CHAPTER 3 ECONOMIC AND FINANCIAL FEASIBILITY STUDY

3.1 Methodology of Economic and Financial Analysis on Introduction of the Grid-Connected PV System

Since one of the objectives of the Study is to confirm institutional measures necessary for disseminating grid-connected PV systems, conditions that are conducive to high economic and financial feasibility will be verified in the economic and financial analysis, and sensitivity analysis which examines some cases altering institutional conditions (surplus power purchasing system, subsidies, funds, etc.).

3.2 Setting of Preconditions

3.2.1 Conditions on PV System, Operation and Maintenance

The preconditions on PV system, operation and maintenance are as follows. These conditions are common to each type. Prices are those in effect as of May 2009.

PV system

PV system cost	:	US$ 20,380/kW including cost for construction works, installation works, design and supervision
Import duties	:	25% on equipment and materials price

Operation and maintenance

Diesel fuel price	:	US$ 0.63/ℓ (STO price MRf 8.1/ℓ)
Lubricant price	:	US$ 2.28/ℓ
Diesel fuel required to generate 1kWh	:	Male’ 0.26ℓ/kWh, Hulhumale’ 0.28ℓ/kWh
Lubricant required to generate 1kWh	:	0.001ℓ/kWh (same on Male’ and Hulhumale’)
DEG maintenance cost	:	US$ 0.034/kWh (same on Male’ and Hulhumale’)
PV system maintenance cost	:	US$ 0.004/kWh (same on Male’ and Hulhumale’)
Lifetime of main system components	:	PV panels: 30 years, Other parts: 15 years

Power consumption

Consumption amount to total power generation	:	94%
Ratio of power consumption on Male’ Island and Hulhumale’ Island	:	75%

Breakdown of power consumption by consumer category
on Male' Island and Hulhumale' Island:
Domestic: 45%　Businesses: 35%　Government and schools: 20%

Administration cost　：US$ 0.039/kWh

Exchange rate　：US$ 1.00 ＝ ¥95.69 ＝ MRf 12.8 (end of May 2009)

Concerning measures for disseminating the grid-connected PV system in the Maldives, since STELCO is due to be privatized and government subsidies for STELCO to make up a deficit will no longer be available, supporting measures to reduce the financial burden on the initial investment will be needed. Besides, as introduction of the PV system can be also extended to the private sector, cases for introduction by solely STELCO and introduction by STELCO and the private sector will be examined.

Possible capacity 13.49MW is the figure derived from the results of technical feasibility study as the maximum capacity. Initial investment cost for the capacity 13.49MW will be US$ 253.7 million (MRf 3,247 million). Since STELCO recorded deficit in the current account for the last three years and the central government also faces financial difficulties, it is necessary to calculate figures necessary for examination of institutional framework and examine viable installation capacity. Therefore, three cases, 13.49MW, 6MW and 3MW, are analyzed and the capacity suitable for the Maldives is examined. In the case of introduction by STELCO and the private sector, the system will be introduced through STELCO for the first five years from 2011 to 2014. It is assumed that introduction by the private sector will be carried out at one-third of the annual capacity from 2015.

Introduction capacity and power generation for both cases is shown in Table 3.2.1-1.

Table 3.2.1-1　Introduced Capacity and Generation by Implementing Body (2011 – 2020)

a. Introduction by solely STELCO

(1) Capacity 13.49MW

		2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Capacity (kW)	Yearly	1,340	1,350	1,350	1,350	1,350	1,350	1,350	1,350	1,350	1,350
	Cumulative	1,340	2,690	4,040	5,390	6,740	8,090	9,440	10,790	12,140	13,490
Generation (kWh)		1,620,663	3,253,420	4,886,178	6,518,935	8,151,693	9,784,450	11,417,207	13,049,965	14,682,722	16,315,480

(2) Capacity of 6MW

		2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Capacity (kW)	Yearly	599	599	599	599	599	601	601	601	601	601
	Cumulative	599	1,198	1,797	2,396	2,995	3,596	4,197	4,798	5,399	6,000
Generation (kWh)		724,461	1,448,921	2,173,382	2,897,842	3,622,303	4,349,182	5,076,061	5,802,941	6,529,820	7,256,700

(3) Capacity of 3MW

		2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Capacity (kW)	Yearly	300	300	300	300	300	300	300	300	300	300
	Cumulative	300	600	900	1,200	1,500	1,800	2,100	2,400	2,700	3,000
Generation (kWh)		362,835	725,670	1,088,505	1,451,340	1,814,175	2,177,010	2,539,845	2,902,680	3,265,515	3,628,350

b. Introduction by STELCO and the Private Sector

(1) Capacity 13.49MW

		2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
(1) STELCO											
Capacity (kW)	Yearly	1,340	1,350	1,350	1,350	900	900	900	900	900	900
	Cumulative	1,340	2,690	4,040	5,390	6,290	7,190	8,090	8,990	9,890	10,790
Generation (kWh)		1,620,663	3,253,420	4,886,178	6,518,935	5,434,462	6,522,967	7,611,472	8,699,977	9,788,481	10,876,986
(2) Private Sector											
Capacity (kW)	Yearly	0	0	0	0	450	450	450	450	450	450
	Cumulative	0	0	0	0	450	900	1,350	1,800	2,250	2,700
Generation (kWh)		0	0	0	0	2,717,231	3,261,483	3,805,736	4,349,988	4,894,241	5,438,493

(2) Capacity of 6MW

		2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
(1) STELCO											
Capacity (kW)	Yearly	599	599	599	599	399	401	401	401	401	401
	Cumulative	599	1,198	1,797	2,396	2,795	3,196	3,597	3,997	4,398	4,799
Generation (kWh)		724,461	1,448,921	2,173,382	2,897,842	2,414,868	2,899,455	3,384,041	3,868,627	4,353,213	4,837,800
(2) Private Sector											
Capacity (kW)	Yearly	0	0	0	0	200	200	200	200	200	200
	Cumulative	0	0	0	0	200	400	600	801	1,001	1,201
Generation (kWh)		0	0	0	0	1,207,434	1,449,727	1,692,020	1,934,314	2,176,607	2,418,900

(3) Capacity of 3MW

		2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
(1) STELCO											
Capacity (kW)	Yearly	300	300	300	300	200	200	200	200	200	200
	Cumulative	300	600	900	1,200	1,400	1,600	1,800	2,000	2,200	2,400
Generation (kWh)		362,835	725,670	1,088,505	1,451,340	1,209,450	1,451,340	1,693,230	1,935,120	2,177,010	2,418,900
(2) Private Sector											
Capacity (kW)	Yearly	0	0	0	0	100	100	100	100	100	100
	Cumulative	0	0	0	0	100	200	300	400	500	600
Generation (kWh)		0	0	0	0	604,725	725,670	846,615	967,560	1,088,505	1,209,450

Source : Prepared by the Study Team

3.2.2 Price Forecast of the Grid-Connected PV System

With regard to past price movements of grid-connected PV systems throughout the world, the International Energy Agency (IEA) has implemented a study, “the Cost and Performance Trends in Grid-Connected Photovoltaic Systems and Case Studies” covering 11 countries including Japan, Europe and North America. According to the results of the study, the median value of the grid-connected PV system cost in each year does not always display a linear trend, however, since the cost was US$16/W in 1992 and US$8/W in 2006, an overall trend of cost reduction can be seen.

Prospects regarding future price movements in grid-connected PV systems are indicated in NEDO’s PV Roadmap toward 2030 (PV2030+). According to the roadmap, the cost of PV power generation will be 23 yen/kWh in 2010 and 14 yen/kWh in 2020. The roadmap also sets the development target of PV module production cost at 100 yen/W for 2010, 75 yen/W for 2020, and less than 50 yen/W for 2030.

Based on the forecast scenario in this roadmap, the annual average cost will fall by approximately 3.9% per year for power generation and 2.5% per year for PV module production between 2010 and 2020. Therefore, it is assumed that the cost of the grid-connected PV system over the project period falls by 2.5% on average per year up to 2020.

3.3 Financial Analysis

3.3.1 Preconditions

(1) Project Period

The project period is 25 years from 2010 to 2034.

(2) Cost

Financial cost consists of investment cost, replacement cost, operation and maintenance cost and import duties. The preconditions for calculating the costs are as indicated in Section 5.2, while the cost of introducing the grid-connected PV system is assumed to go down every year in line with the scenario of PV system cost reduction in the NEDO roadmap. Under the case of installation by STELCO and private sector, power purchasing from the PV system installed by the private sector, it is assumed that the power purchasing from the private sector is only for excess power from the viewpoint of demand control. It is assumed that rate of excess power purchasing is 20 percent and purchasing price is MRf 3/kWh which is average of the unit production cost for 2006 and 2007. In this case, part of the power generated by the PV system will be consumed at source. STELCO do not need to supply power equivalent to the consumption at source. Therefore, the operation and maintenance cost for the volume of power generation is counted as negative cost.

(3) Revenue

The financial revenue from the grid-connected PV system is composed of electricity tariff from the consumers and saving of fuel costs that would be incurred in generating the same amount of power by diesel generator. Concerning tariff revenue, it is assumed that US$0.28 (MRf 3.52) will be set as unit price per kWh. In addition, with regard to unit price of the diesel fuel and lubricant reduced by introducing the grid-connected PV system, the STO price as of end of July 2009 and average price for the last three years are applied to diesel oil and lubricant oil respectively. Under the case of installation by STELCO and private sector, it is assumed that excess power from the PV system installed by the private sector is sold to STELCO. Therefore, the amount of excess power purchasing becomes negative revenue. Besides, consumption at source causes decline in STELCO’s sales so that the amount of consumption at source is also negative revenue.

(4) Assessment of Feasibility

The financial internal rate of return (FIRR) is used to analyze feasibility of the project. Discount rate applied is 12%.

3.3.2 Results of Financial Analysis

After completion of installation in 2019, the revenue will exceed the cost, however, net present value of the project for the project period is negative for all the cases, 13.49MW, 6MW and 3MW because investment cost is too huge against the revenue generated from the PV system during the installation period. In order to attain 12% of FIRR under the condition that the current electricity tariff does not change, supporting measures from the government, such as import duties exemption and financial assistance, should be applied during the initial investment period from 2010 up to 2019.

<Examination of installation capacity from the financial aspect>

Expenditure of the government is composed of current expenditure and capital expenditure, and the subsidies for state-owned enterprises like STELCO are included in the current expenditure. STELCO will not be able to receive the subsidies to make up deficit after completion of the privatization. National development expenditure, which is included in capital expenditure, is utilized for construction of infrastructure and investment in facilities. The development expenditure can be assumed as a source of financial assistance for the cost reduction of initial investment in PV system which will be installed by STELCO.

Table 3.3.2-1 shows the amount of financial assistance from the government and cost borne by STELCO. Supposed that import duties exemption is applied to the equipment of the PV system, the financial assistance from the government should be US$ 20.7 million for 13.49MW, US$ 9.2 million for 6MW, and US$ 4.6 million for 3MW under the case of installation by solely STELCO. The amount for STELCO’s portion under the case of installation by STELCO and private sector should be US$ 17.5 million for 10.79MW, US$ 7.8 million for 4.8MW, and US$ 3.9 million for 2.4MW.

Table 3.3.2-1 Financial Assistance Necessary for the Initial Investment and STELCO’s Cost

a. Installation by solely STELCO

		Capacity		
		13.49 MW	6 MW	3 MW
Initial investment	(MRf)	3,247,699,675	1,444,469,809	722,201,412
	(US$)	253,726,537	112,849,204	56,421,985
< Financial Assistance >				
Financial assistance to initial investment	(MRf)	2,651,422,015	1,179,265,152	589,678,148
	(US$)	207,142,345	92,130,090	46,068,605
Ration of financial assistance to initial investment (%)		81.64%	81.64%	81.64%
Average assistance per year	(MRf/year)	265,142,201	117,926,515	58,967,815

	(US$/year)	20,714,234	9,213,009	4,606,861
Ratio to development expenditure（%）		12.9%	5.7%	2.9%
< Cost borne by STELCO >				
Total cost	(MRf)	596,277,660	265,204,657	132,612,577
	(US$)	46,584,192	20,719,114	10,360,358
Yearly cost	(MRf/year)	59,627,766	26,520,466	13,261,258
	(US$/year)	4,658,419	2,071,911	1,036,036
Ratio of yearly cost to depreciation for 2008		105.6%	47.0%	23.5%

b. Installation by STELCO and Private Sector (STELCO's portion)

		Capacity		
		10.79 MW	4.8 MW	2.4 MW
Initial investment	(MRf)	2,621,752,532	1,165,969,412	583,102,047
	(US$)	204,824,417	91,091,360	45,554,847
< Financial Assistance >				
Financial assistance to initial investment	(MRf)	2,233,470,982	994,455,311	497,462,230
	(US$)	174,489,920	77,691,821	38,864,237
Ration of financial assistance to initial investment (%)		85.19%	85.29%	85.30%
Average assistance per year	(MRf/year)	223,347,098	99,445,531	49,746,223
	(US$/year)	17,448,992	7,769,182	3,886,424
Ratio to development expenditure（%）		10.9%	4.8%	2.4%
< Cost borne by STELCO >				
Total cost borne by STELCO	(MRf)	388,281,550	171,514,101	85,729,130
	(US$)	30,334,496	13,399,539	6,697,588
Yearly cost borne by STELCO	(MRf/year)	38,828,155	17,151,410	8,572,913
	(US$/year)	3,033,450	1,339,954	669,759
Ratio of yearly cost to depreciation for 2008		68.7%	30.4%	15.2%

Note: Import duties exemption is not included in the amount of financial assistance.

Source : Prepared by the Study Team

As a measure to reduce diesel consumption, making the transition from the conventional diesel power generation to renewable energy is consistent with the carbon neutral policy announced by the Government of Maldives. Therefore, development expenditure can be regarded as one of the financial sources for introduction of the grid-connected PV system. However, implementation method of the public works is being reviewed through promotion of privatization and utilization of private finance, in order to improve the financial deficit.

With regard to the other financial sources, green tax which the President of the Maldives revealed could be considered. Tax revenue will increase by US$ 6.3 million per year. Power generation by the grid-connected PV system will contribute to reduction of CO_2 emission through decreasing fossil fuel consumption. Therefore, utilization of the tax revenue for introduction of the PV system seems to be consistent with the objective of the green tax.

Maximum possible capacity is 13.49MW in Male' and Hulhumale, however, the capacity over 10MW is very huge in the world. Considering the financial constraints of both the government and STELCO mentioned above, 3MW is the installation capacity which can be realized with utilization of green tax as a source of financial assistance from the government.

3.4 Economic Analysis

3.4.1 Preconditions

(1) Cost

Economic costs for dissemination of the grid-connected PV system are investment cost, replacement cost and operation and maintenance cost. The conversion factor 0.9 is applied to calculation of economic prices.

(2) Benefit

The economic benefits from introducing the grid-connected PV system are tariff revenue from the consumers, consumer surplus comparing the cost per kWh for introduction of private generator by the consumers to electricity price of STELCO and saving of fuel costs that would be incurred in generating the same amount of power by diesel facilities. Concerning fuel costs, the State Trading Organization (STO) centrally administers diesel fuel trading in the Maldives, and STELCO has to purchase diesel for power generation from the STO. However, because the STO has a monopoly on oil and fuel products and its prices do not correctly reflect the market price, the economic benefit of fuel cost savings is calculated based on the diesel price in the Singapore market adopted as an indicator of the international price.

<Consumer Surplus>

Difference of the consumption cost per kWh between the private generator and power purchasing from STELCO is total MRf 23.02 (MRf 22.8 + MRf 0.22). Supposed the current average electricity price is the lowest willingness to pay (P1) and the unit cost on introduction of private generator is the highest willingness to pay (P2), a figure corresponding to 25 percent of the difference between P1 and P2 is considered as the consumer surplus[1]. According to the figures shown in the above table, the consumer surplus per kWh is MRf 5.76, which corresponds to 25 percent of MRf 23.02, the difference of the cost per kWh between the private generation and power purchasing from STELCO. In order to utilize the figure in the economic analysis, it is converted to the international price by the official exchange rate and the standard conversion factor 0.9, and finally the consumer surplus of US$ 0.41/kWh is obtained.

