, these indicators could be even worse. Reflecting the deficit-showing operations since 2006, the interest coverage ratio indicating the capacity to pay principal and interest is a negative figure, reflecting deficit operation from 2006 onwards. Unless this financial situation is remedied, that would have an influence on investment renewable energies and renewal of the existing facilities.

Table 3.2.4-3 STELCO Financial Performance Indicators

| | 2004 | 2005 | 2006 | 2007 |
|---|---|---|---|---|
| Operating ratio | 0.89 | 0.90 | 1.17 | 1.18 |
| Liquidity ratio | 1.73 | 1.59 | 1.10 | 0.59 |
| Own capital ratio | 55% | 59% | 52% | 35% |
| Interest coverage rate | 1.91 | 2.19 | -4.58 | -5.65 |

Source : Prepared by the Study Team from STELCO financial statements

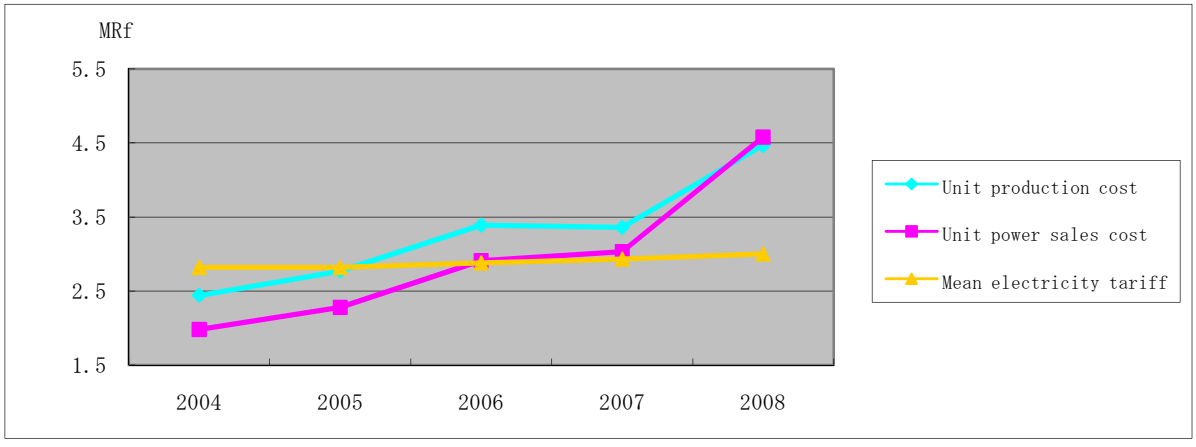
Table 3.2.4-4 and Figure 3.2.4-1 show unit costs and average electricity tariffs from 2004 to 2008. The unit production cost is the cost required to generate 1 kWh of electricity; the unit power sales cost is the cost required to sell 1 kWh of electricity; and the average electricity tariff is the amount paid by consumers for 1 kWh of electricity. In 2004 and 2005, the average electricity tariff exceeded the unit production cost and unit power sales cost and the business recorded an ordinary profit as indicated in Table 3.2.4-4. However, the situation was reversed in 2006, when unit production cost and unit power sales cost exceeded the average electricity tariff. The difference between the unit power sales cost and the average electricity tariff was MRf 0.03/kWh in 2006, MRf 0.10/kWh in 2007 and MRf 1.58/kWh in 2008. This means that selling every 1 kWh of electricity have generated loss of the amount since 2006. This deterioration in the financial situation has come about due to the electricity tariff held down by the government policy as a measure to address poverty, and the rapid increase in power consumption over this period. Accordingly, in order to improve this financial standing of STELCO, it will be necessary to conduct a full-scale review of pricing, control demand, reduce operating expenses and make greater use of long-term liabilities rather than short-term liabilities.

Table 3.2.4-4 Power Sales Income, Costs and Average Electricity Tariffs

| | 2004 | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|---|
| Power sales income (MRf) | 396,398,430 | 464,334,992 | 550,245,288 | 639,808,246 | 727,600,647 |
| Total cost (MRf) | 391,284,504 | 513,586,557 | 719,387,073 | 822,115,850 | 1,233,919,808 |
| Sales cost (MRf) | 278,287,641 | 374,227,036 | 555,279,719 | 660,865,342 | 1,110,551,775 |
| Fuel cost (MRf) | 201,970,191 | 293,477,424 | 436,283,213 | 544,377,881 | 942,211,554 |
| Unit production cost (MRf/kWh) | 2.44 | 2.77 | 3.39 | 3.36 | 4.47 |
| Unit power sales cost (MRf/kWh) | 1.98 | 2.28 | 2.91 | 3.03 | 4.58 |
| Average electricity tariff (MRf/kWh) | 2.82 | 2.82 | 2.88 | 2.93 | 3.00 |

Source : Prepared by the Study Team based on STELCO financial statements and data on generated electrical energy.

Note : Unit production cost = Total cost ÷ Total power generation; Unit power sales cost = Sales cost ÷ Totalelectrical power selling; Average electricity tariff = Power sales income ÷ Total electrical power selling




Source : Prepared by the Study Team based on STELCO financial statements and data on generated electrical energy.

Figure 3.2.4-1 Unit Cost and Average Electricity Tariff

### 3.2.5 Restructuring of the Electric Power Sector

The recently inaugurated Nasheed administration has vigorously promoted the decentralization of public services that were hitherto controlled by the central government, the privatization of government-owned enterprises and the introduction of private sector capital to government-financed corporations with a view to accelerating economic growth and improving the living standard of citizens. In line with these policies, restructuring of the electric power sector is still in progress. Specifically, based on the Decentralization Law that is currently being prepared, it is planned to establish utility companies in each province (newly established administrative divisions) and for provincial governments to consign electricity, gas, public water supply and sewerage services to these utility companies. The utility companies are initially operated under 100% government funding, however, a request for declarations of interest was announced in February 2009 with a view to introducing private sector capital under the PPP (Public Private Partnership) model. In Maldives, private sector investment has conventionally been actively promoted in developing resort islands, and the intention here is to apply the same technique to public services, however, since the demand for regional public services is small and transport costs for materials and fuel are high, it is difficult to make returns and thus attract private sector investment.

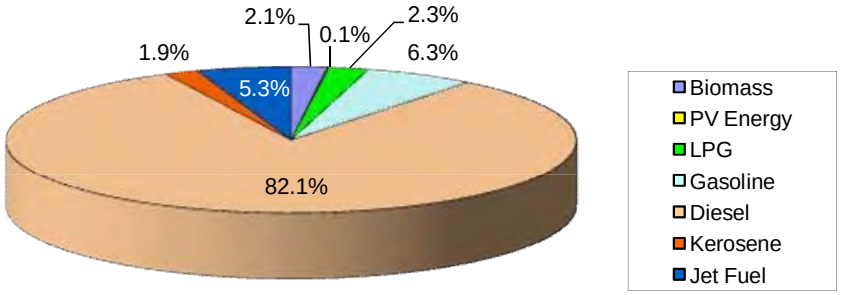
Operation of the power supply utility was started in April 2009 in three out of the country's seven provinces (Upper North, North and Upper South) and nine atolls, and responsibility for the maintenance of power generating and distribution facilities in these areas has been transferred from STELCO to utility companies. Concerning STELCO, it is planned to focus supply activities into North Central Province in and around Male' Island and improve the financial situation through introducing private sector capital including foreign capital. Towards this end, STELCO is surveying the operation and maintenance conditions of power facilities on the islands included in the new supply area in North Central Province (a total of 34 inhabited islands including Male' Island).

The Ministry of Economic Development, Invest Maldives has formed a joint venture with STELCO and has been advertising for partner companies to participate in the electricity utility since March 25, 2009, and as of the cutoff date of May 25, it appears that Expression of Interest (EOI) had been received from around 15 companies.