[1] Regarding the methodology of calculation of consumer surplus on electricity development project, refer to "Example of Indicator for Economic Analysis by Willingness to Pay on Electricity Development Project in the Developing Countries based on the results of socio-economic survey in the rural area of Malawi", Toshiyuki HAYASHI, Senior Adviser of JICA

< International Price of Diesel Fuel >

As for the fuel cost, management of domestic transaction of diesel fuel is unified to State Trading Organization (STO) in the Maldives. STELCO has to procure the diesel fuel from STO for the power generation. Transaction of oil products is monopolized by STO and the proper market price is not reflected in the domestic price. Therefore, Singapore market price is used as a benchmark for conversion of domestic diesel price to the international price. With regard to the difference between those prices from 2004 onward, the Singapore market price is 75 percent of the STO price on average, while the amount increased in a phase of downturn in Singapore market price. Therefore, coefficient of 0.75 is used for conversion of the diesel fuel price to the international price.

(3) Assessment of Feasibility

Supposed that the financial assistance which meets FIRR 12 percent is provided by the government to the initial investment cost of the capacity 3MW, EIRR is 23.50 percent for the case of installation by solely STELCO and 27.93 percent for the STELCO's portion under the case of installation by STELCO and private sector. Both the installation patterns turned out to be economically feasible for the base case.

3.4.2 Results of Economic Analysis

With regard to the consumer surplus comparing the cost per kWh for introduction of private generator by the consumers to electricity price of STELCO, since the data will be collected and the value will be calculated during the period of the third site survey, the economic analysis will be also carried out during same period.

3.5 Assessment of Impact on Investment Profitability of CDM Project Implementation

One method for improving the profitability of investment into the grid-connected PV system is to register the CO_2 emission reductions arising from the reduction in diesel power generation as a CDM project, and to sell the CERs that can be dealt through the project registration. However, in order to realize implementation as a CDM project, it is necessary to undergo a series of procedures ranging from project design document (PDD) preparation to validation, registration and verification. If the revenue from CER sales exceeds the costs of these procedures, the attempt to improve the investment profitability through implementation as a CDM project will be an effective measure. Therefore, in order to verify the improvement in investment profitability resulting from CDM project implementation, it is necessary to grasp CER trading price movements in markets and the cost of project registration.

3.5.1 Movements in the CER Trading Price

It is assumed that CER prices on the European Climate Exchange (ECX), which is one of the European markets that have a great impact on emission credit prices, will move between the lowest price recorded in February 2009 and the highest price since then in May 2009, and the average price during this period of €11.25 (approximately US$15.75) is used as the CER price in this study.

3.5.2 Project Formulation Cost

CDM project formulation will require a process of project planning, preparation of project documents, validation and project registration, and this will be followed by implementation, monitoring, verification and certification. CERs can only be acquired in the event where issue of CERs is permitted. This series of procedures incurs costs and, according to the "Clean Development Mechanism: A User's Guide" by the UNDP, CDM project transaction costs can be divided into the costs incurred before implementation and those incurred during implementation.

Since total introduction capacity of the grid-connected PV system under the project is less than 15 MW, it is expected that the project will be implemented as a small-scale CDM project. Therefore, the minimum level in the range of cost estimate shown in the UNDP guide is adopted as the pre-operational costs, while the lowest rates is adopted for CER sales rewards and risk management in the operational stage. However, concerning the monitoring and verification, since an annual cost of US$3,000 for foreign consultants is unrealistic, a cost of US$10,000 is assumed in this study. Table 3.5.2-1 shows the transaction costs in the pre-operational and operational stages.

Table 3.5.2-1 Transaction Costs in Small-Scale CDM Project Formulation

Cost Item	Rough Cost (US$)
1. Pre-operational stage	
(1) Feasibility assessment	5,000
(2) Preparation of Project design document (PDD)	25,000
(3) Validation	10,000
(4) Registration	10,000 per year
(5) Legal work	20,000
2. Operational stage	
(1) Rewards for CER sales success	5% of CER value
(2) Risk mitigation	1% of CER value
(3) Monitoring and verification	10,000 per year

Source : Prepared by the Study Team based on The Clean Development Mechanism: A User's Guide, Chapter 5, UNDP

3.5.3 Profit from CDM Project Formulation

Table 3.5.3-1 shows profits in the case where the project is implemented as a CDM project. The cost for the process of project formulation and registration will incur at the first year, and the cost for registration, monitoring, verification and others like rewards for CERs sales success and risk mitigation will incur from the second year. CER trading will be conducted from the second year when power generation by the installed PV system will be commenced. Regarding the capacity of 3MW, the annual revenue will exceed the annual cost in 2016 under the cases of installation by solely STELCO. The cumulative cost up to 2020 exceeds the cumulative revenue by US$ 67,709. The annual revenue will exceed the annual cost in 2019 under the cases of installation by STELCO and private sector and the revenue is US$ 4,520. However, the cumulative balance up to 2034 is - 59,600 US$ even though 25 years pass from the installation of the PV system. Therefore, CDM project formulation would not be profitable under the case of 3MW.

Table 3.5.3-1 Profit from CDM Project Formulation

a. Installation by solely STELCO

(3) Capacity 3MW (Unit: US$)

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Total
Revenue												
CER sales (US$)		3,913	7,826	11,738	15,651	19,564	23,477	27,389	31,302	35,215	39,128	215,203
Cost												
Project formulation	60,000											60,000
Registration	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	110,000
Monitroing & Verification		10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	100,000
Other		235	469	704	940	1,174	1,409	1,643	1,878	2,113	2,347	12,912
Sub-Total	70,000	20,235	20,469	20,704	20,940	21,174	21,409	21,643	21,878	22,113	22,347	282,912
Profit (Loss)	-70,000	-16,322	-12,643	-8,966	-5,289	-1,610	2,068	5,746	9,424	13,102	16,781	-67,709

b. Installation by STELCO and Private Sector (STELCO's portion)

(3) Capacity 2.4MW (Unit: US$)

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Total
Revenue												
CER sales (US$)		3,913	7,826	11,738	15,651	13,043	15,651	18,260	20,868	23,477	26,085	156,512
Cost												
Project formulation	60,000											60,000
Registration	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	110,000
Monitroing & Verification		10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	100,000
Other		235	469	704	940	782	940	1,096	1,252	1,409	1,565	9,392
Sub-Total	70,000	20,235	20,469	20,704	20,940	20,782	20,940	21,096	21,252	21,409	21,565	279,392
Profit (Loss)	-70,000	-16,322	-12,643	-8,966	-5,289	-7,739	-5,289	-2,836	-384	2,068	4,520	-122,880

Source : Prepared by the Study Team

3.6 Financial Plan for investment

Since privatization of STELCO is being proceeded, STELCO will not be able to receive the subsidies for making up a deficit from the government, it is not realistic for STELCO to raise funds from the financial markets under the condition where there is no supporting measures to reduce financial burden on initial investment in the grid-connected PV system. Therefore, it is necessary to provide the financial assistance by utilizing the green tax which is going to be newly introduced in 2010 as a financial source to reduce initial investment burden. Table 3.6-1 shows an investment financing plan for the Government of Maldives and STELCO on the initial investment of installation of the grid-connected PV system with the capacity of 3MW.

Table 3.6-1 Investment Financing Plan for Installation of PV System with Capacity of 3MW

a. Installation by solely STELCO

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Total
Capacity (kW)		300	300	300	300	300	300	300	300	300	300	3,000
Financial Assistance (million US$)	4.99	4.91	4.82	4.74	4.65	4.56	4.48	4.39	4.31	4.22		46.07
STELCO (million US$)	1.12	1.10	1.08	1.06	1.05	1.03	1.01	0.99	0.97	0.95		10.36
Total	6.11	6.01	5.90	5.80	5.70	5.59	5.49	5.38	5.28	5.17		56.43

b. Installation by STELCO and Private Sector (STELCO's portion)

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Total
Capacity (kW)		300	300	300	300	200	200	200	200	200	200	2,400
Financial Assistance (million US$)	5.22	5.13	5.04	4.95	3.24	3.18	3.12	3.06	3.00	2.94		38.86
STELCO (million US$)	0.90	0.88	0.87	0.85	0.56	0.55	0.54	0.53	0.52	0.51		6.70
Total	6.11	6.01	5.90	5.80	3.80	3.73	3.66	3.59	3.52	3.45		45.56

Source : Prepared by the Study Team

3.7 Budget to be prepared for Execution of Each Measure

Budget necessary for execution of each measure is as follows

(1) Import Duties Exemption

Total amount of import duties to be exempted in case of the capacity 3MW : US$ 11,336,384
Import duties for 2.4MW of the STELCO's portion for Measure D : US$ 9,187,726

(2) Financial Assistance (Green Tax and Development Expenditure) and Carbon Tax

For the case of installation by STELCO and provate sector (Measure D), the financial assistance for the STELCO'S portion is as follows.

Total amount of financial assistance to initial investment : US$ 38,864,237
Annual average amount (Total amount is divided by 10) : US$ 3,886,424
Annual amount from green tax : 61% of green tax revenue
Annual amount from development expenditure : 2.4% of development expenditure

<Contribution Ratio of Green Tax and Shortfall>

61% from green tax	= US$ 3,886,424	➔ No shortfall
50% from green tax	= US$ 3,150,000	➔ Shortfall US$ 736,424
30% from green tax	= US$ 1,890,000	➔ Shortfall US$ 1,996,424
0% from green tax	= US$ 0	➔ Shortfall US$ 3,886,424

<Contribution from Green Tax for Shortfall>

61% from green tax	➔ No shortfall
50% from green tax	➔ Necessary amount US$ 736,424
30% from green tax	➔ Necessary amount US$ 1,996,424
0% from green tax	➔ Necessary amount US$ 3,886,424

<Contribution from Carbon Tax for Shortfall and the Amount/kWh >

61% from green tax	➔ No shortfall	
50% from green tax	➔ Necessary amount US$ 736,424	= MRf 0.003/kWh
30% from green tax	➔ Necessary amount US$ 1,996,424	= MRf 0.007/kWh
0% from green tax	➔ Necessary amount US$ 3,886,424	= MRf 0.014/kWh

(3) Amount to be paid by STELCO for Excess Power Purchasing

Conditions of excess power purchasing by STELCO, purchased amount and purchasing price are as follows.

Assumptions:

- The amount of excess power purchasing is 20 percent.
- Purchasing price is MRf 3/kWh, which is equivalent to the unit production cost.

Total purchased power (from 2015 to 2020)	: 1,088,505kWh
Necessary budget for purchasing (from 2015 to 2020)	: US$ 250,356

CHAPTER 4 DETAILED DESIGN OF THE PILOT PROJECT

4.1 Examination and Selection of Pilot Project sites

Comparative examination was carried out according to the "Evaluation of potential sites in Male' Island and Hulhumale' Island" at the beginning of the report on the 14 potential sites that were selected in Chapter 2.4, and the sites were ranked in the order of priority. 6 out of 14 sites were selected as pilot project sites after being ranked highly according to the following criteria. Table 4.1-2 shows the reasons behind the selection of the pilot project sites, Figure 4.1-1 shows the location map of the sites.

Table 4.1-1 Selection Criteria of Pilot Project sites

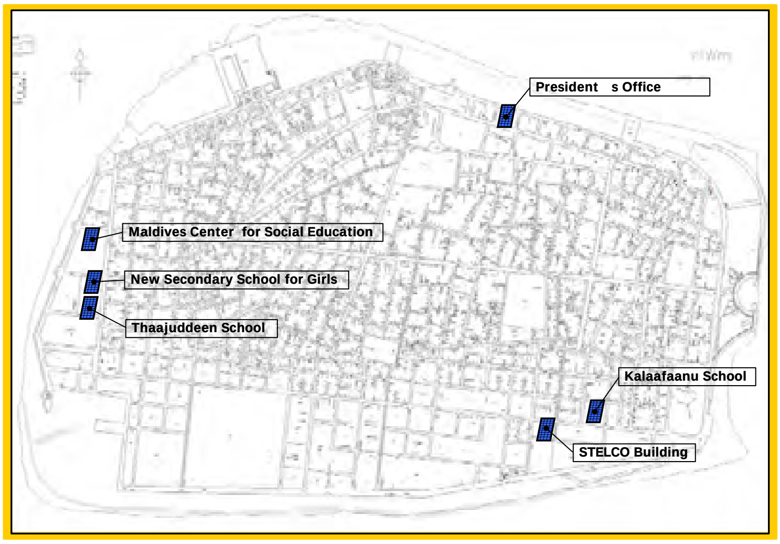
①	PV system capacity is relatively large.
②	Can be a model case for other potential sites.
③	Engineers or technicians who can appropriately implement PV system maintenance can be secured.
④	Reliability of the distribution system is not extremely low.
⑤	PR effect is large and access to the facilities is easy.

Source： Prepared by the Study Team

Table 4.1-2 Pilot Project Sites

No	Site	Output Capacity (kWp)	Reasons for Selection
1	STELCO Building	45 kWp	It satisfies selection criteria ②, ③, ④ and ⑤; there are no solar irradiation obstructions, and it is easy to establish a maintenance setup using the company employees.
2	Kalaafaanu School	85 kWp	It satisfies selection criteria ①, ②, ③ and ⑤, and it is easy to establish a maintenance setup because of proximity to STELCO. Moreover, being a school that was constructed under Japanese grant aid, As-built documents are available, making it easy to plan renovations and reinforcement. Also, the structural strength is deemed to be reliable.
3	Maldives Center for Social Education	100 kWp	It satisfies all the selection criteria. In particular, since sports events and so on are staged here, it will have a high PR effect. Moreover, being a school that was constructed under Japanese grant aid, As-built documents are available, making it easy to plan renovations and reinforcement. Also, the structural strength is deemed to be reliable.
4	Thaajuddeen School	130 kWp	It satisfies selection criteria ①, ②, ④ and ⑤ and has the largest PV output of the six sites. Moreover, being a school that was constructed under Japanese grant aid, As-built documents are available, making it easy to plan renovations and reinforcement. Also, the structural strength is deemed to be reliable.
5	New Secondary School for Girls	100 kWp	It satisfies selection criteria ①, ②, ④ and ⑤, and since it is located adjacent to Site No. 3, it will have a high PR effect. Moreover, being a school that was constructed under Japanese grant aid, As-built documents are available, making it easy to plan renovations and reinforcement. Also, the structural strength is deemed to be reliable.
6	President's Office	20 kWp	It satisfies selection criteria ②, ③, ④ and ⑤, and it is easy to establish a maintenance setup because the facility has its own maintenance staff. Also, installation a PV system in the presidential office will have a high PR effect.

Source： Prepared by the Study Team

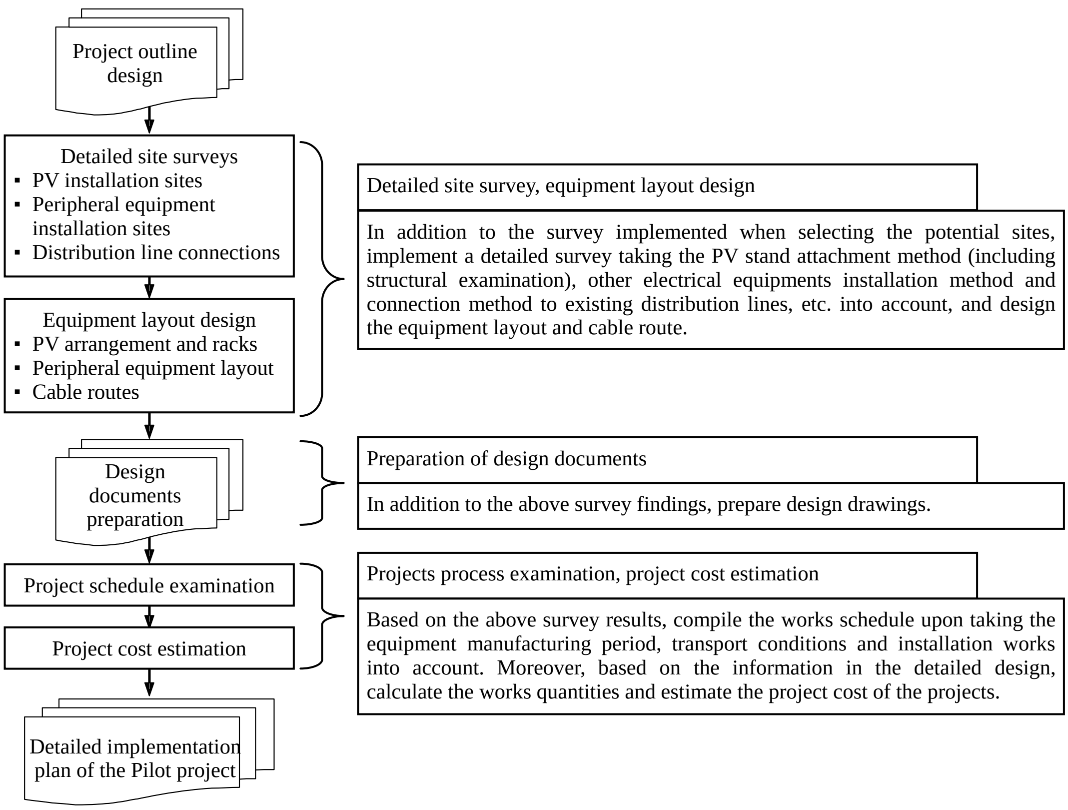


Source： Prepared by the Study Team

Figure 4.1-1 Map of the Pilot Project Sites

4.2 Detailed Design Procedure for the Pilot Project Sites

In conducting detailed design of pilot project sites, the detailed site surveys, the detailed specifications examination of equipment, equipment layout design and preparation of design documents, etc. will be carried out according to the following procedure.



Source： Prepared by the Study Team

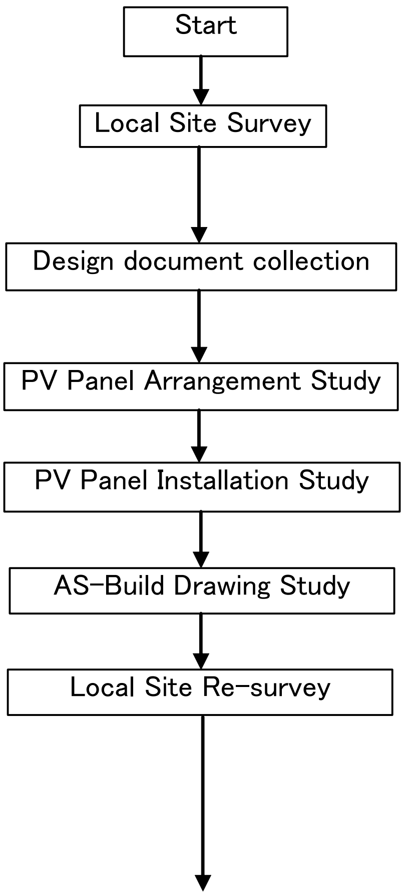
Figure 4.2-1 Detailed Design Procedure of the Pilot project

4.3 Detailed design of Structure reinforcement

About the potential sites decide by the 1st and 2nd survey, Frame type and member section was an clear for field survey and AS-BUILD drawings. The safety of the these structure were confirmed with the Japanese standard, when the solar panels were installed on the building roof or roof floor. Reinforcement detail design is done if necessary. Solar panel weights is $0.35kN/m^2$ (include base channel weight). As for the specification of the main member, by the next.

Concrete design strength	: 21N/mm2
Reinforcing bar	:JIS SD345
Steel	:JIS SS400

Working flowchart which affects details design is shown in the following.



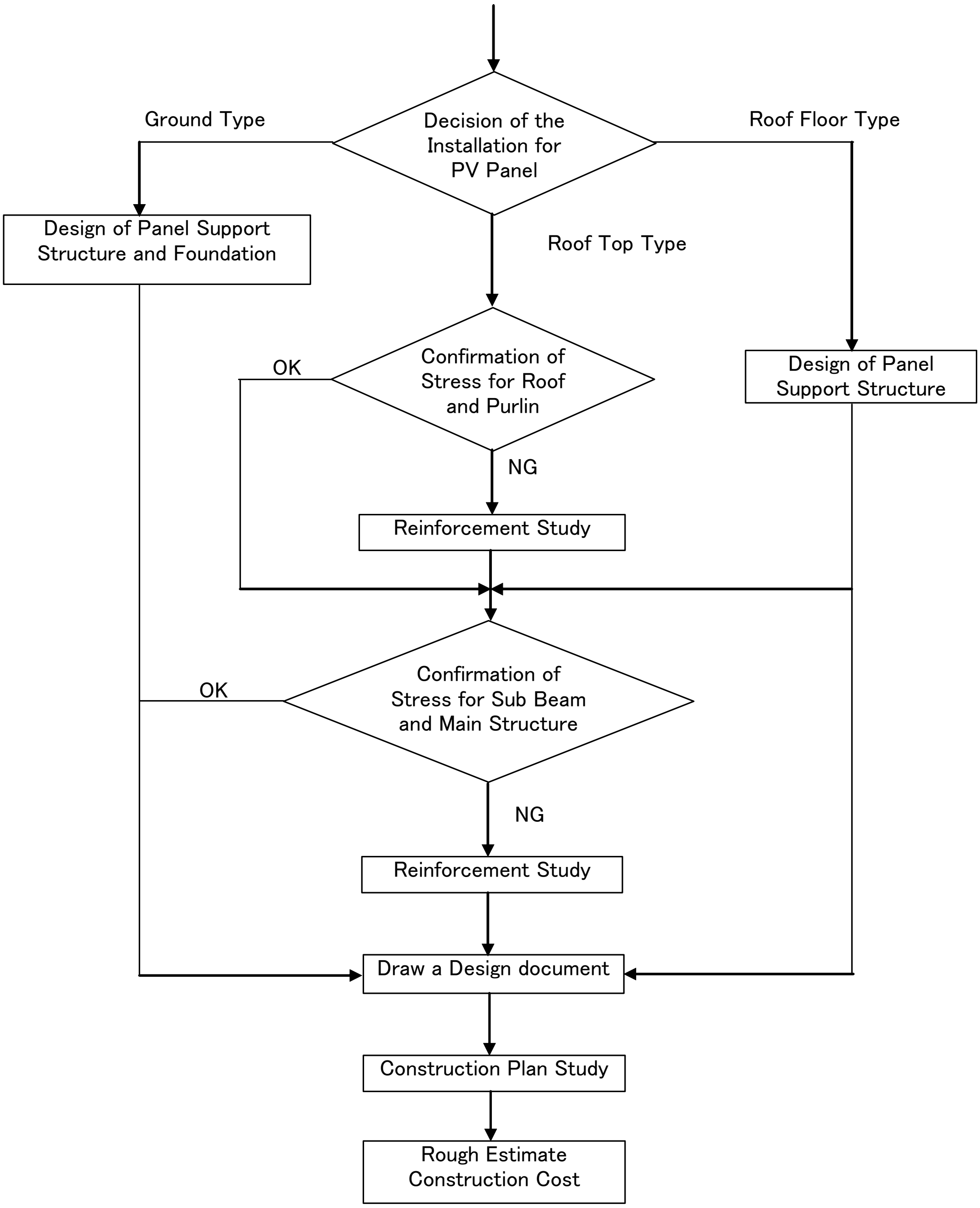


Figure 4.3-1 Working flowchart which affects details design

Table 4.3-1 Detail examination result for Building in the Pilot Project Sites

Site Name	AS-Build Drawing, Completed year	Support Type	Surface Condition	Contents of Repair and Reinforcement	Examination Result for Main Structure
STELCO Building	Ready,2000	Roof Floor	Some of the Tile come off	Construction of Panel Support Structure, Footing, and waterproofing	No problem
Kalaafaanu School	Ready,1989	Roof top	Bad Roofing	Exchange of the roof material	No problem
Maldives Center for Social Education	Ready,1992	Roof top	Depleted Roofing for age passes	Exchange of the roof material	No problem
Thaajuddeen School	Ready,2004	Roof top	No problem	Coating improvement of roof （Prevention of deterioration）	No problem
New Secondary School for Girls	Ready,2009	Roof top	No problem	Unnecessary	No problem
President's office	Ready,2002	Roof top	No problem	Coating improvement of roof （Prevention of deterioration）	No problem

As it is shown in the above table, the reinforcement of Main Structure is unnecessary in all site. However, completed year was not same in each building, and there was the deterioration of the roof material. So, It was decided that each building replaced all the roof materials. (Kalaafaanu School, Maldives Center for Social Education) Then, the roof of the Thaajuddeen School and the President's Office does coating improvement.

4.4 Technical Transfer of the Detailed Design Technique

4.4.1 Concept of the Technical Transfer for Detailed Design

Since the goal of the technical transfer for detailed design is to enable employees of MHTE and STELCO to understand the detailed design procedure of as described in 4.2, work was divided according to the technical level of each staff member and the technical transfer was conducted while jointly implementing the practical duties and field surveys.

4.4.2 Contents of the Technical Transfer for Detailed Design

The Study Team implemented technical transfer of the following field survey items and results analysis methods through the detailed design process.

(1) Information collection (acquisition of basic data)
(Existing design documents, existing distribution network drawings, solar radiation data, etc.)
(2) Field survey method
(Identification of connection parts, examination of solar radiation obstructions, confirmation of existing electricity rooms, etc., and examination of cable routes, etc.)
(3) Analysis of field survey findings
(Examination of panel arrangement, PV output, equipment arrangement, cable routes, etc.)
(4) Summarization of survey results
(Compilation of the technical specifications)

4.4.3 Report of the Technical Transfer for Detailed Design

(1) Information Collection

The Study Team offered the guidance to the counterparts on the method for collecting the minimum basic information required for advancing the field surveys and detailed design of the grid-connected PV systems, and the Study Team and counterparts jointly implemented the information collection work. The following photograph shows the data logger being attached for collecting solar irradiation data on Hulhumale' Island.

(2) Field Survey Method

The Study Team formed a working group with the staff of the MHTE and STELCO and jointly implemented the detailed study and design of the 45 kWp grid-connected PV system planned on the STELCO Company building. The planned cable rough drawings for this building and similar data, the field survey methods (equipment layout, cable routes, etc.) were conducted and the data needed for detailed design were collected.

STELCO Lecture and Survey Conditions at the STELCO Building

(3) Analysis of Field Survey Results

The results obtained from the above survey, the counterparts prepared the PV layout and structural drawings, and the Study Team assisted in calculating the work quantities from those drawings and finishing the work in a joint effort.

Guidance on Preparation of PV Panel Layout Drawing using CAD Software

Furthermore, in order to improve the understanding regarding operation and maintenance of the grid-connected PV system in addition to planning and design, the Study Team conducted guidance on operation and maintenance technology utilizing the PV and DEG hybrid system on Mandau Island and the grid-connected PV system on Lahm Atoll.

4.5 Beneficial Effects of Grid-Connected PV System Introduction

4.5.1 Estimated PV Power Generation

For simplification, the horizontal surface amount of solar radiation was adopted when calculating the monthly average amount of solar radiation on the installed surface, and the impacts of obstructions discussed in 2.3 were taken into account. Concerning the impact of shade, this is conventionally examined upon considering the direct connection of PV modules, however, for the sake of simplification, in cases where roofs contain partial solar radiation obstructions; conservative values were calculated assuming the whole roof to be affected.

Table 4.5.1-1 Annual PV Power Generation at Each Pilot Project Site

Island	Site Name	PV Capacity [kWp]	Annual Power Generation [kWh/year]
Male'	STELCO Building	45	45,739
	Kalaafaanu School	85	117,069
	Maldives Center for Education	100	120,945
	Thaajuddeen School	130	157,228
	New Secondary School for Girls	100	90,778
	President's Office	20	24,189
	Total	480	555,948

Source :Prepared by the Study Team

Assuming that the installation of grid-connected PV systems to the pilot project sites on Male' Island is completed by 2011, the cumulative power generation will be as follows:

Cumulative power generation by 2020 = Pilot project of total annual PV Power generation x 10 years
= 555,948 kWh x 10
= 5,559,480 kWh

4.5.2 Saving on Diesel Fuel Consumption

Using the same technique as described in 2.11.2, the effect in terms of diesel fuel consumption saving was calculated. By using the fuel consumption coefficient on Male' Island of 0.26 [liter/kWh], the annual diesel fuel saving works out as follows:

Annual diesel fuel saving = Annual PV Power Generation on pilot project sites x 0.26
= 555,948 kWh x 0.26 liter/kWh
= 144,546 liter

Accordingly, the cumulative saving on diesel fuel consumption over than 10 years to 2020 are 1,445,460 liters.

4.5.3 CO_2 Emission Reductions

Based on the diesel fuel savings as calculated in 4.5.2, the following coefficient was used to calculate the amount of CO_2 emission reductions

CO_2 reduction [kg] = Light oil CO_2 emission coefficient* x Diesel fuel saving

= 2.62 [kg-CO_2/liter] x Diesel fuel saving [liter]

* Concerning to the emission coefficient, the Total Emissions Calculation Method Guidelines of the Ministry of Environment were quoted.

As a result, it is estimated that the annual CO_2 emission reductions at the pilot project sites are 379 tons, and that the total CO_2 emission reductions over than 10 years up to 2020 are 3,790 tons.

CHAPTER 5 RECOMMENDATIONS FOR DISSEMINATION OF THE GRID-CONNECTED PV SYSTEM

5.1 Legal Systems concerning Dissemination of New Energies in the Maldives

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. Currently, there are no legal systems related to new energies, although the MHTE and MEA (regulatory agency) are preparing an Act geared to the introduction of renewable energies including PV power generation. This Act is thought to correspond to the Japanese New Energy Law (Special Measures Law concerning Promotion of New Energy Usage, etc.). For reference purposes, Table 5.1-1 shows the laws in Japan that relate to new energy, while Table 5.1-2 shows the new energy legislation items thought to be required when applying to the case of the Maldives.

Table 5.1-1 Japanese Laws concerning New Energies

New Energies
- Law concerning Promotion of Development and Introduction of Petroleum-Substitute Energies
- Special Measures Law concerning Promotion of New Energy Use, etc. (New Energy Law)
- Special Measures Law concerning Utilization of New Energies by Electricity Utility Operators (RPS Law)

Table 5.1-2 Necessary Items of the Japanese New Energy Law when Applying to the Maldives

Article	Outline
Article 1 Objective	Concerning the objective of the New Energy Law (Objective: To take necessary steps in order to promote efforts by citizens concerning new energy use and facilitate use of new energies, with a view to securing the stable and appropriate supply of energy according to the socioeconomic environment).
Article 2 Definitions	Definition of new energies and scope of application of the law (Applicable scope: Energies that are not sufficiently disseminated due to economic constraints but need to be promoted in order to introduce petroleum-substitute energies)
Article 3 Basic Policy	Concerning the method of deciding basic policy (Determination method: The basic policy must be proposed by the Minister of Economy, Trade and Industry and receive Cabinet approval with consideration given to the long-term prospects for energy demand and supply, characteristics of new energy utilization, etc., technical standards and environmental impacts, etc.)
Article 4 Efforts of energy users, etc.	Concerning efforts of energy users, etc. (Effort: Energy users must strive to use new energies, etc. while paying attention to the basic policy).
Article 5 New energy use guidelines	Concerning the method of deciding new energy use guidelines (Determination method: The new energy use guidelines shall be determined by the Minister of Economy, Trade and Industry with consideration given to the long-term prospects for energy demand and supply, characteristics of new energy utilization, etc., technical standards and environmental impacts, etc.)
Article 6 Guidance and advice	Concerning guidance and advice (Guidance and advice: The Competent Minister can implement guidance and advice concerning the items to be established in the new energy use guidelines).

Article	Outline
Article 8 Authorization of use plans	Concerning authorization of use plans (Authorization: Parties seeking to use new energies, etc. in business activities must prepare a use plan concerning the energy in question and receive authorization for it).
Article 9 Revisions, etc. of use plans	Concerning revision of use plans determined in Article 8 (Revision: When authorized parties revise use plans concerning the authorization in question, they must receive authorization from the Competent Minister).
Article 14 Collection of reports	Concerning reporting on the state of implementation with respect to authorized operators (Report: The Competent Minister shall be able to seek reports from authorized operators concerning the state of implementation of authorized use plans).
Article 15 Competent Minister(s)	Concerning the definition of Competent Minister(s) (Definition: The Competent Minister(s) shall be the Minister of Economy, Trade and Industry and the Minister(s) with jurisdiction over operations conducted by users).
Article 16 Penalties	Concerning penalties concerning the above agreements (Penalty: Persons who do not give the report stipulated in Article 14 and those who give false reports shall receive penalties).

Source : Prepared by the Study Team from Japan's Special Measures Law concerning the Promotion of New Energy Use, etc.

5.2 Dissemination Promotion Policies and Systems (Incentives)

The following paragraphs examine appropriate dissemination policies and systems for promoting grid-connected PV systems in the Maldives based on systems geared to the introduction and dissemination of renewable energies, in particular PV power generation, and the operating condition of such systems in overseas countries.