## 3.3 Energy and Electricity Demand and Supply Situation

### 3.3.1 Energy Demand and Supply

According to the National Energy Policy-Maldives 2005, assuming actual values from 2002 to be the latest statistical data, the composition of nationwide primary energy supply of 223,970 (toe) is as follows: imported fossil fuels led by diesel fuel (82%) account for approximately 98%, and domestic energy resources comprising biomass and solar energy account for 2%. Accordingly, the government is trying to break away from the fragile energy supply dependent on imported fossil fuels through promoting the renewable energies primarily solar energy, conducting DSM and improving energy efficiency.



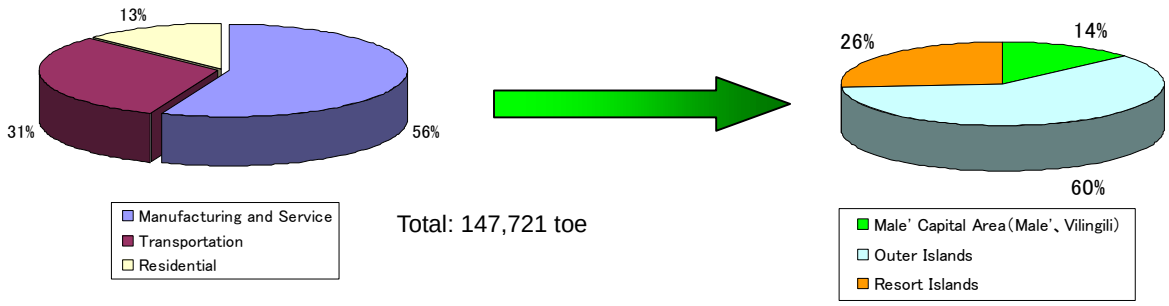

Source： National Energy Policy – Maldives 2005

Figure 3.3.1-1 Breakdown of Primary Energy Supply in the Maldives (2002)

According to the National Energy Policy, the breakdown of final energy consumption in Maldives is as shown in Figure 3.3.1-2. This shows that the manufacturing and service sectors account for the largest share of 56.2% and that consumption is especially high in outer islands and resort islands. Looking at the breakdown of consumption in outer islands, conventional energies such as kerosene, LPG and biomass account for the major share, while this ratio goes down when viewed in terms of overall electricity demand as described later. In the transport sector, energy consumption for ocean transport (speed boat and dhoni (wooden boats equipped with diesel engines)) between Male' and resort islands / outer islands accounts for 58% of total consumption.

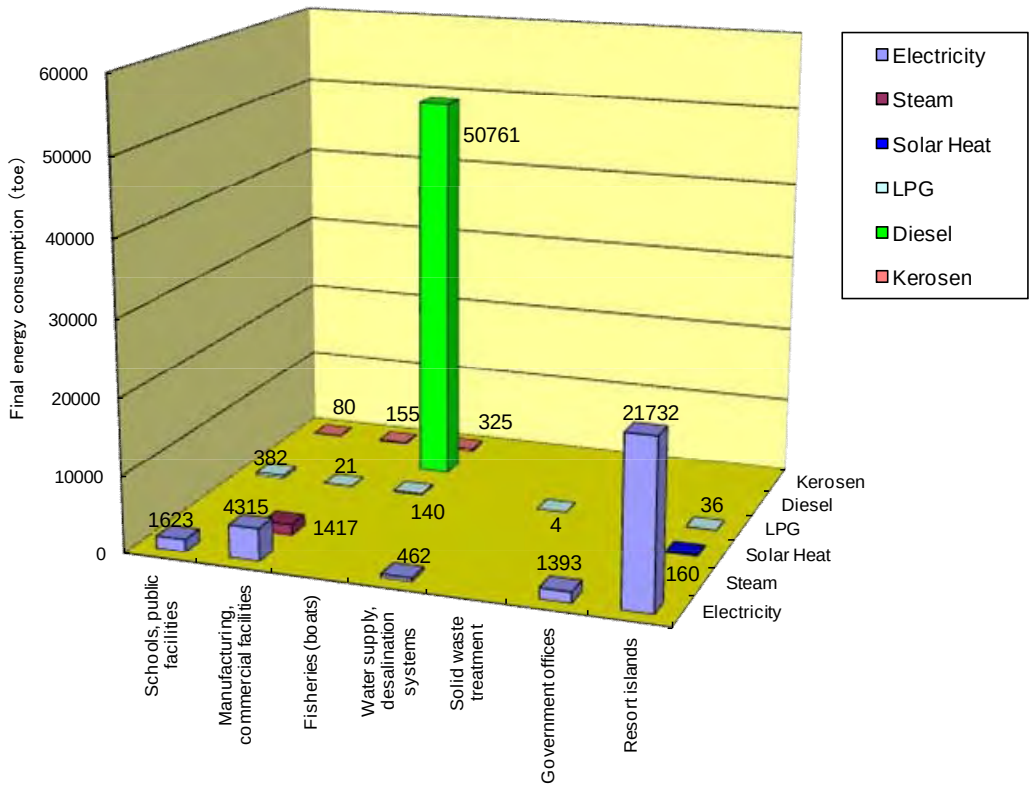
Total energy consumption has been increasing rapidly at more than 10% per year recently. This trend has largely been driven by higher consumption in the electric power sector and transport sector, while consumption has also been growing in the fisheries and tourism sectors. Looking at the sector-separate breakdown of energy consumption in 2002, as is indicated in Figure 3.3.1-3, diesel fuel for shipping and electricity consumption on resort islands are the dominant items. If looking at the housing sector only, as is shown in Figure 3.3.1-4, electricity consumption accounts for around 70% of overall energy consumption on Male' Island and Vilingili Island, whereas on other outer islands, biomass (34%) and

LPG (26%) account for higher shares, thereby indicating a large disparity between the metropolitan area and outer islands in terms of the energy consumption structure.



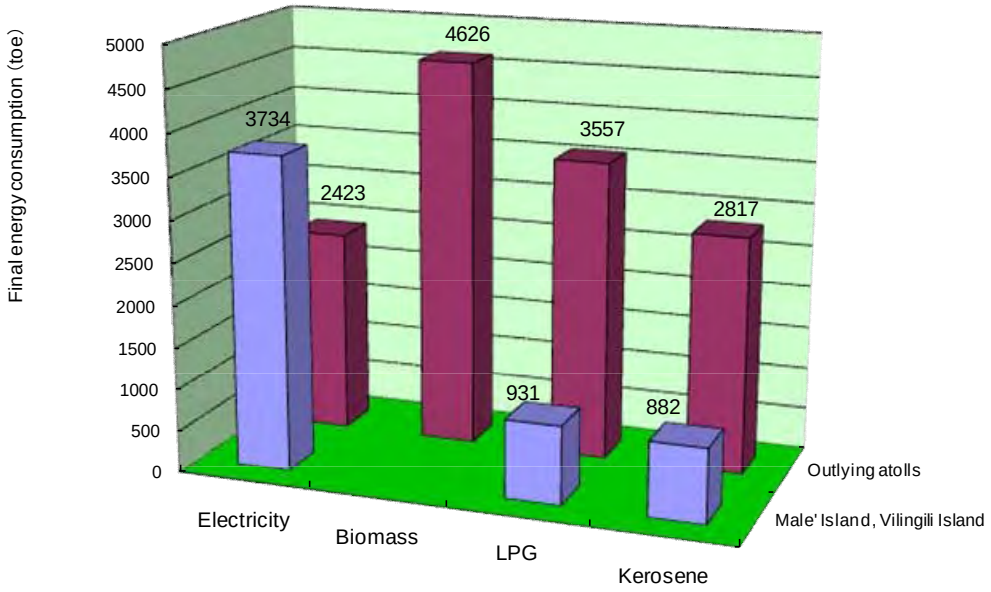

Source： National Energy Policy-Maldives

Figure 3.3.1-2　Breakdown of Final Energy Consumption in Maldives (2002)




Source： National Energy Policy-Maldives

Figure 3.3.1-3　Breakdown of Final Energy Consumption
(Industrial and Commercial Sectors) in the Maldives (2002)



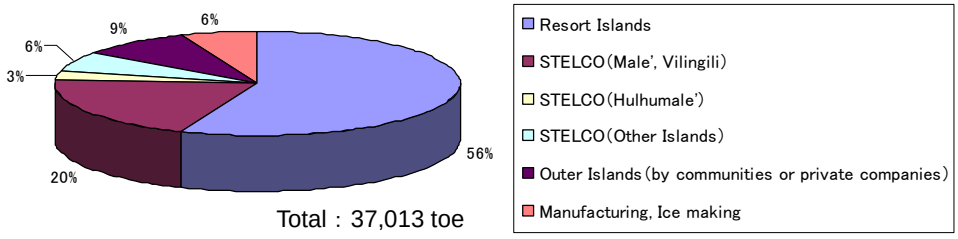

Source： National Energy Policy-Maldives

Figure 3.3.1-4 Breakdown of Final Energy Consumption (Housing Sector) in the Maldives (2002)

### 3.3.2 Power Supply and Demand

(1) General Survey

Whereas approximately one-third of the population had no access to electricity in 1990, that figure has now been reduced to around 3% and the power supply infrastructure has been widely expanded to outer atolls. However, in terms of share of generated electric energy, resort islands account for 56% of the total, while the major islands (32 islands including Male') served by STELCO account for 29%. Only 9% of total power is generated in outer islands where the demand density is lower.

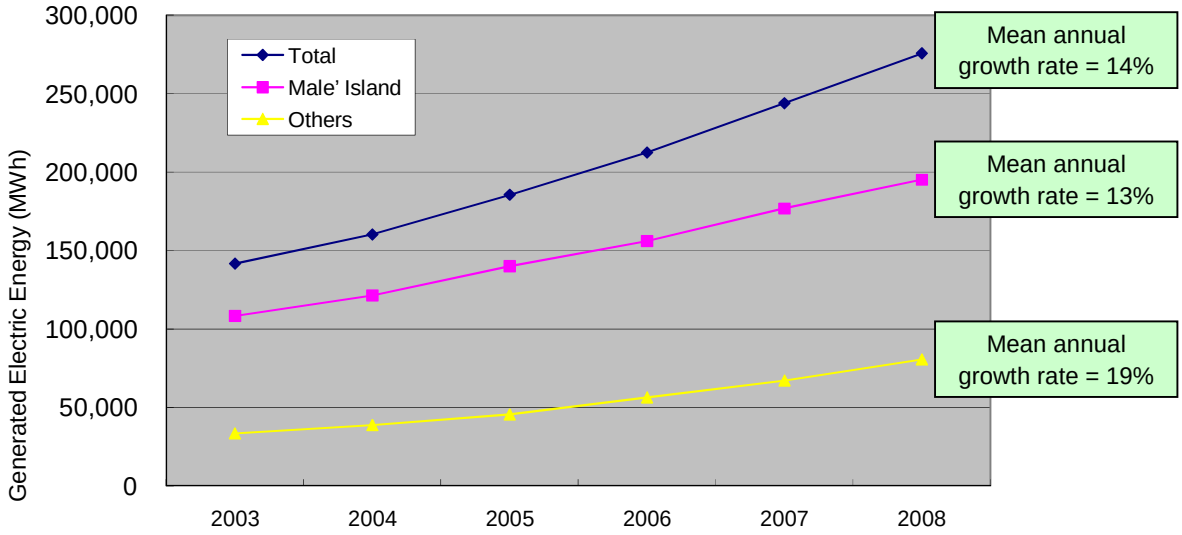



Source： National Energy Policy-Maldives 2005

Figure 3.3.2-1 Breakdown of Generated Electric Energy

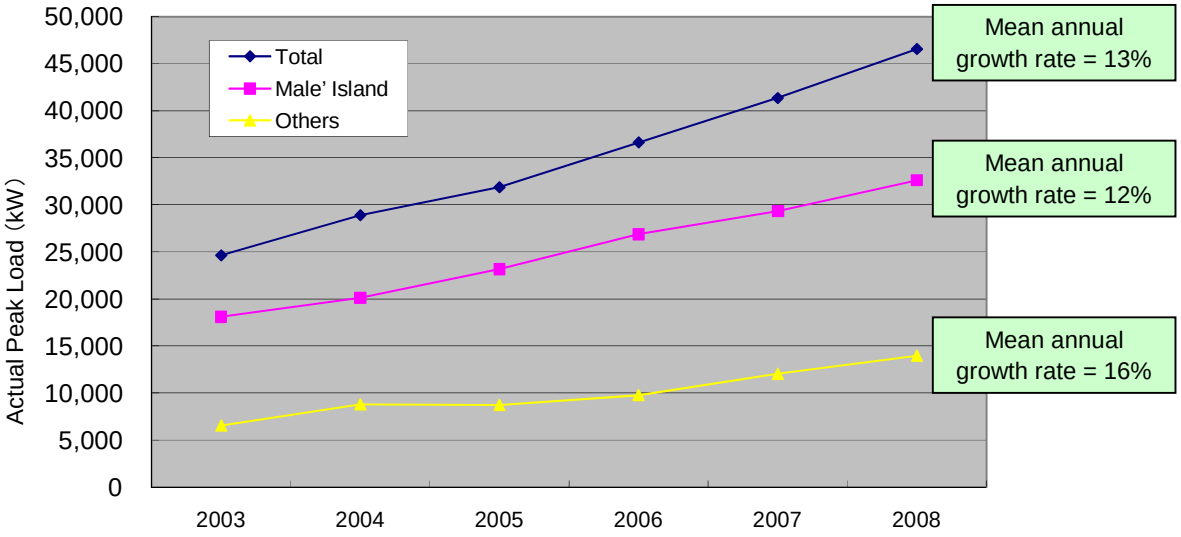
Furthermore, when viewed in terms of the per capita power consumption, whereas the figure is between 170~350 kWh in outer islands, it is approximately 1,300 kWh in Male' metropolitan area, indicating a major disparity between the outer islands and the capital area.

The overall STELCO supply area displayed a high growth rate of 14% on average per year based on generated electric energy and peak load over the five years from 2003 to 2008, showing that the demand for electric power is greatly increasing not only in Male' metropolitan area but all the main islands served by STELCO.