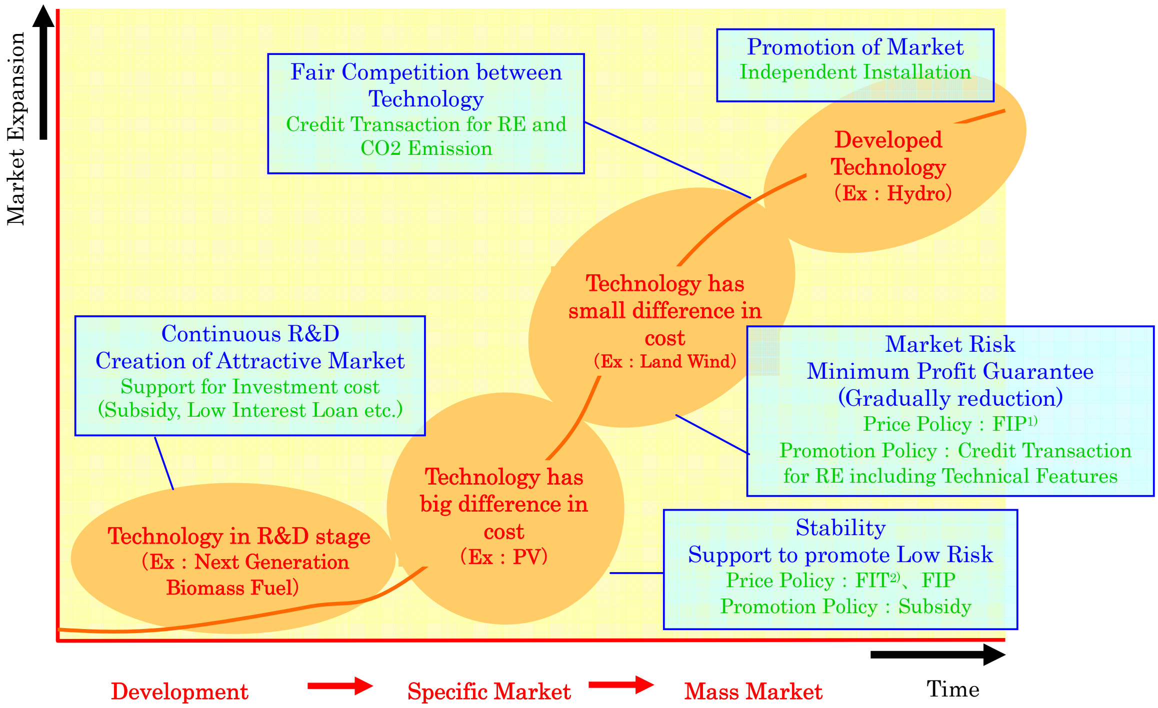
5.2.1 Outline of Dissemination Promotion Measures

In "Deploying Renewable 2008" of the International Energy Agency (IAE) and "The Support of electricity from renewable energy sources" by the EC, survey and analysis are carried out on policies for disseminating renewable energy in each country, in particular the Renewable Portfolio Standard (RPS) and the fixed price purchasing system (FIT system). Here, based on existing literature in overseas countries and studies made by the Japanese Ministry of Economy, Trade and Industry[1] and the Ministry of Environment[2], the features and issues of general options that may be considered as policies for the promotion of renewable energy including PV power are organized.

According to the IEA, in terms of economic theory, under the ideal conditions, policy for fixing the amount of new energy introduced (RPS system) and price fixing policy (FIT system) display the same level of efficiency. In both systems, accurate system design and fine system adjustments are important elements for success, and it is regarded as important to combine the following dissemination promotion measures according to the level of technology (development stage, verification stage,

1 "Concerning measures for promoting introduction of renewable energy in key countries," February 13, 2009
2 "Concerning measures for disseminating renewable energy geared to construction of a low-carbon society (recommendations)," February 2009

practical application stage, etc.) and conditions for market introduction (initial introduction stage, dissemination stage, maturation stage, etc.).



Note : 1) FIP (Feed-in Premium) : Purchasing Price is to add the fixed premium (Bonus) to the market price
2) FIT (Feed-in Tariff) : Purchasing Price is the fixed price
Source : "Deploying Renewables 2008" IEA

Figure 5.2.1-1 Combining Policies for Disseminating Renewable Energies

The following paragraphs describe representative dissemination promotion measures based on reference to Japan's experience and advanced examples in Europe and America.

(1) RPS System

RPS stands for Renewable Portfolio Standard, a system whereby the government makes it compulsory for electricity operators to supply a certain ratio of electric power from renewable energies. Concerning the introductory price, it is possible to realize introduction and expansion with high cost effectiveness through utilizing the market to promote cost competition between different renewable energies. Meanwhile, since various renewable energies which comprise different technical standards and cost levels are exposed to the same competitive environment, little progress tends to be made in introducing PV power and other renewable energies that have relatively high introductory costs. Moreover, since it is not possible to predict purchase prices in the future, another issue is that the investment recovery period cannot be fixed.

(2) Fixed Price Purchasing System (FIT System)

In this system, electric power generated from renewable energies is purchased at a fixed price by power companies over a certain period. If an appropriate purchase price is set in consideration of the technical standard and cost level of each renewable energy, since it is possible to predict the investment recovery period, investment in renewable energy is accelerated. Moreover, through enhancing transparency concerning the cost burden of the markup on electricity tariffs, it becomes possible to conduct stable system operation over the long term.

The important design factor in the FIT system is the purchase price setting. If the price is set too low, the effect of promoting introduction is low, while if it is too high, the high price is passed onto consumers in electricity tariffs, thereby leading to perennial tariff inflation. In addition, it is necessary to periodically review the purchase price according to the pace of dissemination and cost reductions arising from technical development.

(3) Surplus Power Purchasing System

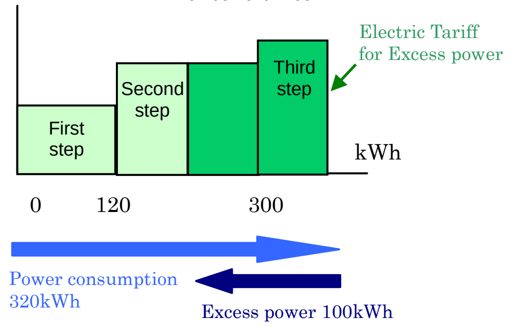
In this system, surplus electricity that is not consumed within consumer premises is autonomously purchased by electric utility operators based on individual contracts. This appears similar to the FIT system, however, whereas all generated electricity is purchased at a fixed price making it easier for investors to compile business plans in the FIT system, the surplus power purchasing system has a major drawback in that it is difficult to project revenue and expenditure balance because only surplus electricity that isn't consumed is made available for purchase. Moreover, since the purchase price of surplus power by electric utility operators is frequently set at the same level as the sale price, leading to extremely long investment recovery periods (around 25~30 years), and the system doesn't guarantee purchase over the long-term since it depends on the autonomous efforts of operators, it doesn't provide an incentive for introducing new energies in large amounts.

The example of the unit price in Excess power purchasing system for Residential solar power system

(Unit : JY/kWh)

	A Co.	B Co.
Mater rate lighting	24.13 22.86 17.87	25.00
Time-of-day lighting	32.48 30.74 23.87	25.00

The example of A Co.
(Power consumption 320kWh、Excess power 100kWh)
＜Household use＞



Source : "Concerning measures for promoting introduction of renewable energies in key countries," Resources and Energy Agency

Figure 5.2.1-2 Outline of Japan's Surplus Power Purchasing System

(4) Introduction Subsidy System

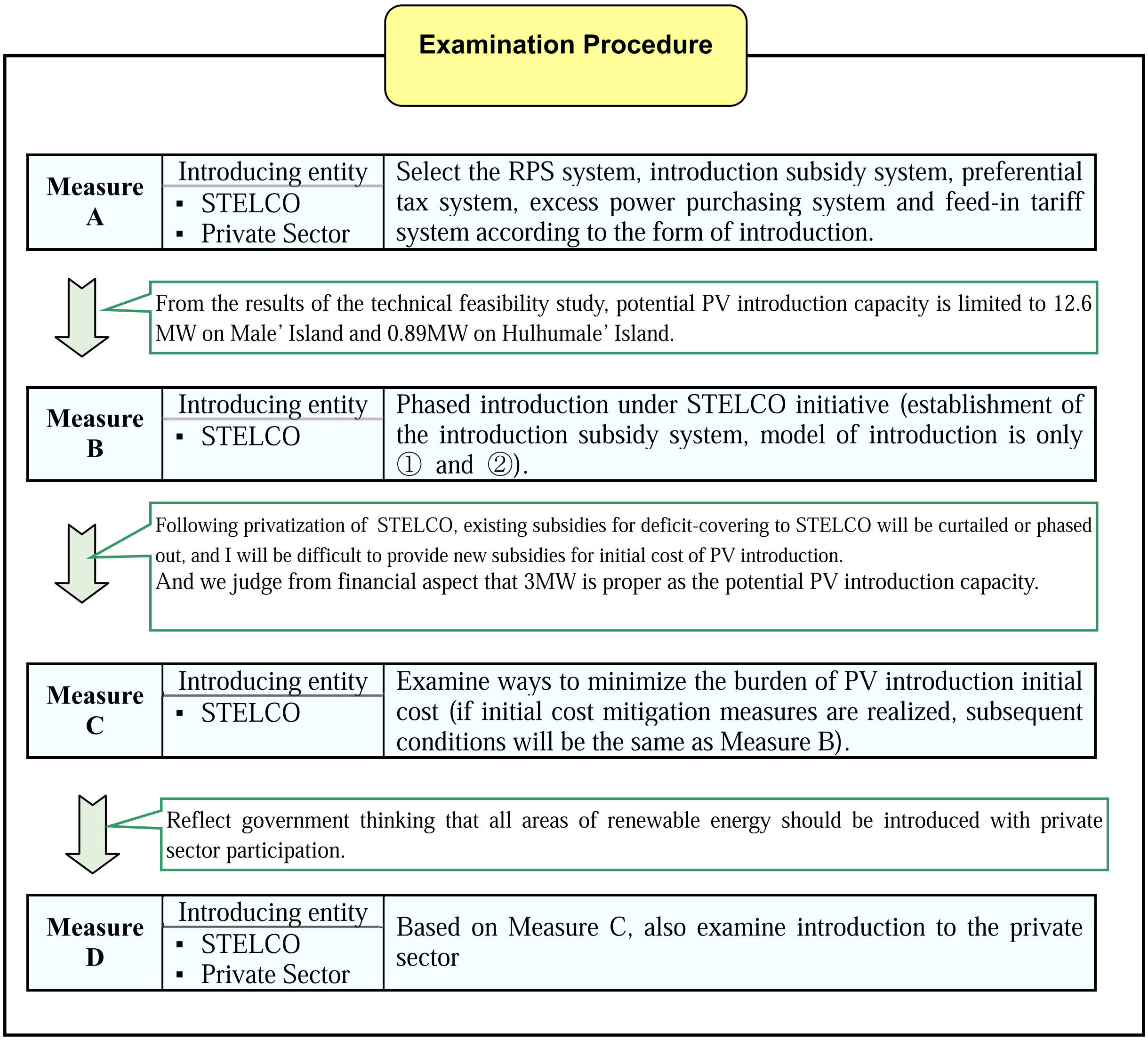
This system entails the government subsidizing part of the costs of introducing renewable energies. It is effective for directly compensating price differentials in the stage where initial introduction costs are high, however, there is a limit to the total amount of subsidies that can be provided each year. Moreover, under single-year budgets, a drawback to this system is that it isn't clear how long it can be continued and it is difficult to compile long-term investment plans. Furthermore, problems are pointed to regarding the administrative cost of operating subsidies and the fact that administrative procedures are concentrated into certain times during the year.

5.2.2 Dissemination Promotion Policies (Draft) in the Maldives

On March 15, 2009, President Nasheed announced a plan for the Maldives to become the world's first carbon-neutral state based on conversion to renewable energies within 10 years. Accordingly, legal systems should be enacted in line with this concept. In the stage prior to the start of field surveys, the Study Team considered that dissemination measures (RPS system, subsidies, preferential tax system, surplus power purchasing system, feed-in-tariff system) would be required according to each mode of introducing the grid-connected PV system (Measure A). However, findings from the technical feasibility study revealed that capacity for grid-connected PV system introduction would be restricted to 12.6 MW on Male' Island and 0.89 MW on Hulhumale' Island. The technical feasibility study also concluded that, from the viewpoint of maintaining power quality following the introduction of grid-connected PV systems, it would be ideal for STELCO to initially take the initiative and to phase in systems in cooperation with the Government of the Maldives. Therefore, a plan to successively introduce 13.49 MW (Male' Island and Hulhumale' Island) under STELCO initiative over the coming 10 years including the pilot project period (Measure B) was formulated and, following consultations with the Maldivian side, willingness to cooperate was confirmed from the CEO of STELCO. On the other hand, the Government of the Maldives is successively advancing the privatization of STELCO with a view to attracting private sector capital including foreign investment and thereby improving the financial standing of the electric power sector in general. According to a high-ranking official in the Ministry of Finance, in line with the privatization of STELCO, government subsidies for deficit-covering that have been provided since 2005 will be cut or phased out, and in that event STELCO will have little choice but to enforce major electricity tariff hikes. Moreover, since the government cannot afford to provide subsidies, this means that no subsidies for initial cost will be available from the government to support PV introduction after STELCO becomes privatized. Accordingly, judging that the 3MW of PV introduce capacity is realistic due to the smallest impact to the Maldives finance and assuming a measure based on STELCO initiative, methods for disseminating PV introduction without subsidies were considered (Measure C). The Government of the Maldives is considering building systems for promoting all areas of renewable energy for decades to come. When it comes to introducing and disseminating grid-connected PV systems, although it can be appreciated that entrusting activities to STELCO is a realistic approach, opportunities should also be given to other entities. Therefore, starting from the base of Measure C, examination was conducted assuming additional introduction to the private sector (Measure D). In Measure C, the following support measures for mitigating initial investment, which is the biggest obstacle to introducing PV, were proposed to and jointly examined among the Ministry of Finance, MHTE, MEA, STELCO and other agencies concerned:

(a) Application of preferential tax measures to PV facilities
(b) Utilization of Green Tax
(c) Utilization of Development Expense
(d) Introduction of Carbon Tax
(e) Revision of Electricity Tariff

As a result of discussing these methods with a high-ranking official in the Ministry of Finance, the agreement was generally obtained. Therefore, the Measure D is our final proposal created by considering the measures for mitigating PV introduction initial cost with the wishes of the Government of the Maldives. However, following the privatization of STELCO, since there is a possibility that reshuffling of top management may result in a major change in policy direction, it will be necessary to continue the discussions and pay close attention to the developments regarding privatization of STELCO.



Source : Prepared by the Study Team

Figure 5.2.2-1 Examination Procedure for Measures geared to Supporting Introduction of Grid-Connected PV Systems

The result of Measure D as our final proposal is shown as follow.

Measure D Examination Results

①Measures for mitigating PV introduction initial cost

In the Measure D, based on the findings of Measure C, the examination was conducted assuming that both STELCO and the private sector introduce the grid-connected PV systems and that introduction to the private sector begins in 2015. The following measures (a)～(e) was examined in the Measure C as the measures for mitigating the PV introduction initial cost. These measures will be applied in the Measure D for only STELCO after 2015 from the financial conditions in the Maldives (Only (a) will be applied for the private sector as well.) And the grid-connected PV system introduction capacity in the private sector is assumed to 100kW per year from 2015 to 2020.

Measures for mitigating PV introduction initial cost

(a) Adaptation of Preferential Tax Measure Exemption for PV facilities
(b) Utilization of Green Tax
(c) Utilization of Development Expense
(d) Introduction of Carbon Tax
(e) Revision of Electricity Tariff

(a) Adaption of Preferential Tax Measure Exemption for PV facilities

「The Import Tax Exemption」 is proposed, here. The import tax in the Maldives imposes 25% to the equipment price. As a result of the discussing the possibility of the import tax exemption for the PV facilities with a high-ranking official in the Ministry of Finance, the agreement was generally obtained with the feasible. And when the preferential tax will be adapted, the exemption price concerning 2.4MW which STELCO will introduce will be approximately US$9.2million, although the total exemption price concerning 3.0MW is approximately US$11million.

(b) Utilization of Green Tax

「Green Tax」 is the plan which collects US$3 per tourist and foresees to increase the tax income of US$6.3 million（MRf80.6 million）per year in that announcement based on the assumption of 700,000 tourists per year and 3 days as the average staying day. The utilization of the green tax for grid-connected PV system can be thought to relate to the purpose of the green tax, because the power generation by grid-connected PV system can contribute the CO_2 emission reduction. And this green tax is thought as the first priority, because this tax is being imposed from now on and the target of the utilization has not been clarified yet.