Source： STELCO

Figure 3.3.2-2 Generated Electric Energy in the STELCO Supply Area

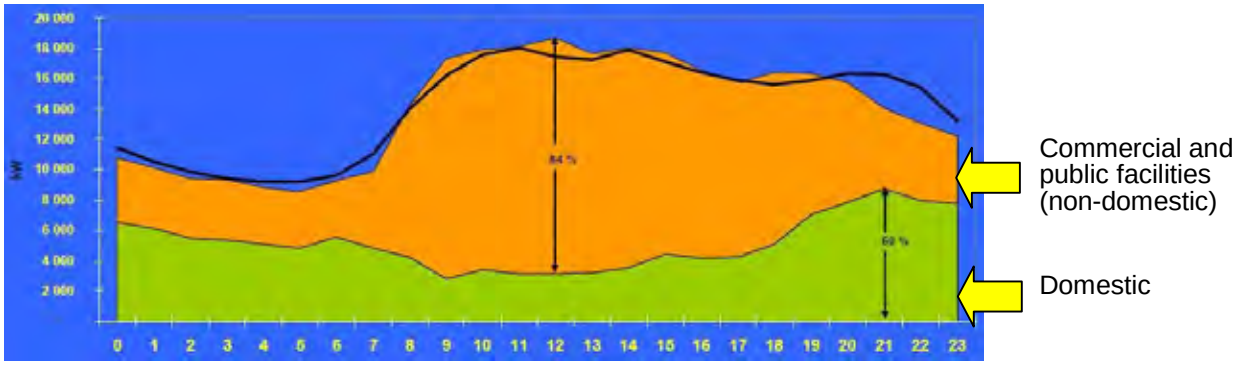



Source: STELCO

Figure 3.3.2-3 Peak load in the STELCO Supply Area

Looking at the breakdown of power consumption in Male' and Hulhumale', domestic consumption accounts for the largest share on both islands, where refrigerators (18%), lighting facilities (17%) and electric fans (12%) account for the largest share. However, during the daytime peak, since power consumption for commercial and public facilities grows to 80% of total demand as indicated in Figure3.3.2-4, it may be effective to reduce peak load through improving the energy efficiency of air conditioning units and other appliances in these sectors to promote DSM.

Since the peak demand in Male' occurs during the daytime when the PV power generation is the largest, introduction of the grid-connected PV system will make it possible to reduce the peak load and energy from diesel engine generators (DEGs). However, since the power generated by the grid-connected PV system will be influenced by weather conditions, the grid-connected PV system will not be able to cover the maximum system demand currently provided by DEGs. In order to supplement the grid-connected PV system and realize economic power operation, in addition to promoting the grid-connected PV system, it will be important to disseminate DSM measures such as limiting daytime peak demand and encouraging energy conservation activities.

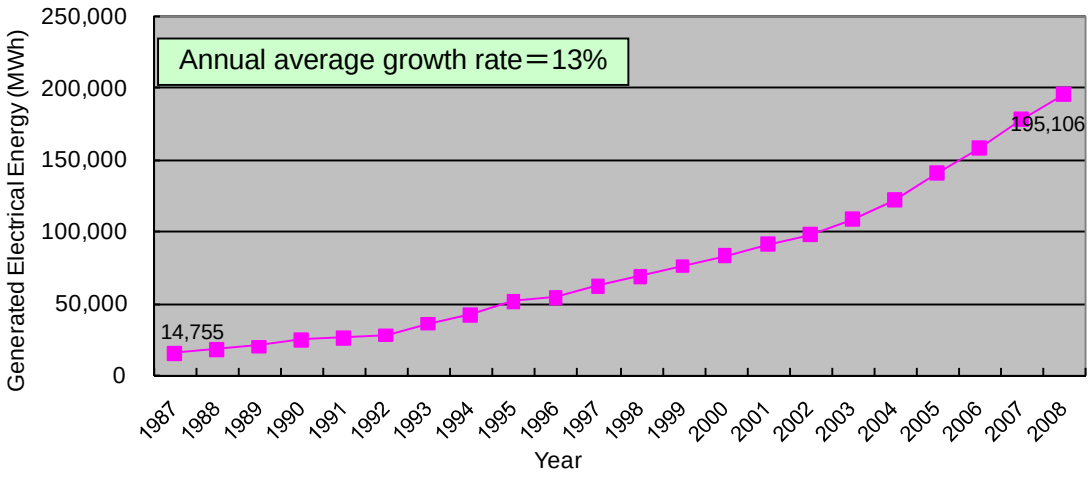


Source : STELCO

Figure 3.3.2-4 Daily Load Curve in Male'

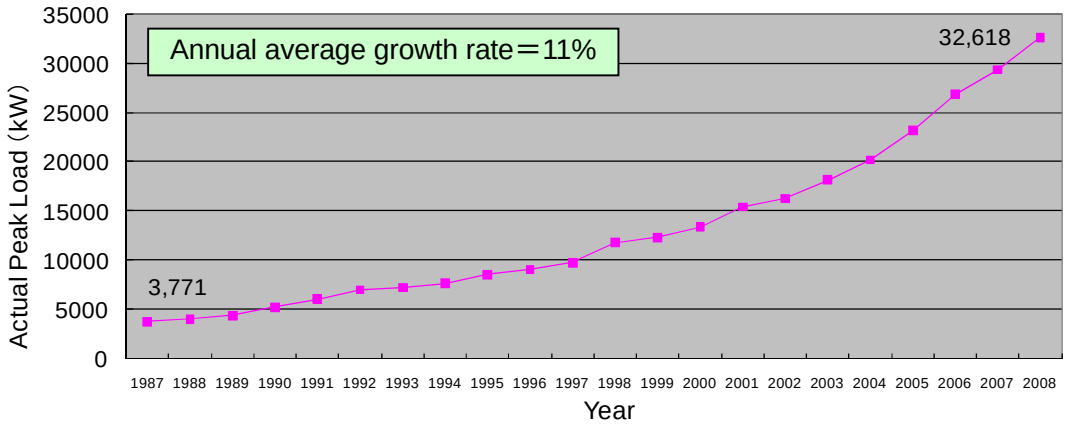
(2) Demand and Supply Situation on Male' Island

As is shown in Figure 3.3.2-5, Male' Island is already saturated with development plans and is experiencing a dramatic growth in generated electric energy of on average between 11~15% per year due to population influx, dissemination of air conditioners, etc. and consequent increase in electricity demand. Moreover, when analyzed in terms of peak load, in 2008 this reached 32 MW, accounting for approximately 96% of the available capacity (approximately 33 MW) of DEGs installed on Male' Island, and the electricity demand and supply situation is likely to become highly strained in the near future.




Source: STELCO

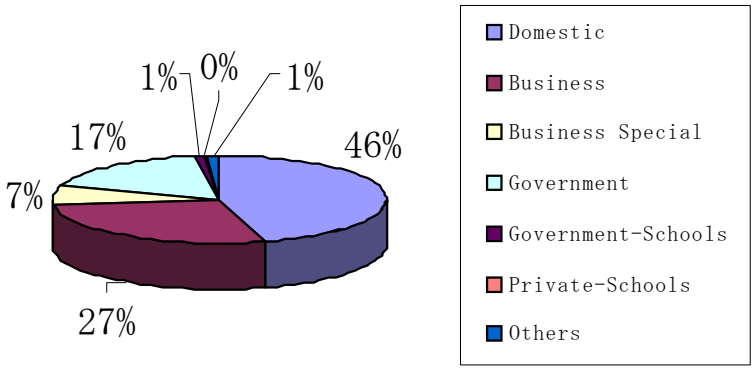
Figure 3.3.2-5 Generated Electrical Energy on Male' Island




Source: STELCO

Figure 3.3.2-6 Peak Load on Male' Island

Domestic demand accounted for the largest share (46%) of power consumption on Male' Island in 2008.