(c) Utilization of Development Expense

「The Development Expense」 is the development expense in the capital expense as the resource for the infrastructure development and the equipment investment and is expected as the resource of the financial support for mitigating the PV introduction initial cost by STELCO. This Development Expense can be thought as one of the measures for mitigating PV introduction initial cost, because the introduction of grid-connected PV system as the measure for reduction of the diesel fuel relates to the carbon-neutral policy announced by the Maldives government. However, this development expense is thought as the second priority, because this is the existing resource and there might be the necessity of changing the existing plan.

(d) Introduction of Carbon Tax

「Carbon tax」 generally refers to the system of taxing fossil fuels with a view to the limiting demand, while at the same time using tax revenues for the environmental countermeasures. When this tax is introduced in the Maldives, it is proposed that a tax of a few percentage points be levied on the fossil fuels such as gasoline and diesel so that the collection can be widely implemented. The introduction of the carbon tax which has also the effectiveness as the environmental measures is reasonable, because in the Maldives, especially on Male' Island, there is a high concentration of motorbikes and cars despite the restricted land area, the traffic environment and the public sanitation are in appalling condition. When the carbon tax is introduced, its impact will reach the commodities and the electricity tariff and so on. However, judging from the current standard of living in the Maldives, the minor tariff rises are thought to be acceptable; moreover, the tariff rises will have the effect of enhancing the awareness of the environmental load among the ordinary citizens. However, if this carbon tax is arranged, the imposed rate should be considered as small as possible, because the carbon tax might have the possibility of triggering the increasing electricity tariff again, although there is the new electricity tariff structure was applied on Nov 1st.

(e) Revision of Electricity Tariff

「Revision of Electricity Tariff」 which increases the electricity tariff to cover the shortage which can not be covered by the measures (a)～(d) is proposed as the final measure, here. The reason why this measure is though as the final measure is that it is not realistic to increase the electricity tariff again in the near future against the decision of increasing the electricity tariff on Nov 1st in the STELCO territory.

Table 5.2.2-1 Necessary amount of price in Green Tax, Development Tax and Carbon Tax after Import Tax Exemption in Measure D

Installation by STELCO and private sector (STELCO's portion: 2.4MW)	Contribution Rate from the Green Tax			
	61%	**50%**	**30%**	0%
Necessary amount（US$）		**3,886,424**		
Allowable amount（US$）	3,886,424	**3,150,000**	**1,890,000**	0
Shortfall（US$）	0	**736,424**	**1,996,424**	3,886,424
Ratio of shortfall to the national development expenditure	-	**0.5%**	**1.2%**	2.4%
Collection of shortfall from carbon tax (MRf/kWh)	-	**0.003**	**0.007**	0.014

Source： Prepared by the Study Team

Based on the result of Table 5.2.2-1 and the previous examination, it can be judged that the adoption of 50% or 30% of the green tax would be realistic. That reason is composed of the following 3 items.

① The green tax has the enough remaining part and it can be utilized for the other plans after utilizing for the PV system

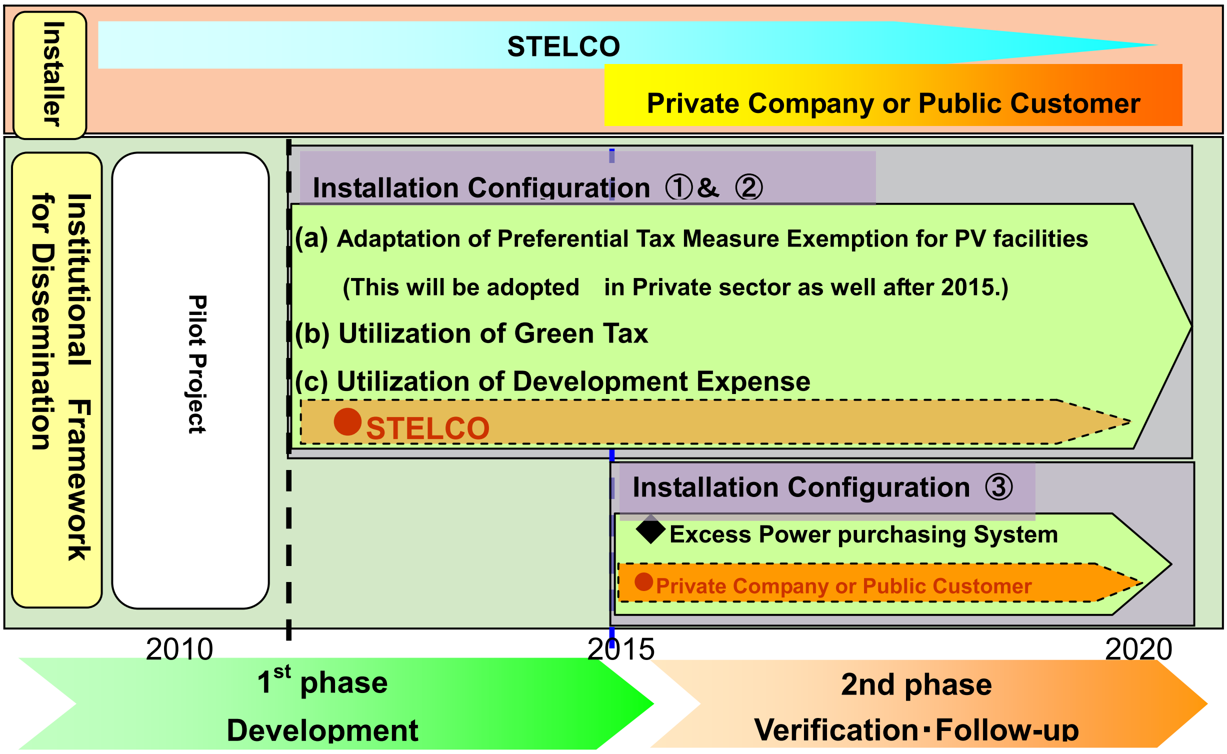
② The ratio of the shortfall to the national development expenditure is 0.5% or 1.3%, their ratios are very small and can be thought realistic.

③ The collection of the shortfall from the carbon tax can be mitigated in the small amount.

②Purchasing system for introducing into the private sector

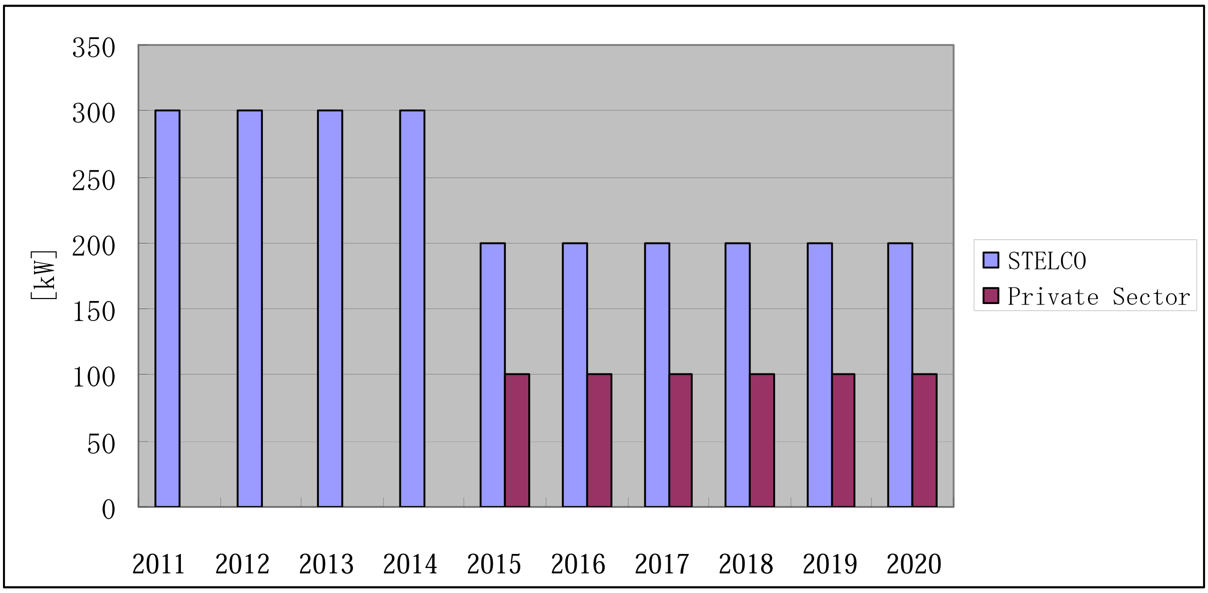
When it comes to introducing to the private sector, two methods, i.e. the total power purchasing system and the excess power purchasing system, are available, however, the latter of these shall be assumed here. This is because, amidst the tight electricity demand and supply situation and difficulties in securing the land for new power generation facility sites, implementation of the excess power purchasing system can be expected to have a secondary effect of limiting the demand for power.

Regarding the purchasing price, it has been concluded that it is appropriate that the purchasing price is set as the same as the unit price of the generating cost or less than the unit cost of the generating cost. Because it is not realistic that if the purchasing price is set t several times of the average of electricity tariff, the payback period will be so long due to the small area in the building roof in the Male' and Hulhumale' Island, the small capacity of the introduced PV system and the small excess power from the introduced PV system. Concerning STELCO, STELCO will not be able to gain any merits if the purchasing price is set higher than the average of electricity tariff. On the other hand, from the result of our hearing investigation to the private sector, it was found out that there are some implementers, etc. who desired to introduce the PV system to gain the merit only by mitigating the energy consumption inside house thanks to the next increasing electricity tariff (Nov. 1^{st}). Accordingly, if the purchasing price is set, it will be able to be the small incentive for the implementers such as the persons who the previous sentence says and STELCO also will be able to gain the merit to purchase the excess power at the cheaper price than the unit cost of the generating cost. Consequently, regarding the purchasing price, the previous conclusion has been achieved, here.



Source： Prepared by the Study Team

Figure 5.2.2-2 Conceptual Image of Dissemination Measures and Systems Introduction in Measure D



Source： Prepared by the Study Team

Figure 5.2.2-3 Introduction amount of Grid-connected PV system

Table 5.2.2-2　Projected Form of Policies and Systems for Introducing and Disseminating Grid-Connected PV Systems in Measure D

No.	Mode of Introduction	Installation Site	PV Equipment Owner	Features, Issues, Requirements, etc.	Dissemination Policies, Systems
①	STELCO introduces PV equipment as its own equipment into its own buildings.	Own buildings, etc.	STELCO	- Since the PV equipment and peripheral equipment belong to STELCO, design of the PV installations is easier. - There is some freedom in selecting PV installation sites.	- Revision of electricity tariffs - Establishment and operation of a renewable energy fun - Pooling of revenues derived from electricity tariffs in the pilot project - Application of preferential tax measures to PV facilities
②	STELCO installs its own PV equipment on roofs, etc. leased from other companies.	Other parties' buildings, etc.	STELCO	- Constraints and rental fees on PV installation sites are predicted. - Consultations regarding equipment management and security are required. - Since the PV equipment belongs to STELCO, there is no need to consider charges.	- Revision of electricity tariffs - Establishment and operation of a renewable energy fun - Pooling of revenues derived from electricity tariffs in the pilot project - Application of preferential tax measures to PV facilities
③	Building owners install PV equipment as their own power sources and sell excess power to STELCO.	Other parties' buildings, etc.	Building owners, etc.	- Since systems are normally used for private consumption, there are relatively few backflows of excess power and the impact on distribution lines is small. - Guidelines, etc. concerning technical requirements for protective devices, etc. when connecting to the grid need to be established as fair standards.	- Revision of electricity tariffs - Establishment and operation of a renewable energy fun - Pooling of revenues derived from electricity tariffs in the pilot project - Application of preferential tax measures to PV facilities - Excess power purchasing system

Source :　Prepared by the Study Team

5.2.3　Future Issues for Examination regarding the Grid-Connected PV System Dissemination Promotion Policies and Systems

The Measure D is our final proposal in this study which incorporates methods for mitigating the PV introduction initial cost with the wishes of the Government of the Maldives. Table 5.2.4-1 summarizes the future examination issues regarding the dissemination policies and systems.

Table 5.2.3-1 Future Examination Issues regarding Dissemination Policies and Systems

Dissemination Policies and Systems	Future Examination Issues
Application of a preferential tax system to PV installation	- Continuous discussion for realization and clarification of procedure will be necessary.
Utilization of Green Tax	- Evaluation of amount of utilization and continuous discussion will be necessary.
Utilization of Development Expanse	- Evaluation of amount of utilization and continuous discussion will be necessary.
Introduction of Carbon Tax	- Clarification of target, evaluation of amount of utilization and continuous discussion will be necessary.
Revision of electricity tariffs	- Electricity tariffs from Nov 1st will be increased by STELCO, continuous discussion concerning how far tariffs can be raised for PV introduction will be necessary.
Excess power purchasing system	- It is necessary to set the purchase price. - It is necessary to establish criteria for installing excess power measuring meters, etc. - In the event where PV systems are scattered throughout the private sector, it will be necessary to conduct technical support in order to maintain the demand and supply balance and quality of power. - In the event where commercial consumers on Male' Island introduce private power generation, since power supply by STELCO will be suspended, it will be necessary to revise the existing system which makes it impossible to receive STELCO power supply while operating private power generation. - Examination of the maintenance setup is needed.
Other	- Arrangement of guideline for grid-connected PV system for private sector, etc. will be necessary.
General	Concerning dissemination policies and systems necessary for the future introduction and dissemination of PV, the main points have been identified and agreed with the Maldivian side. In future, it will be necessary to discuss these in more detail while carefully watching developments in the privatization of STELCO.

Source： Prepared by the Study Team

5.3 Technical Criteria and Guidelines, etc. for Introduction of Grid-Connected PV Systems

In the Maldives, connecting private generating equipment to the power grid is currently prohibited, and corporations and individuals who own private generators can only conduct private power supply without receiving power from STELCO. Interconnection is not permitted because private generators are not fitted with adequate synchronous control functions and protective devices and there is concern over negative impacts on the STELCO grid. Moreover, the technical criteria and requirements concerning interconnection are not clearly specified.

When it comes to connecting PV power generation systems to the grid, it will first be necessary to revise these regulations and examine the requirements that are needed for interconnection. Table 5.3-1 shows the current conditions and technical requirements from the viewpoints of stable supply, power quality, network protection, security and operation (based on the Japanese Grid-Connection Requirements and Guidelines related to Securing Power Quality, October 1, 2004, of the Natural Resources and Energy Agency) that will need to be examined in the Maldives from now on.