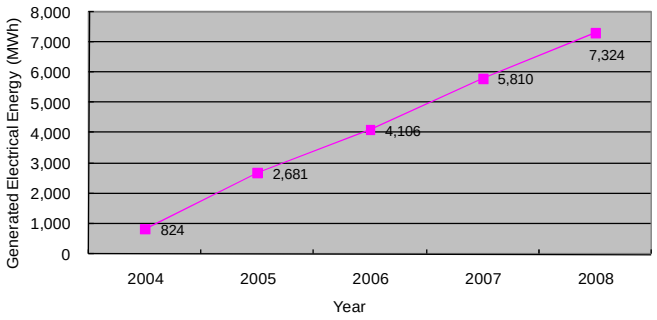



Source： STELCO

Figure 3.3.2-7 Power Consumption by Sector on Male' Island (2008)

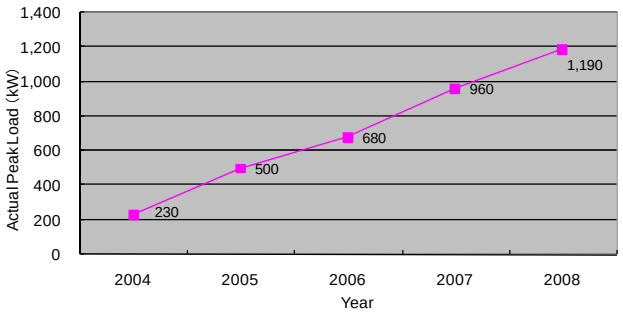
(3) Demand and Supply Situation on Hulhumale' Island

Following the start of electricity supply in 2004, Hulhumale' Island, which is currently undergoing development, is experiencing growth in generated electric energy of 73% per year on average. In terms of peak load, this reached approximately 1.2 MW in 2008, equivalent to approximately 58% of the available capacity of DEGs introduced to Hulhumale' Power Plant (approximately 1.9 MW: Units 1 and 2 are currently idle due to deterioration of equipment). Judging from this ratio, although there appears to be a relatively large amount of spare supply capacity, peak load is growing at approximately 50% per year on average and like Male' Island the electricity demand and supply situation will become tight soon. Having said that, it is scheduled to introduce a 2.5 MW DEG under the 2009 budget, and this should relieve the demand pressure for the time being.




Source : STELCO

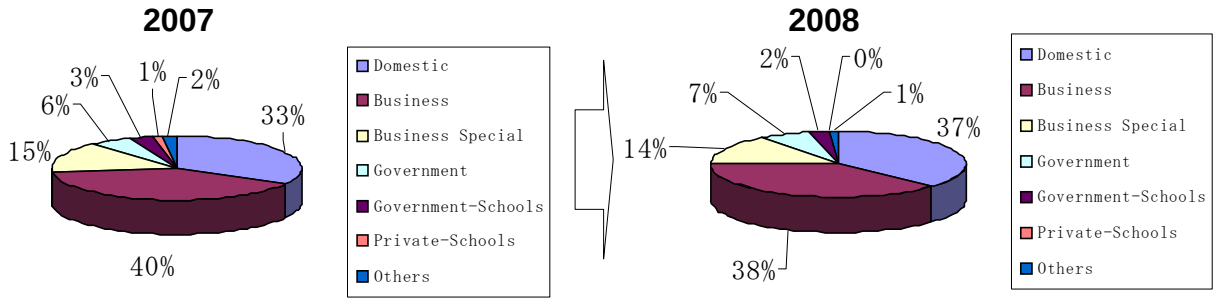
Figure 3.3.2-8 Generated Electric Energy on Hulhumale' Island




Source : STELCO

Figure 3.3.2-9 Peak load on Hulhumale' Island

Looking at the breakdown of electricity consumption on Hulhumale' Island, the business sector accounts for the largest share, however, in line with the resettlement program from Male' Island, power consumption in the domestic sector is rising.




Source: STELCO

Figure 3.3.2-10 Power Consumption by Sector on Hulhumale' Island

### 3.3.3 Electricity Tariffs and Fuel Prices

As shown in Table 3.3.3-1, STELCO's electricity tariff was specific rate based on a four-stage incremental system by consumer category and geographical distinction between Male' metropolitan area and other areas. However, new tariff structure was applied to the Greater Male' Region from November 2009 as shown in Table 3.3.3-2, responding to recent downturn in business.

Table 3.3.3-1 STELCO Electricity Tariffs (from July 2005 to October 2009)

Unit: MRf

| | Domestic | | | | Government / Public Schools / Private Schools | | | | Business / Special Business | | | | Special Tariff |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0-100 | 101-200 | 201-300 | ≥301 | 0-100 | 101-200 | 201-300 | ≥301 | 0-100 | 101-200 | 201-300 | ≥301 | 0-∞ |
| Male' | 1.60 | 1.70 | 2.15 | 2.20 | 2.15 | 2.25 | 2.65 | 3.75 | 3.15 | 3.25 | 3.65 | 3.75 | 2.35 |
| Hulhumale' | 1.60 | 1.70 | 2.15 | 2.20 | 2.15 | 2.25 | 2.65 | 3.75 | 3.15 | 3.25 | 3.65 | 3.75 | |
| Outlying islands | 2.20 | 2.75 | 3.50 | 3.50 | 2.25 | 3.50 | 3.75 | 3.75 | | | | | |

Source : STELCO

Table 3.3.3-2 Tariff Structure for Greater Male' Region (from November 2009)

| Band | Domestic | Non-Domestic (Business,, government, etc.) |
|---|---|---|
| Band A (0 – 100 kW) | 2.25 | 3.30 |
| Band B (101 – 300 kW) | 2.50 | 3.35 |
| Band C (301 – 500 kW) | 2.95 | 3.65 |
| Band D (501 – 600 kW) | 3.55 | 4.00 |
| Band E (601 kW 以上) | 3.85 | 4.35 |

Source : STELCO

Note: Greater Male' Region includes Male', Hulhumale', Villingili and Thilafushi islands.

Table 3.3.3-3 shows the number of consumers by category, and from this it can be seen that Male' Island alone accounts for approximately 55% of the total.

Table 3.3.3-3 Number of Consumers by Category

| | Domestic | Business | Government | Schools | Public Facilities | Total |
|---|---|---|---|---|---|---|
| Male' | 17,920 | 5,663 | 723 | 82 | 82 | 24,474 |
| Hulhumale' | 762 | 173 | 65 | 3 | 8 | 1,011 |
| Outlying islands | 34,297 | 7,892 | 1,703 | 195 | 217 | 44,304 |

Source : STELCO

Table 3.3.3-4 shows the electricity consumption and average electricity tariffs by category for Male' Island and Hulhumale' Island over the last three years. On Male' Island and Hulhumale' Island, households, which consume electricity at low tariffs held down by the government policy, account for approximately 45% of total electricity consumption. Looking at the average tariff, whereas the combined total for Male' Island and Hulhumale' Island was MRf 2.86/kWh in 2008, the tariff paid by the households was just MRf1.93/kWh. In comparison, since businesses, government and schools pay

a tariff of MRf3.65/kWh, higher than the total for both islands, it can be seen that business, government and school tariffs fill in a gap of the held-down tariff level for the households. Moreover, in line with the increase in production costs, the cost ratio to power sales cost is also decreasing year by year. Up to 2007, the average tariff in businesses, government and schools was higher than the unit power sales cost, however, following the elevated fuel cost in 2008, the cost ratio showed a major decline, resulting in the unit power sales cost below not only the average tariff for the households but also the tariff for businesses, government and schools.