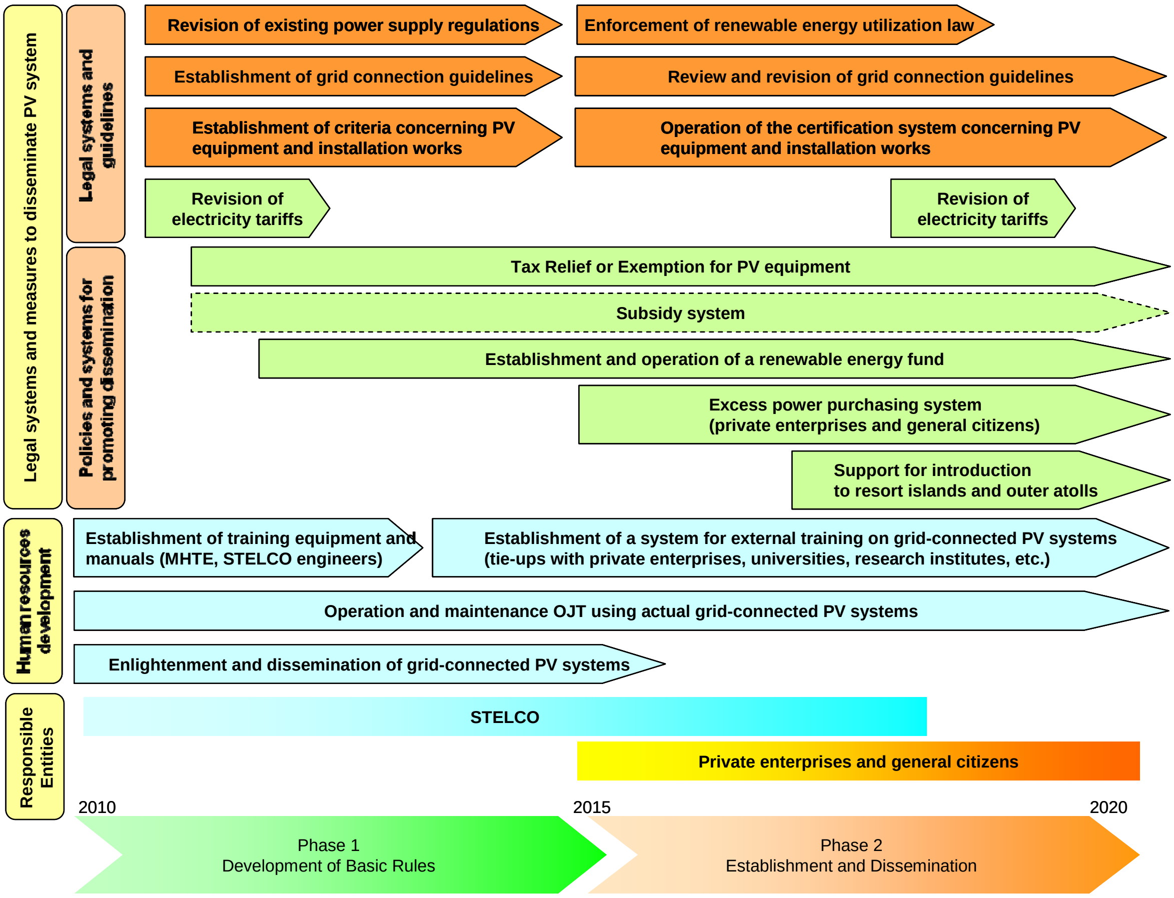
Table 5.3-1 Technical Requirements of Grid-Connection Guidelines and Results of Examination of Application to the Maldives

						Examination Issues
Power capacity		Less than 50 kW	Less than 2,000kW (Including special high voltage distribution lines (no more than 35 kV) less than 10,000 kW)	Less than 10,000 kW	2,000kW or more	As a result of the potential study, there is no possibility of connecting 2,000 kW or more at 1 site.
Voltage class		Low voltage distribution lines	High voltage distribution lines	Spot network distribution lines	Special high voltage distribution lines	Low voltage (230/400V) or high voltage (11,000 V) interconnection. Examine separately for each grid-connected system without establishing capacity divisions.
		100/200V	6,600V	22kV or 33kV	7kV or more	
Protective equipment		Over voltage relay (OVR) Under voltage relay (UVR) Over frequency relay (OFR) Under frequency relay (UFR)	Same as left	Same as left	Same as left	Only in cases of three-phase interconnection concerning overvoltage (OVR), undervoltage (UVR), over frequency (OFR) and under frequency (UFR) and overvoltage ground (OVGR)
		-	Overvoltage ground relay (OVGR)			
Islanding operation (Detection method)		Prohibited			With reverse power: Possible (frequency relay or transfer trip system is required)	For security and operation reasons, prohibit islanding operation and adopt both active and passive detection functions as standard.
		Both active and passive method	Same as left	Reverse power relay (RPR)	Without reverse power: Prohibited (Frequency relay or reverse power relay)	
Power factor	With reverse power	・As a rule, power factor at the receiving point shall be 85% or more seen from the grid side and shall not be the leading power factor. ・If necessary for preventing voltage increase, the power factor can be held to 80%. ・When using a small output inverter or in cases where the receiving point power factor is deemed appropriate as in general households, the generating facility power factor shall be at least 85% when controlling with reactive power and at least 95% when not controlling.			Value to sustain an appropriate voltage on the grid	Adopt a power factor where the voltage fluctuation at the interconnection point is within the scope of voltage control criteria (nominal voltage±10%).
	Without reverse power	Generating facilities power factor is 95% or more.	As a rule, power factor at the receiving point shall be 85% or more seen from the grid side and shall not be the leading power factor.			
Automatic load control			When there is danger of interconnected power lines or transformers going into overload when generating facilities drop out, take automatic limiting measures.			As a rule, do not install automatic load control, and secure equipment capacity that ensures there is no overload even when the generating equipment drops out.
Countermeasures for Constant voltage fluctuation		When there is danger of deviation from appropriate values for low voltage consumers due to reverse power, take steps to automatically adjust voltage by using the reactive power control function or output control function. (However, this function may be omitted in small output inverters). If the above steps cannot be taken, reinforce distribution lines and so on.	When there is danger of deviation from appropriate values for low voltage consumers connected to general distribution lines, take automatic load control measures. If these are insufficient to resolve the problem, reinforce distribution lines or connect with dedicated lines. When there is danger of deviation from appropriate values for low voltage consumers due to reverse power, take steps to automatically adjust voltage through using the reactive power control function or output control function.	When there is danger that voltage fluctuation caused by drop-out of generating facilities will deviate from the constant voltage by more than 1-2%, take measures to automatically limit load.	When there is danger that voltage fluctuation caused by drop-out of generating facilities will deviate from the constant voltage by more than 1-2%, take measures to automatically adjust voltage.	Secure equipment capacity to ensure that the scope of voltage control criteria (nominal voltage±10%) is not deviated from even when the generating equipment drops out. If there is risk that back flows will cause deviation outside of the voltage control criteria scope, equipment with the reactive power control function or output control function.
Instantaneous voltage fluctuation countermeasures		Adopt a self-exciting inverter possessing automatic synchronizing function.				Same as left
Prevention of unexpected parallel-off		Adopt a system whereby parallel off doesn't arise and operation can be continued or automatic return can occur when instantaneous voltage drop time and setting time are within the under voltage relay setting time.	Ensure that parallel off doesn't arise in cases of failures outside of the connected grid. If parallel off does occur, adopt a system whereby unwanted breaking (breaking other than that if independent operation) can be avoided in the generating facilities due to excessive power fluctuation within a time shorter than the automatic switching time of parallel off caused by reverse power relay or under voltage relay, etc.	Ensure that parallel off doesn't arise in cases of failures outside of the connected grid. With respect to failures in the interconnected grid and up to the protector circuit breaker, open the protector circuit breaker in the failed line and maintain the connection with sound lines without conducting parallel off.	Ensure that parallel off doesn't arise in cases of failures outside of the connected grid. If parallel off does occur, adopt a system whereby unwanted breaking (breaking other than that if independent operation) can be avoided in the generating facilities due to excessive power fluctuation within a time shorter than the automatic switching time of parallel off caused by reverse power relay or under voltage relay, etc.	Protective relay settings (including time settings) shall be variable. Adopt the settings established by STELCO to prevent parallel off due to faults on other feeders.
Communication system		Install security communications telephone facilities (dedicated security telephone equipment, telecommunications operator special line, general telephone or mobile phone, etc.) between the business offices or dispatching centers of electric operators on the grid side and installers of generating facilities, etc.			Connect with a special high voltage power line of 60 kV or more and, in cases where there is reverse power flow, install supervision or telemeter equipment between dispatching centers of operators on the grid side and installers of generating facilities, etc.	As a result of the study, communications equipment such as security phone equipment, etc. is deemed to be unnecessary. Concerning online measurements, etc., examine separately according to the grid operating needs.

Source：Prepared by the Study Team based on data of the Natural Resources and Energy Agency in Japan

5.4 Medium to Long-Term Plans for Introducing Grid-Connected PV Systems

When it comes to introducing grid-connected PV systems and promoting dissemination over the medium to long-term, the first thing to do is to establish a single roadmap (see Figure 5.4-1) for related agencies and organizations including other donors and to clarify the respective roles of each. The Study regards 2020 as the target year and divides the coming 10 years into Phase 1 (2010~2015) and Phase 2 (2016~2020), and the medium to long-term plans to disseminate grid-connected PV systems in each phase are as indicated below. Furthermore, an examination of human resources development based on capacity assessment of organizations and personnel concerned with the introduction of grid-connected PV systems is given in 5.6.



Source： Prepared by the Study Team

Figure 5.4-1 Roadmap (Draft) geared to Dissemination of Grid-Connected PV Systems

(1) Phase 1: Development of Basic Rules (2010~2015)

In this Phase 1, immediately after completion of the Study, utilizing the outputs of the pilot project which is planned and designed in the Study, it is desirable to actually introduce and start operating grid-connected PV systems as early as possible, with a view to utilizing the outputs of dissemination measures, human resources development and technology transfer. Moreover, through accumulating and assessing implementation design, tender and consultant supervision know-how and operating data acquired during the pilot project, it will be important to prepare for the introduction of grid-connected PV systems by private sector enterprises and ordinary households in the Phase 2 period. At this stage, since it is still too early to introduce grid-connected PV systems by private enterprises and households, the plan is for STELCO to take the initiative in introducing systems to government buildings and public facilities such as schools and hospitals, etc. in Male' Island and at the same time to widely inform the citizens of the Maldives about the effects of PV systems. Also, when STELCO promotes the introduction of grid-connected PV systems, it will be necessary to train and educate possible retailers and contractors for PV equipment who will take the initiative in installing systems to private sector in the future.

1) Establishment of Legal Systems and Guidelines

In order to promote the introduction of grid-connected PV systems to private sector enterprises and general households in the Phase 2 period, it will be necessary for the government to establish the following regulations and guidelines concerning power supply reliability and quality, public safety and safety for electrical works during this Phase 1 period.

① Revision of existing electric power supply regulations

The legislation regulating the electric utility in Maldives is the Law governing public services (Law No. 4 of 1996). According to Article 2, this law defines public services as electric power, telephones, public water supply, and sewerage. According to Article 3 of this law, parties that implement public services (government agencies, state-owned enterprises, private operators) must register with government regulatory agencies and comply with the regulations imposed by such agencies.

Based on Article 3 of the Law governing public services, the specific contents of regulations pertaining to the electric utility are stipulated in the "Regulations on public supply of electricity in Male' and outer Atolls (1993)" established by the Maldives Energy Authority (MEA), which is the regulatory agency for the electric utility. According to Article 1 of this regulation, entities that aim to operate electric utilities must register to MEA and receive the necessary approval. These regulations prescribe the basic technical items that need to be followed by electric utility operators concerning power generating and distribution facilities. For power generating facilities, since existing regulations were compiled only for diesel power stations, it will be necessary to stipulate the minimum required criteria from the viewpoint of quality control for PV equipment assuming the case where entities other than STELCO introduce grid-connected PV systems.

② Grid-connection guidelines

After Phase 2 period, since grid-connected PV systems will be introduced through private sector enterprises and ordinary households, it will be necessary to establish technical requirements concerning grid connection and provide guidelines that facilitate fair technical discussions between entities to install PV system and the electric utility (STELCO). The Japanese Grid Connection Technical Requirements and Guidelines, which were announced in 1986, have undergone numerous revisions reflecting technical development trends and changes to the electric utility law, and the original guidelines were divided into the “Interpretation of Technical Standards for Electric Facilities” and the “Technical Requirements and Guidelines for Grid Interconnection for Securing Quality of Power Supply” in 2004. Similarly, it is forecast that guidelines in Maldives will need to undergo revisions from Phase 2 onwards to reflect changes in the environment.

③ Technical criteria concerning PV instruments and installation works

Standards of the IEC (International Electrotechnical Commission) are widely applied as international standards for PV generating instruments, however, in Japan, designs based on JIS criteria are more common. IEC Technical Committee 82 (PV generating systems) is currently surveying applied standards in each country and is seeking to promote common standards with the IEC standards. In Maldives, since the potential capacity for system introduction is relatively limited, it is unrealistic to expect the establishment of new domestic standards. Rather, it is more important to ensure thorough quality control of PV-related products through applying international standards (IEC, etc.) and establishing the product inspection setup when works are complete. The existing STELCO workshop on Male’ Island is the ideal place for implementing PV product inspections, however, it will first be necessary to receive MEA authorization for the applied standards and to establish a manual for product inspections. In addition, when purchasing grid-connected PV systems, rather than purchasing PV modules and power conditioners as isolated items, it is better to select manufacturers who can procure, install, test and adjust total systems, and thereby ensure that poor quality products from emerging countries do no enter the domestic market.

2) Dissemination Promotion Policies and Systems

During Phase 1 period, the target will be for STELCO to achieve the PV installation capacity for 2015 in accordance with the plan proposed in the technical feasibility study while utilizing experience from the pilot project. Accordingly, the MHTE (or MEA) shall establish a pool system utilizing generated electric energy returns from the grid-connected PV systems installed under the pilot project, and use this to subsidize the initial investment required to introduce grid-connected PV systems as scheduled. Other methods for mitigating initial investment include exemption or reduction of import duties for PV products, introduction of Green tax or Carbon tax, establishing a Renewable Energy Fund, revising electricity tariffs, and so forth[3]. When it comes to the Phase 2 activity of introducing grid-connected PV systems to private sector enterprises and ordinary households, it is planned to encourage introduction through the excess power purchasing system, so it will be necessary to start examinations into methods for setting the excess power purchase price, measuring surplus power and reading meters under this system.

(2) Phase 2: Establishment and Dissemination (2016~2020)

1) Establishment of Legal Regulations and Guidelines

The legal regulations and guidelines for introducing grid-connected PV systems which were established in Phase 1 will undergo amendment and revision during Phase 2 period based on actual operating performance. This will be important for building a regulatory setup which corresponds to actual conditions. Towards this end, regular meetings (around once every six months) will be held between the MHTE, MEA, STELCO and entities who install grid-connected PV system to discuss issues in current legal regulations and guidelines, impediments to future large-scale system introduction and necessary improvements. The MEA will probably take the initiative in these examinations, however, since MEA doesn't currently possess the organizational or personnel capacity to do this, it will be necessary to consider the utilization of technical cooperation by Japan and other donors as well as the recruitment of foreign consultants.

In Japan, "Act on the Promotion of New Energy Usage (New Energy Law)" and "Act on Special Measures concerning New Energy Usage by Electric Utilities (RPS Law)" contain the basic government policy concerning the comprehensive promotion of new energies. In the rest of Asia, Renewable Energy Act of 2008, R.A.9315 was established in the Philippines on December 16, 2008, and based on this the Philippine government is promoting renewable energies through the establishment of the State Renewable Energy Department and provision of tax exemptions. In Maldives, no such legal systems exist, and there are no legal stipulations concerning numerical targets for introduction of renewable energies including grid-connected PV systems, provisions in the event where targets are not met, and the division of roles between related organizations and so on. Moreover, in order to

3 For details on dissemination promotion policies, see 5.2 (Dissemination Promotion Policies and Systems (Incentives)).

attract major investment in the future, it will be necessary to examine preferential tax systems concerning income tax and indirect taxes, etc., and legislative measures will be essential in such case. However, since the potential capacity for grid-connected PV system introduction on Male’ Island and Hulhumale’ Island by 2020 is limited, it may be more realistic to reexamine the necessity for more strict measures based on a renewable energy law while considering the actual dissemination after Phase 1 period.

2) Establishment of Dissemination Promotion Policies and Systems

As was mentioned in 5.2, the Study Team has proposed excess power purchasing system for promoting the introduction of grid-connected PV systems to private sector and general households in tandem with planned introduction to STELCO in Phase 2. When it comes to applying such a system, it may be necessary to adjust the unit purchase price while regularly monitoring the scale of PV systems being introduced by general households. Under the Study, PV introduction targets are set for each year with a view to achieving the target capacity by 2020, and it will be necessary to review the target years and capacities for introduction while taking the government’s latest renewable energy policies and actual introduced capacities into account. Also, since Maldives does not have a master plan of energy supply including renewable energies, it will be desirable to compile a nationwide medium to long-term master plan which includes outer atolls taking into account dissemination of grid-connected PV systems in the Male’ metropolitan area during Phase 1. In addition, another future issue will be the widespread education and awareness raising of PV system and DSM techniques to people including MATI and resort owners, etc.

5.5 Action Plan for Introduction of Grid-Connected PV Systems

This section describes the action plan for implementing the medium to long-term plan indicated in 5.4 by the entities involved in grid-connected PV system introduction, i.e. the MHTE, MEA and STELCO. In Maldives, PV systems have been introduced under donor support in the past, and the MHTE, as the policy planning department, follows up system maintenance conditions and conducts troubleshooting, etc. However, expected roles and responsibilities among the said three organizations are unclear. Therefore, as is shown in Table 5.5-1, the Study Team has prepared the action plans required of each entity for grid-connected PV system and has obtained the consent of each entity in separate consultations.

As is shown in the table, the MHTE, which is the supervisory agency in charge of energy administration, manages the formulation and implementation of policies for promoting the dissemination of grid-connected PV systems, while the MEA compiles and manages the necessary regulations, guidelines and technical criteria, etc. based on the said policies. It is desirable that the electricity utility, STELCO, compiles demand and supply plans that take the future introduction of grid-connected PV systems into account, plans and designs systems, and takes charge of maintenance. In this way, when introducing grid-connected PV systems, it is necessary to clarify the roles of each organization and to establish the work flow starting from the upstream ministry (MHTE) and moving down through the independent monitoring agency (MEA) to utility (STELCO).