Table 3.3.3-4 Electricity Consumption and Average Tariffs on Male' Island and Hulhumale' Island

2006

| | Power Consumption (kWh) | Share of Power Consumption | Average Tariff (MRf/kWh) | Average Tariff Ratio to the Male' & Hulhumale' total | Ratio to Power Sales Cost |
|---|---|---|---|---|---|
| Domestic | 63,192,534 | 45% | 1.91 | 0.67 | 0.66 |
| Businesses | 48,372,804 | 34% | 3.64 | 1.27 | 1.25 |
| Government & schools | 29,934,856 | 21% | 3.65 | 1.27 | 1.26 |
| Male' & Hulhumale' total | 141,500,194 | 100% | 2.87 | - | 0.99 |

2007

| | Power Consumption (kWh) | Share of Power Consumption | Average Tariff (MRf/kWh) | Ratio to Average Tariff for the Male' & Hulhumale' total | Ratio to Unit Power Sales Cost |
|---|---|---|---|---|---|
| Domestic | 72,178,416 | 45% | 1.92 | 0.67 | 0.64 |
| Businesses | 56,187,496 | 35% | 3.65 | 1.27 | 1.21 |
| Government & schools | 33,384,524 | 21% | 3.65 | 1.27 | 1.21 |
| Male' & Hulhumale' total | 161,750,436 | 100% | 2.88 | - | 0.95 |

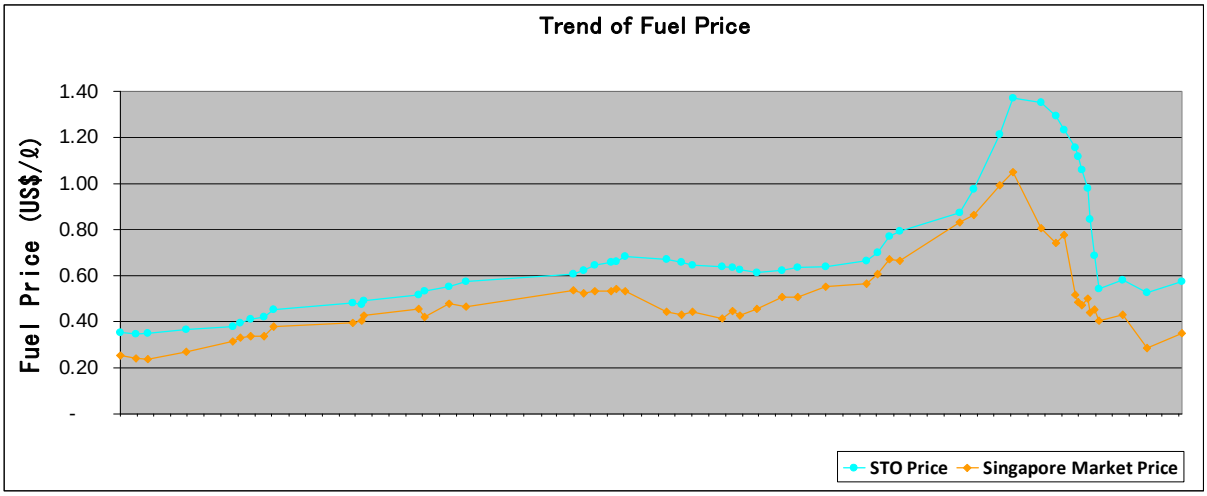
2008

| | Power Consumption (kWh) | Share of Power Consumption | Average Tariff (MRf/kWh) | Ratio to Average Tariff for the Male' & Hulhumale' total | Ratio to Unit Power Sales Cost |
|---|---|---|---|---|---|
| Domestic | 81,287,660 | 46% | 1.93 | 0.68 | 0.48 |
| Businesses | 63,299,124 | 36% | 3.65 | 1.27 | 0.91 |
| Government & schools | 32,970,307 | 19% | 3.65 | 1.27 | 0.90 |
| Male' & Hulhumale' total | 177,557,091 | 100% | 2.86 | - | 0.71 |

Source： Prepared by the Study Team from STELCO data on power generation

Figure 3.3.3-1 shows movements in the price of diesel fuel procured by STELCO from the STO (State Trading Organization Plc) for the Male' metropolitan area and the price of the Singapore market. The diesel prices showed an upward trend between 2004 and the middle of 2006, and the prices in July 2006 became approximately twice as much as those in January 2004. After that, the prices entered a period of gradual decline but increased again in 2007, and the prices in June 2008 had risen to approximately four times as much as those in January 2004. From June 2008, there was a rapid drop in the prices, however, the recent trend of price escalation has greatly affected the financial condition of

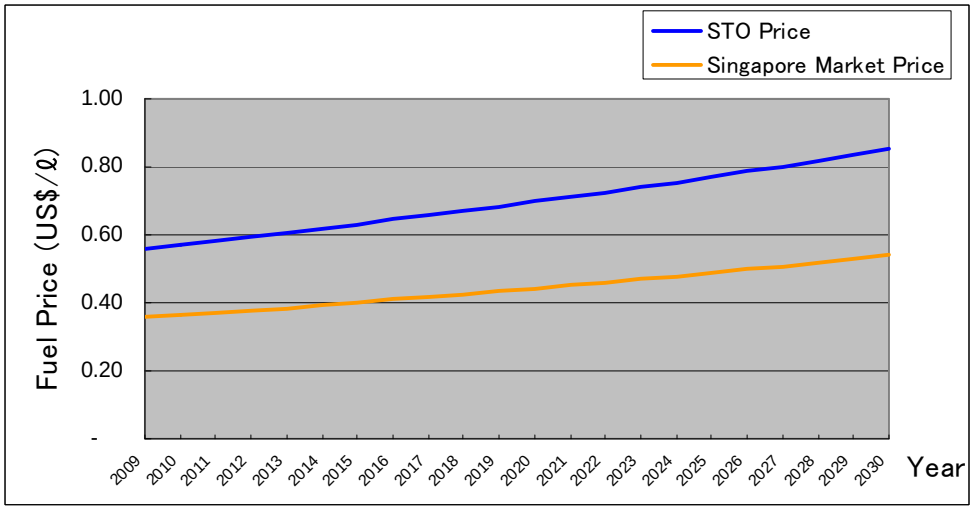
STELCO. The diesel price from the STO has been around MRf7 (approximately US$0.55) since the beginning of the year 2009. As indicated in the MDP manifesto, if the oil and fuel products market is opened to the private sector, making it possible to purchase diesel (which accounts for the majority of operating expenses) from multiple suppliers, this is likely to lead to a reduction in fuel costs.




Source : STELCO
Note : The STO price is the price for Male' metropolitan area (Male', Vilingile, Hulhumale').

Figure 3.3.3-1 Movements in Diesel Prices

Concerning the future fuel price, according to the U.S. EIA (U. S. Data Projections, yearly projections to 2030), annual average increase rate in the fuel price for power generation is projected as 2%. Based on this projected rate of increase, the future price in the STO price and Singapore market price up to 2030 would be as shown in Figure 3.3.3-2, taking the average price from January to April 2009 as the reference value.




Source : Prepared by the Study Team based on energy statistics and projections by the U.S. EIA (U.S. Data Projections, yearly projections to 2030).

Figure 3.3.3-2 Projected Diesel Fuel Prices (2009-2030)

### 3.3.4 Current Situation and Reinforcement Plan in Male' Metropolitan Area (Male' Island and Huluhumale' Island)

(1) Current Condition and Reinforcement Plans of Generating Facilities on Male' Island

On Male' Island, in order to respond to the above electricity supply and demand situation, the road adjoining the power plant inside the STELCO compound has been closed to allow the installation of DEGs (1MW x 6 units, made by Cuimmins Co. of the US.), which have been procured as emergency power sources. These generating facilities are intended to operate as high-speed rotating (1,500 rpm) power sources during emergencins and at times of short-term overload, and the engines and generators could become damaged or lose efficiency if they continue to be used as base power sources. The demand for power has continued to increase following installation of the emergency power sources: compared to the potential output of 32,946 kW, peak load of 32,618 kW has been recorded in the past (September 11, 2008), meaning that there is only around 300 kW space capacity.

In February 2009, the tripping of one diesel generator caused by problems in the fuel system led to Male' Island's first island-wide power outage (lasting a few hours) in 10 years, highlighting the growing severity of the supply and demand situation. In response to this situation, STELCO plans to install additional emergency generators (1.6 MW x 7 units, made by Cuimmins Co. of the US.) using the government budget on government-owned land on the west side of the current power plant. Two of these generators are container-type units scheduled for installation in October 2009, while the remaining five will be housed in a power plant building which will be built as well and are scheduled to go into operation at the end of 2009.

In addition to these emergency power sources, STELCO commenced the Fourth Power System Development Project under support from DANIDA (Denmark) in 2009. This entails the procurement and installation of two DEGs (8 MW) and construction of foundations for three units and is scheduled for completion in 2010. It is planned to procure and install the third unit under this plan in 2011. After completion of the Fourth Power System Development Project, the six units of emergency generators located in road inside the STELCO compound will be removed.

Table 3.3.4-1 Generating Facilities at Male' Power Station (June 2009)

| No. | Engine Model | Manufacturer | Rated Output (kW) | Start of Commercial Operation |
|---|---|---|---|---|
| 1 | 12V32D | Wartsila Diesel | 4,320 | October 1998 |
| 2 | 6R32 | | 2,160 | June 1991 |
| 3 | 6R32 | | 2,160 | June 1991 |
| 4 | 6R32E | | 2,160 | March 1994 |
| 5 | 16V32E | | 5,760 | March 1996 |
| 6 | 18V32LN | | 6,500 | September 2002 |
| 7 | 18V32LN | | 6,500 | September 2002 |
| 8 | KTA 50 G3 | Cuimmins | 1,000 | June 2006 |
| 9 | KTA 50 G3 | | 1,000 | June 2006 |
| 10 | KTA 50 G3 | | 1,000 | June 2006 |
| 11 | KTA 50 G3 | | 1,000 | June 2006 |
| 12 | KTA 50 G3 | | 1,000 | January 2007 |
| 13 | KTA 50 G3 | | 1,000 | January 2007 |
| 14 | QSK60 G6 | | 1,600 | May 2008 |
| 15 | QSK60 G6 | | 1,600 | May 2008 |
| Total | | | 38,760 | |

Source : STELCO

Figure 3.3.4-1 Diesel generating facilities installed on the public road adjoining the STELCO power plant

Figure 3.3.4-2 Site for installation of emergency power generating facilities

(2) Current Condition and Reinforcement Plans of Generating Facilities on Hulhumale' Island

The island's power plant comprising 2,240 kW of DEGs (800 kW x 2 units, 640 kW x 1 unit) went into operation in 2004. The building and foundations of the power plant have been designed to installation additional facilities (1 MW x 4 units), however, extensions have been successively implemented to respond to the rapidly growing demand for power in line with the island's development, and in June 2009 Unit 2 was upgraded from 640 kW to 1,000 kW. The total rated output as of June 2009 is 4,000 kW as is shown in Table 3.3.4-2. Future development plans are uncertain due to the fluid nature of development on Hulhumale' Island, however, since the power house design capacity has already been reached, any future reinforcement will involve construction of new plant site.

Table 3.3.4-2 Facilities at Hulhumale' Power Station (as of June 2009)

| No. | Engine Model | Manufacturer | Rated Output (kW) | Start of Commercial Operation |
|---|---|---|---|---|
| 1 | KTA 50 G2 | Cuimmins | 800 | December 2004 |
| 2 | KTA 50 G2 | | 1,000 | June 2009 |
| 3 | KTA 50 G2 | | 1,000 | July 2007 |
| 4 | KTA 50 GS8 | | 1,200 | November 2008 |
| Total | | | 4,000 | |

Source : STELCO

### 3.3.5 Current Condition and Reinforcement Plans of Distribution Facilities in Male' Metropolitan Area (Male' Island and Hulhumale' Island)

(1) Current Condition and Reinforcement Plans of Distribution Facilities on Male' Island

All feeder trunk lines (upstream) from power stations have already been converted to bigger size cables (185 sqmm, permissible current 350 A), and there are no further reinforcement plans at the present time. Concerning branch of distribution lines, lines are either being renewed or converted to heavy lines in tandem with the installation and replacement of transformers for extending supply to new consumers (new buildings, etc.). However, this installation and heavy line conversion work is being implemented for new consumers on a haphazard basis, meaning there is no annual written plan or systematic reinforcement program.

According to STELCO, distribution facility reinforcement plans for the immediate future are as follows.

Table 3.3.5-1 Distribution Facility Reinforcement Plans

| Feeder No. | Section | Cable Size [$mm^2$] |
|---|---|---|
| FD2 | 58B – 58A | 70 → 185 |
| FD4 | 33 – 31A | 70 → 185 |
| | 31A – 47 | 70 → 185 |
| | 47 – 39 | 70 → 185 |
| | 39 – 90 | 70 → 185 |
| | 31A– 25 | 70 → 185 |
| | 25 – 31B | 70 → 185 |
| | 31B – 35 | 70 → 185 |
| FD6 | 70 – 40 | 70 → 185 |
| FD9 | 41B – 19 | 70 → 185 |

Source : STELCO

(2) Current Condition and Reinforcement Plans of Distribution Facilities on Hulhumale' Island

Since distribution lines on Hulhumale' Island have ample spare capacity compared to demand, reinforcement works are only implemented in areas where it is necessary to install or replace transformers and install new distribution lines or upgrade lines to heavy lines as new customers arise. Accordingly, as on Male' Island, there are no future reinforcement plans. On the other hand, even though a distribution system reinforcement plan should be compiled according to development plans in the target areas, the frequent revision of island development plans due to political considerations means that such a plan cannot be prepared.

## 3.4 Dissemination of PV Generating Facilities

### 3.4.1 Introduction by the Government of the Maldives and Other Donors

Maldives has already installed small-scale PV systems for navigation lights for shipping and telecommunication facilities on remote islands. However, little progress has been made in applications for supplying power to domestic, public and business facilities. According to the results of the energy demand and supply survey of 2002, renewable energy use accounts for approximately 2% of primary energy supply, while PV power accounts for just 0.1%. In the National Energy Policy too, attention is drawn to the need for creation of subsidy systems for initial investment and capacity development of related agencies in order to mitigate barriers to the introduction of PV.

Recent years have witnessed the increasing introduction of hybrid systems combining PV systems with DEGs and wind power generators, however, the operation and maintenance system after installation has not yet been established, so it is necessary to dispatch consultants from overseas countries in the event of system failures. According to the MHTE, the following hybrid systems are in operation as of June 2009, however, operating conditions will need to be confirmed on the site.

Table 3.4.1-1 Hybrid Systems Introduced by the Government of the Maldives and Other Donors

| No. | Installed Site | Fund Source | System Composition and Capacity |
|---|---|---|---|
| 1 | Alifu Dhaalu Atoll, Mandhoo Island | UNDP (GEF) | PV (12.8kWp) + diesel |
| 2 | Raa Atoll, Faninu Island | UNIDO | PV (5kWp) + wind power (3.5kW) + diesel |
| 3 | Baa Atoll, Goidhoo Island | UNIDO | PV (5kWp) + wind power (3.5kW) + diesel |
| 4 | Haa Alifu Atoll, Uligamu Island | Maldives Gas | PV (2.5kWp) + wind power (43.2kW) + diesel |
| 5 | Meemu Atoll, Raimandhoo Island | Maldives Gas | PV (2.5kWp) + wind power (32.4kW) + diesel |
| 6 | Gaafu Alifu Atoll, Kondey Island | Maldives Gas | PV (5kWp) + wind power (10.8kW) + diesel |