Table 5.5-1 Action Plans for Dissemination of Grid-Connected PV Systems

		MHTE	MEA	STELCO
Role required as an organization [Note]		➢ Compilation and implementation of energy and electric power policy ➢ Setting of medium to long-term development plans and development targets ➢ Collaboration with multinational agencies and donors ➢ **Planning and implementation of dissemination promotion policies for introducing PV power generation**	➢ Compilation and implementation of energy and power supply regulations (for implementing the policies compiled by the MHTE) ➢ Authorization with respect to power generation and retailing electric utility operators ➢ Approval for grid-connected PV installation applications ➢ Totaling and management of energy statistics ➢ **Compilation and operation of regulations and guidelines necessary for introducing grid-connected PV systems**	➢ Power supply according to the regulations compiled by the MEA ➢ **Compilation of demand and supply plans that take the introduction of grid-connected PV systems into account** ➢ **Design of grid-connected PV systems according to the regulations and guidelines prepared by the MEA** ➢ **Operation and maintenance of grid-connected PV systems**
Action plan	Short-term	➢ Completion of national energy policy that integrates the manifesto of the ruling party (Maldivian Democratic Party) ➢ Establish a pool system for accumulating future investment funds, and save profits calculated from the generated electric energy in the pilot project. ➢ In accordance with the recommendations of the Study, compile and implement support measures (subsidies, surplus power purchasing system) for promoting introduction of grid-connected PV systems. ➢ Enlightenment and dissemination activities targeting private enterprises and ordinary citizens based on the pilot project ➢ Renew the F/S contents and update future grid-connected PV introduction plans.	➢ Compilation and implementation of legal regulations and guidelines for implementing support measures for promoting grid-connected PV system introduction as compiled by the MHTE ➢ Compilation of PV equipment technical criteria and installation criteria. ➢ Revision of electricity tariffs for making up the initial investment required for introducing grid-connected PV systems ➢ Assessment and monitoring of grid-connected PV systems installed in the pilot project ➢ Preparation of application and consultation procedures and documents assuming applications for connection from private enterprises and general consumers	➢ Enhancement of operation and maintenance capacity via the operation of grid-connected PV systems installed in the pilot project ➢ Addition of training items related to grid-connected PV system operation and maintenance in the external training system. ➢ Preparation of electricity demand and supply plans that assume introduction of grid-connected PV systems ➢ Preparation of measuring and tariff collection methods that assume introduction of grid-connected PV systems ➢ Activities for enlightenment of private sector enterprises and ordinary citizens via implementation of the pilot project ➢ Preparation of methods for determining feasibility of grid connection regarding applications for connection from private sector enterprises and ordinary citizens
	Medium to long-term	➢ Support for establishment of a Renewable Energy Fund (provisional name) by the Ministry of Finance ➢ Compilation of a National Energy Master Plan integrating grid-connected PV systems and isolated PV systems ➢ Compile and implement support measures for promoting introduction of grid-connected PV systems in outlying atolls. ➢ Promote introduction of PV power generation and DSM to resort islands in cooperation with the Ministry of Tourism, Art and Culture.	➢ Preparation of legal regulations for introducing PV systems to outlying atolls and resort islands ➢ Establishment of an authentication system concerning PV-related equipment and installation works ➢ Implementation of authorization for tariff setting, measuring and tariff collection in the surplus power purchasing system ➢ Establishment of a monitoring setup for PV systems installed on outlying atolls (for example, liaison offices, agents, etc.)	➢ Staging of seminars for enhancing the design capacity of private enterprises and works contractors in grid-connected PV system projects ➢ Implementation of tariff setting, measuring and tariff collection in the surplus power purchasing system

(Note) The roles required when introducing grid-connected PV systems are indicted in bold lettering.

Source : Prepared by the Study Team

5.6 Human Resources Development Plan

5.6.1 Capacity Assessment of Counterpart Agencies, etc.

(1) Capacity on the Individual Level

The Energy Section, which is responsible for energy administration within the MHTE, has ten employees, of them only two engineers the Assistant Director, Ahmed Ali, is an engineer (MA in engineering), while the other seven are graduates of high school regular courses. Of these seven, two studied for a year at a technical institute and obtained electrical and electronic engineering certificates, however, they do not possess a technical skill based in practical work. Accordingly, the MHTE wants to send these personnel overseas in order to learn energy policy and regulation, energy economics, energy security and renewable energies, etc. However, because the Energy Section does not have a plan or budget for human resources development, it will be necessary for prospective government employees to apply for and succeed in overseas study programs.

MEA has four employees including one engineer. He has worked as a lecturer of electrical and electronic engineering at a college of higher education.

STELCO has a workforce of 449 employees, however, there are only 20 electric engineers who are qualified as Professional Engineers, while only two engineers have experience of PV planning and operation. One of these engineers worked on the RETDAP project under UNDP, while the other has worked in the telephone company Dhiraagu. Both these engineers have acquired technology while using resources outside of STELCO.

In all organizations, the counterparts for the Study Team are willing to cooperate with the Study Team on Fridays and Saturdays even after regular working hours, and they displayed a lot of interest in the Study, high willingness to participate and adequate awareness of the need to introduce grid-connected PV systems. However, top managers tend to be swamped in everyday work and have little prospective or incentive for medium to long-term. As they have depended on donor support in the past, they generally display little ownership on projects.

(2) Capacity on the Organization Level

Capacity on the organization level refers to material, human and intellectual resources, ownership, organizational management setup and organizational culture[4] necessary for resolving issues and achieving goals that have been imparted to an organization or taken on by the organization itself. Concerning human resources, in order to introduce grid-connected PV

4 “Case Analysis concerning Capacity Development (CD), Energy Efficiency and Conservation”

systems to Maldives, it is important for MHTE, MEA and STELCO to secure adequate employees, and for these employees to have incentive to fulfil their duties and accumulate skills inside the organization. However, MHTE and STELCO employees frequently undergo transfers (overseas training is especially frequent) and skills that are acquired in manufacturer training programs, etc. tend to stay with individuals. The intellectual resources management is also inadequate and document and electronic data storage methods are left on individuals, meaning that organizations cannot deal with the situation when staff members are absent or transferred.

Although the MHTE has a Human Resource Section, it only gathers the training (overseas study) needs of each section and presents them to the Ministry of Human Resource, Youth and Sports, however, it needs to prepare a setup for developing human resources in a planned manner. Similarly, as for MEA, collecting applications for OJT and overseas study programs is the main activity of human resources training, and no organized setup has been established.

Human resources training in STELCO consists of the following activities: ① Off-JT by internal and external experts (consumer services, computer skills, cable connections, DEG maintenance, general affairs, linguistics, financial affairs, etc.), ② OJT by senior staff, and ③ training by consultants and manufacturers when handing over projects. In the past, STELCO utilized the overseas training system to allow between two and five employees to obtain degrees in Australia, the United Kingdom, Malaysia and Singapore, etc. every year, however, this system was discontinued in 2003 due to deterioration of financial condition. The STELCO Human Resource Department is composed of six employees and works on gathering annual training needs and compiling training plans in each department, however, the training budget was cut in 2009 due to the worsening financial situation.

(3) Capacity on the Social and Institutional Levels

Concerning capacity on the social and institutional levels, the Study Team ascertained the capacity of government agencies (stakeholders) which have jurisdiction over public facilities (schools, stadiums, hospitals, etc.) expected to be among the first to introduce grid-connected PV systems, and also legal systems and the mechanism to introduce grid-connected PV system.

These government agencies do not adopt an organized approach to climate change and global environmental problems like their Japanese counterparts, however, it would be difficult to expect such capacity in Maldives too. In order to advance the introduction of grid-connected PV systems, it will first be necessary to conduct organized awareness raising activities that involve these government agencies.

Maldives has no Laws or Acts for promoting the introduction of renewable energies including PV power generation (equivalent to the New Energy Law and RPS Law in Japan), however, the MHTE recognizes the need to immediately establish a legal system.

5.6.2 Direction of Human Resources Development

In this section, examination is carried out on the direction of human resources development based on the aforementioned capacity assessment findings. On the individual level, during the course of the Study, capacity building has been conducted based on planning and design capacity to introduce grid-connected PV system. Through implementation of the pilot project, it is anticipated that necessary skills for supervision, operation and maintenance for grid-connected PV systems are acquired primarily among STELCO engineers. Concerning capacity on the organization level, in the case of STELCO, it is possible to achieve a certain level of capacity building through adding training programs on grid-connected PV system planning, design, operation and maintenance by external experts (overseas manufacturers and power companies). In case of MHTE and MEA, it is first necessary to establish mission statements and division of duties including conventional energy supply, and then to examine the direction of human resources development for introducing renewable energies and grid-connected PV systems (see 5.4). As for the social and institutional level, after completion of the Study, it will be necessary to advance preparations for introducing regulations and guidelines concerning the Renewable Energy Law (provisional name) and grid connections.

Table 5.6.2-1 Direction of Human Resources Development (Draft)

	Individual	Organization	Social Systems
①Capacity Assessment			
Current issues	→ Since staff have no practical experience of introducing grid-connected PV systems, they cannot conduct the planning and design required for new system introduction. → Staff do not known what to do if existing grid-connected PV systems break down. → Each staff member has a strong sense of responsibility and mission, but they are so inundated with everyday work that they cannot think ahead in the medium to long-term. → Staff have long depended on support from donors and thus have little sense of ownership towards projects.	→ There is no training system for technical employees. → There is a shortage of engineer-class employees equipped with knowledge of renewable energies and PV. → Employees do not stick with the organization due to overseas study and job transfers.	→ There are no Acts geared to the introduction of renewable energies. → Current regulations only target DEGs, but there are no regulations for PV. → There are no standards equivalent to the grid connection standards that exist in Japan.
Capacity needed to resolve issues (short-term)	→ Grid-connected PV system planning and design capacity → Grid-connected PV system maintenance and operation capacity	→ Review the division of roles of each organization and confirm duties that can be implemented under the current setup. → Confer incentives to encourage employees to continue working and to accumulate knowledge and skills within the organization.	→ Resolution of technical issues necessary for grid connection of distributed power sources.
Capacity needed to resolve issues (medium to long-term)	→ The ability to execute work with strong incentive and ownership	→ Establish a training system for technical employees.	→ Introduce a Renewable Energy Act. → Revise existing regulations to include stipulations on PV.
②Issue resolution through the development study			
	→ Improvement of grid-connected PV system planning capacity based on F/S joint work, and enhancement of ownership over plans. → Improvement of detailed design capacity through Pilot Project design → Transfer of operation and maintenance techniques utilizing existing PV systems	→ Recommendation of division of duties and setups for each organization necessary for introducing grid-connected PV systems → Extension of knowledge and skills within the organization utilizing counterpart training	→ Recommendations concerning response to technical issues necessary for grid connection of distributed power sources.
③Issue resolution following completion of the development study			
	→ Learning of grid-connected PV system installation works supervision and operation and maintenance techniques via the Pilot Project. → Learning of grid-connected PV system technology through internal OJT and self-development. → Conferral of incentives (internal recruitment, awards, etc.) for encouraging self-development, and provision of necessary teaching materials and documents, etc.	→ Establish a training system for technical employees based on internal lecturers and lecturers from PV makers.	→ Introduce the Renewable Energy Act. → Revise existing regulations to include stipulations on PV.

Source： Prepared by the Study Team

5.6.3 Human Resource Development Plan

Human resources development comprises three major components: they are ① OJT conducted through everyday work, ② intensive training outside the workplace (in-house training, external training, training at education agencies, and overseas training) i.e. Off-JT, and ③ Self-development. Since all three types are interlinked, it is desirable to combine all three when developing human resources.

In case of Maldives, since there are hardly any people with experience of introducing grid-connected PV systems, it will be difficult to acquire skills through OJT. On the other hand, operation and maintenance technology for conventional power generation and distribution equipment is largely diffused in the workplace via OJT. Accordingly, concerning grid-connected PV systems, potential workplace lecturers who can conduct OJT have been selected and the technical transfer contents indicated in Table 5.6.3-1 are being conducted through jointly conducting technical F/S and detailed design during the Study. Also, major counterparts from MHTE, MEA and STELCO have participated in counterpart training in Japan to learn the subjects such as renewable energy policy, incentive measures to introduce PV system, plan and design of grid-connected PV system. Therefore, those counterparts are expected to disseminate the knowledge and skills inside their organization.

Table 5.6.3- 1 Contents of Technical Transfer Implemented in the Study (including Counterpart Training)

Classification	Contents	Targets
Energy and electric power utility in general	Structure of the electric power utility in Japan	MHTE, MEA
	Policies and systems for introduction of renewable energies in Japan and other advanced countries	MHTE, MEA
	Thinking behind introduction of measures and systems for introducing PV power generation	MHTE, MEA
	Issues and countermeasures for CDM project plans	MHTE, MEA
PV power generation in general	Types and characteristics of PV systems	MHTE, MEA, STELCO
	Legal systems related to PV power generation	MHTE, MEA
	Consideration of social and environmental impacts of PV power generation introduction	MHTE, MEA
	Economic assessment of PV power generation	MHTE, MEA
	Measurement of PV system characteristics	STELCO
	Solar radiation data measurement and utilization methods	MHTE, MEA, STELCO
	Techniques for measuring solar radiation obstructions	STELCO
	Technique for planning layout of PV panels	STELCO
	PV technology research and development	MHTE, MEA, STELCO
Grid-connected PV power generation	Component instruments and their roles in grid-connected PV power generation systems	MHTE, MEA, STELCO
	Issues and technical items in grid connection	MHTE, MEA, STELCO
	Method for measuring power source quality at grid connection points	STELCO
	Technique for selecting sites for introducing grid-connected PV systems	MHTE, MEA, STELCO
	Detailed design technique for introducing grid-connected PV systems	STELCO
	Grid-connected PV system operation and maintenance techniques	STELCO

Source： Prepared by the Study Team

After completion of the Study, it will be necessary to carry out technical transfer of the items indicated in Table 5.6.3-2 taking the above contents into account. However, MHTE, MEA and STELCO will find difficulty to appoint the candidate instructor (trainer) for the technical transfer. Thus first of all "Trainers' Training" to develop the core of human resource development will be necessary. Concerning the method of Trainers' Training, Off-JT is effective, and it will be realistic to transfer technology through periodically inviting external lecturers from overseas ministries, power companies and PV system manufacturers and using actual equipment. Together with Off-JT, it will also be necessary to adopt incentives (internal promotions, awards, etc.) to encourage self-development among employees and provide necessary teaching materials, manuals and so on. Already the Study Team has prepared and explained the contents of "Design Manual for Grid-connected Photovoltaic System". Now Maldives side is expected to develop their own materials and manuals in reference to the above-mentioned materials, taking into consideration of engineering and technical capacity of their own organization.

Table 5.6.3-2 Contents of Technical Transfer Required in Future

Classification	Contents	Target
Basic knowledge of PV systems	Types and features of PV systems	MHTE, MEA, STELCO
	Roles and operating principles of PV system component instruments	MHTE, MEA, STELCO
	Characteristics of PV panels (solar radiation, temperature and I-V characteristics)	MHTE, MEA, STELCO
	Solar radiation data measurement and utilization methods	MHTE, MEA, STELCO
	Economy of PV systems	MHTE, MEA, STELCO
Design of grid-connected PV systems	System installation site survey techniques	MHTE, MEA, STELCO
	PV module selection and array examination methods	MHTE, MEA, STELCO
	Installed capacity calculation and specifications examination methods	MHTE, MEA, STELCO
	Stand design techniques	MHTE, MEA, STELCO
	Generated electric energy potential estimation techniques	MHTE, MEA, STELCO
	Design software (HOMER, RET screen, etc.) utilization methods	MHTE, MEA, STELCO
Grid-connected PV system operation and maintenance	System functions and operating methods	STELCO
	System routine inspections and periodic inspections	STELCO
	System maintenance	STELCO
	Troubleshooting	STELCO
PV power generation-related legal systems	Legal regulations for introducing PV power generation	MHTE, MEA
	Legal systems for disseminating PV power generation	MHTE, MEA
	Requirements for grid-connection guidelines	MHTE, MEA, STELCO
	PV power generation economy examination techniques	MHTE, MEA, STELCO
	Standard specifications of PV power generation equipment	MHTE, MEA, STELCO
DSM/Energy saving	DSM promotion measures	MHTE, MEA, STELCO
	Energy saving promotion measures	MHTE, MEA, STELCO
	SSM thinking	MHTE, MEA, STELCO

Source： Prepared by the Study Team

5.6.4 Collaboration with Faculty of Engineering Technology (FET)

It is highly possible to collaborate with Faculty of Engineering Technology (FET) in Maldives for human resource development on planning, designing and operation of grid-connected PV system. FET holds approx. 400 students (of which nearly 80 students are from Electrical and Electronics Engineering), and approx. 50 teachers including part-time staff. Also FET maintains necessary equipment and materials for experiment in addition to holding lectures.

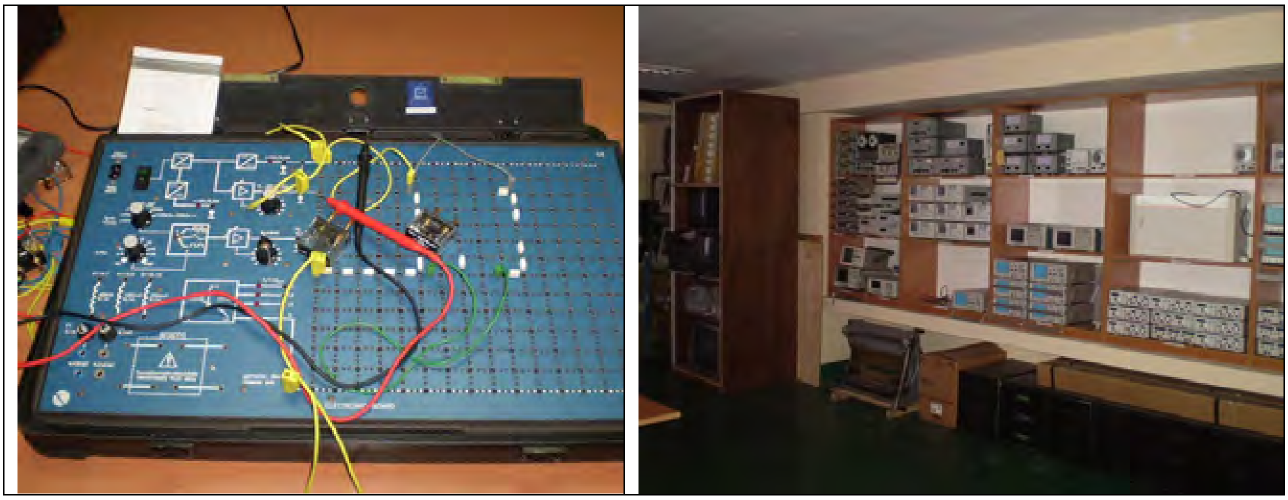


Figure 5.6.4- 1 Equipment for Practical Training at Faculty of Engineering Technology (FET)

Now FET is preparing to hold the new subject "Renewable Energy Systems and Maintenance" to teach how to plan, design and maintain renewable energy systems including PV system. It is one of the project components for Renewable Energy Technology Development and Application Project (RETDAP) under the assistance by UNDP. UNDP plans to hold the course in order to raise the public awareness utilizing the facilities and human resources in FET, since the application for Fund for RE System Application (FRESA) under RETDAP is not growing as expected.

Table 5.6.4-1 shows the outline topic for the course. It is composed of both lecture and practice, and students can obtain the certificate in one semester (15 weeks).

Table 5.6.4- 1 Outline Topic for the "Renewable Energy Systems and Maintenance" (Draft)

Topic	Hours
1. Electrical Energy Sources	
1.1 Scientific forms of Electrical Energy	3
1.1.1 What is Energy	
1.1.2 Forms of Energy	
1.1.3 Law of Conservation of Energy	
1.1.4 Energy Efficiency	
1.1.5 Sources of Energy	
1.2 Non-Renewable Energy Sources	3
1.2.1 Oil	
1.2.2 Natural Gas	

1.2.3 Coal 1.2.4 Uranium 1.3 Renewable Energy Sources 1.3.1 Solar 1.3.2 Wind 1.3.3 Geothermal 1.3.4 Biomass 1.3.5 Hydropower	 3
2. Design and Installation of Solar Power System 2.1 Basic Principles 2.1.1 Volts, Amps and Watts 2.1.2 Photovoltaic Effect 2.1.3 PV Modules 2.1.4 Energy Storage 2.1.5 Control and Conversation 2.1.6 Operation of Solar Stand Alone System 2.2 Suitability 2.2.1 Energy Requirement 2.2.2 Other Power Sources 2.2.3 Solar Resources 2.3 System Components 2.3.1 PV Modules 2.3.2 Batteries 2.3.3 Controllers 2.3.4 Inverters 2.4 Design Procedure 2.4.1 Design Process 2.4.2 Initial Estimates 2.4.3 Site Survey 2.4.4 System Sizing 2.4.5 Component Selection 2.4.6 Wiring 2.5 Installation and Commissioning 2.5.1 Safety 2.5.2 PV Array 2.5.3 Battery 2.5.4 Control Equipment 2.5.5 System Commissioning 2.6 Maintenance Field Visit (Trip to Faafu Magoodhoo and Noonu Randhoo)	 3 3 3 3 3
3. Wind Power System 3.1 Introduction of Wind Energy 3.1.1 History of Wind Energy 3.1.2 Current status and Future prospects 3.2 Wind Power Generators 3.2.1 Tower 3.2.2 Rotor 3.2.3 Gear Box 3.2.4 Power Regulation 3.2.5 Safety Brakes 3.2.6 Induction Generator 3.2.7 Synchronous Generator 3.2.8 Fixed and Variable Speed Operation 3.2.9 Grid-interconnection	 3 3
4. Inverters and Accessories 4.1 Charge Controllers and Batteries 4.2 Power Inverters 4.3 Hybrid and Interactive grid-interconnection Systems 4.4 Net-Metering	 3 3
5. Protection and Safety 5.1 Lightning and Surge Protection	 3

Source : Faculty of Engineering Technology (FET)

FET plans to accept various human resources for instructors even outside from FET for the above-mentioned course. Furthermore, it is advised that some of the topic shall be instructed by engineers from MHTE, MEA and STELCO to make the subject more practical. Also it is expected that students from FET could learn the basic knowledge of renewable energy before they start working at MHTE or STELCO. In the medium-term, more practical training course designed for engineers from MHTE, MEA and STELCO (approx. 2 weeks duration) will be required as the continuous focal point of Off-the-Job Training for the counterparts. Also, further collaboration with technical institutes in third countries (such as India or Sri Lanka) to develop the curricula for renewable energy will be considered as an option.

ATTACHMENTS

Attachment-1 Member list of the Study Team

Name	Assignment	Company
Mr. Tadayuki OGAWA	Team leader / PV Dissemination Policy / CDM / Environmental and Social Considerations	Yachiyo Engineering Co., Ltd.
Mr. Fumikazu DOI	Grid-connected PV System	Shikoku Electric Power Co., Ltd.
Mr. Yoshitetsu FUJISAWA	Institutional Framework for PV Grid-connection / DSM	Shikoku Electric Power Co., Ltd.
Mr. Teruo KURUMADA	Architectural Design / Cost Estimation	Yachiyo Engineering Co., Ltd.
Mr. Akihir SHIMOMURA	Financial and Economic Analysis	Yachiyo Engineering Co., Ltd.
Mr. Tomonori KONDO	Equipment Planning / Detail Design	Yachiyo Engineering Co., Ltd.
Mr.Nobuaki TACHIBANA	Coordinator 1	Yachiyo Engineering Co., Ltd.
Ms. Natsuki SEKI	Coordinator 2	Yachiyo Engineering Co., Ltd.
Mr. Makoto ABE	Coordinator 3 / Distribution Planning	Yachiyo Engineering Co., Ltd.

Attachment-2 List of Parties Concerned in the Recipient Country

President Office

Mr. Ahmed Nasheed	Utility Development Advisor
Mr. Ibrahim Haleem	Assistant Director
Mr. Ahmed Mausoom	Finance Secretary

Ministry of Finance and Treasury

Mr. Ali Hashim	Minister
Mr. Ahmed As-Ad	Minister of State
Mr. Ismail Shafeeq	Permanent Secretary
Mr. Hamdhy Ageel	Executive Director
Ms. Aminath Nashia	Director, External Resources Management Division
Ms. Fathimath Rasha	Assistant Programme Officer
Mr. Mohamed Ifah	Officer, External Resources Management Division
Mr. Ahmed Mush-hid Rasheed	Desk Officer, External Resources Management Division

Ministry of Foreign Affairs

Dr. Hussain Niyaaz	Executive Director
Ms. Farzana Zahir	Director
Mr. Mohamad Shujao	Desk Officer, Economic & Development Dept.

Ministry of Housing, Transportation and Environment

Mr. Mohamed Aslam	Minister
Dr. Mohamed Shareef	Deputy Minister
Mr. Akaram Kamaludeen	Deputy Minister
Mr. Ahmed Saleem	Permanent Secretary
Mr. Ahmed Rasheed	Executive Director, Acting Permanent Secretary
Mr. Amjad Abdulla	Director General
Mr. Ahmed Ali	Assistant Director
Mr. Amir Hassan	Assistant Director
Mr. Khalid Sulaiman	Project Manager
Mr. Shifaz Ali	Senior Engineer
Mr. Mohamed Fazeeh	Electrician
Mr. Ibrahim Naufal	Engineer
Mr. Mohamed Inaz Rasheed	Assistant Project Officer
Mr. Zammath Khaleel	Environment Analyst
Ms.Fathimath Raufa Moosa	Assistant Engineer

Department of National Planning

Mr. Mohamed Imad	Asst. Executive Director

Ministry of Education

Mr. Ahmed Shafeeu	Director General
Mr. Mohamed Yoosuf	Director

Ministry of Tourism, Arts & Culture

Mr. Ahmed Salih	Permanent Secretary

Ministry of Human Resources, Youth and Sports

Mr. Ali Zaki Ahmed	Deputy Director General

Ministry of Civil Aviation & Communication

Mr. Mahmood Razee	Minister
Mr. Aminath Solih	Director General

Maldives Energy Authority

Mr. Abdulla Wahid	Director General
Mr. Muawiyath Shareef	Director

Environmental Protection Agency

Mr. Mohamed Zahair	Director General

Maldives Energy Authority

Mr. Abdul Muhusin Ramiz	Director
Ms. Aishafu Shimana	

Male municipality

Mr. Adam Manik	Chairman
Mr. Ismail Zahir	Director General
Mr. Ahmed Haleem	Deputy Director
Mr. Ishaq Ahmed	Director
Mr. Adam Shakim	Deputy Director General

State Electric Company Limited

Mr. Mohamed Rasheed	Chief Executive Officer
Dr. Zaid Mohamed	Managing Director
Mr. Ali Azwar	Deputy Managing Director
Mr. Mohamed Latheef	Director
Mr. Ahmed Niyaz	Director
Mr. Ali Niyaz	Senior Supervisor
Mr. Ahmed Shafeeu	Senior Engineer
Mr. Amjad Mohamed	Administration Supervision
Mr. Aboobakuru Mohamed	Deputy Director
Mr. Azzam Ibrahim	Senior Engineer
Mr. Ibrahim Athif	Senior Engineer
Mr. Ibrahim Nizam	Electrical Engineer
Mr. Mohamed Shahid	Asst. Engineer
Mr. Ibrahim Nashid	Assistant Engineer
Mr. Ahmed Marsoom	Assistant Engineer
Ms. Emas Ahmed	Finance & Accounting Dept.

Huluhumale Development Corporation

Mr. Mahjoob Shujau	Managing Director
Mr. Ahmed Azleem Ibrahim	Planning Engineer

Faculty of Education Maldives College of Higher Education

Mr. Fathimath Mohamed	Director

Thaajidheen School

Mr. Thoha Saleem	Principal
Mr. Mohamed Shereef	Cash

Maldives Center for Social Education

Ms. Fathimath Ismail	Director
Mr. Ali Saleem	Deputy Principal

Kalaafaanu School

Mr. Naazleem Wafir	Assistant Principal

Hiriya School(New Secondary School for Girls)

Mr. Ali Nazim	Principal

Dhiraagu

Mr. Moosa Ahmed Manik	Manager Power & Infrastructure
Mr. Mohamed Shafiu	Engineering Power Generation

Male' Water & Sewerage Company Pvt. Ltd.

Mr. Ahmed Mujthaba	Manager

CDE Pvt. Ltd

Dr. Simad Saeed	Managing Director

Gedor Architecture Pvt. Ltd

Mr. Thoriq Ibrahim	Director

MITTS Enterprises Pvt. Ltd

Mr. Ali Shareef	Manager

Indira Gandhi Memorial Hospital (IGMS)

Mr. Mohamed Saeed	Deputy Director

Embassy of Japan, Sri Lanka

Mr. Katsuho Hayashi	Second Secretary Economic Cooperation

JICA/JOCV Maldives Office

Mr. Makoto Nonobe	Resident Representative
Ms. Satoko Iwashige	Coordinator

JICA Sri Lanka Office

Mr. Akira Shimura	Chief Representative
Ms. Yasuko Nishino	Senior Representative
Ms. Kotohi Inoue	Assistant Resident Representative
Dr. Keiji Mitsuhashi	Representative
Mr. Cabral Indika	Project Specialist

Attachment-3 Study Implementation Work Flow

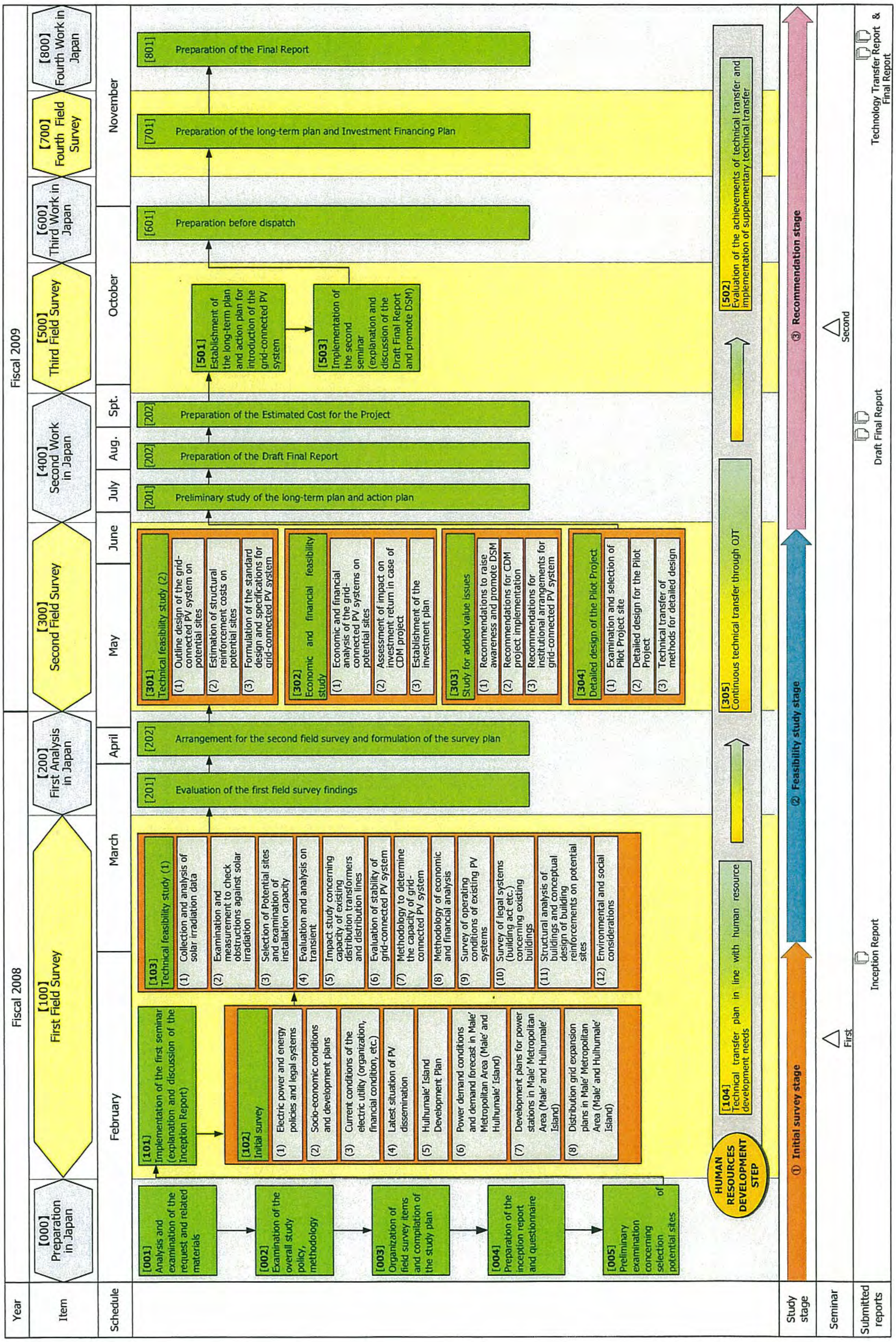


Figure 2-1 Study Implementation Work Flow