Source : MHTE

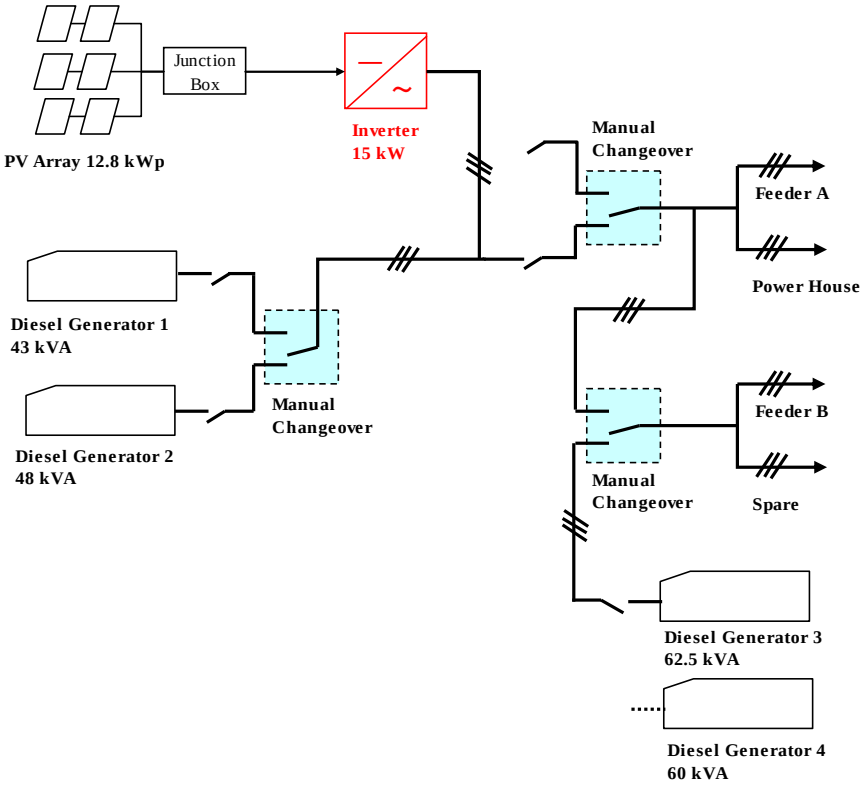
The Study Team had the opportunity to survey at first hand the operating condition of the facilities at No. 1 in the table together with engineers of MHTE and STELCO. This system was introduced by the former Ministry of Communication, Science and Technology (the forerunner of the Ministry of Environment, Energy and Water) as a joint demonstration test for the following two projects under cooperation from donors:

① Renewable Energy Technology Development and Application Project (RETDAP) based on technical cooperation between the UNDP and GEF, and

② The SMILES (Strengthening Maldivian Initiatives for a Long-term Energy Supply) Project based on support from the French Agency for the Environment and Energy Management and Utrecht Enegy Research Center of the Netherlands

PV panels installed on a roof over an island road


Inverter for PV Grid-interconnection




Source： Study Team

Figure 3.4.1-1 PV System Introduced to Mandhoo Island

At the time of works completion in December 2005, this system comprised a 10.5 kWp PV array (75 W x 140 sheets, made by BP Solar Co.), two existing DEGs of 28 kVA and 43 kVA and batteries (lead storage batteries), and a manual changeover switch was used to switch between the PV and DEGs according to time and load conditions. However, because of anticipation among islanders that introduction of the PV system would lead to reduced electricity tariffs, the power demand jumped and exceeded the daytime anticipated load (20 kW) after commencement of operation. Under the initial design, since the protective function of the PV system was intended to ensure automatic parallel off when load exceeds 20 kW, DEGs were used to charge the batteries during most of the daytime hours. Accordingly, the MHTE remodeled the system in 2008 so that the batteries are now disconnected from the grid, and PV system is interconnected with the existing DEGs.

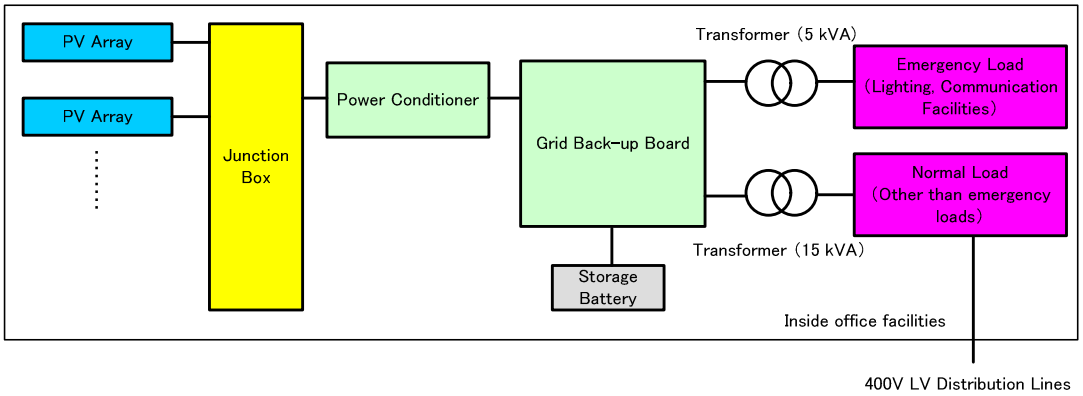
Lead storage batteries which are not in use are currently left in the battery room situated next to the power house. However, since these batteries still appear to be uilized, they can be used in PV systems or diesel power plants at other sites. Moreover, concerning the grid connection inverter that was introduced after the system remodeling of 2008, the Study Team proposed and explained some improvement measures to the MHTE since displays and indicators cannot be viewed from outside and it cannot be identified whether the PV panel is working or not.

Mandhoo Island, where this system is installed, has a population of 373 living in 68 scattered households, and power supply facilities including the PV system are operated and maintained by the Island Community rather than STELCO. The power plant, distribution lines and grid-connected PV system are all managed by a single operator (not an engineer), however, in the event where technical problems occur, support is kindly provided by engineers from neighboring resort islands, or in more pressing cases an electrical engineer is dispatched from Male' Island. Furthermore, no manual has been prepared concerning troubleshooting in the event of accidents in the PV system, and the only available information is a sheet on the control room wall which shows the switching procedure as a hybrid system.

### 3.4.2 Facilities Introduced under Japanese Support

"The Study on Tsunami Recovery, Rehabilitation and Development of Islands in the Republic of Maldives" was implemented by JICA from March 2005 as an emergency development study in response to the Tsunami disaster caused by Sumatra earthquake. This study proposed the reconstruction of administrative facilities (including grid-connected PV systems) on the islands of Gan and Fonadhoo in Laamu Atoll approximately 250 km away from Male' Island, in order to support the reconstruction of public infrastructure. The PV system for administrative facilities (multi-purpose building and island offices) is connected to the existing 400/230 V low voltage distribution line and enables power supply for emergency loads to be continued in the event of distribution line fault. The system went into operation in 2006 as evacuation platforms in cases of emergency such as tsunami disasters.

The Study Team confirmed during the Study that the PV systems are functioning smoothly at both facilities. However, since no budget allocations have been arranged for future battery replacements and employees are not adequately aware of excess power measuring and tariff collection methods in the grid-connected PV system, the Team explained the need for improvements to the Atoll Counselor and confirmed that improvements will be implemented from now on. Figure 3.4.2-1 shows the system block diagram and specifications of representative equipment, while Figure 3.4.2-2 shows the system operating conditions.




| No. | Name of Equipment | Multi-Purpose Building | Island Office |
|---|---|---|---|
| 1 | Solar array (175 W) | 11.2 kW | 5.6 kW |
| 2 | Power conditioner | 10 kW | 10 kW |
| 3 | Grid backup board | 1 set | 1 set |
| 4 | Storage battery | 288V 220Ah | 288V 100Ah |
| 5 | Transformer | 15kVA and 5kVA | 15kVA and 5kVA |

Source： Study Team

Figure 3.4.2-1 Schematic Diagram of Grid-Connected PV System Introduced under Japan's Non-Project Grant Aid


PV generation output display
(Island Office)

PV array
(Island Office)

Measuring Unit
(top row: excess power measurement; bottom row: consumed power measurement) (Island Office)

Grid backup board
(Island Office)

Power conditioners and system transformer
(consolidated government offices)

Technical guidance to the MHTE and power plant staff (consolidated government offices)

Source： Study Team

Figure 3.4.2-2　Operating Condition of the Grid-Connected PV System Introduced under Non-Project Grant Aid