Republic of Maldives

FY2015 Ex-Post Evaluation of Japanese Grant Aid Project

"The Project for Clean Energy Promotion in Male"

External Evaluator: Makiko Soma, Global Link Management Inc.

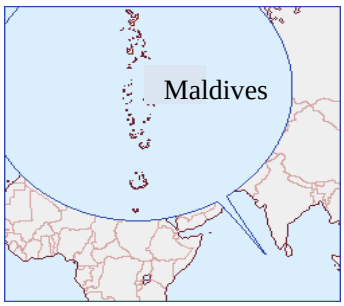
0. Summary

The objective of this project was to improve the power generating capacity, diversify energy supply sources, and build awareness among the citizens on renewable energy through installation of solar Photovoltaic (PV) equipment at five sites in Malé and Hulumalé and training of technicians, thereby contributing to promote joint efforts of Japan and Republic of Maldives (Maldives) to address climate change.

The project has been relevant to development policies and development needs of Maldives both at times of the project planning and the ex-post evaluation. The project was also highly consistent with Japanese ODA policy toward Maldives at the project planning stage. Therefore, its relevance is high. Although the project cost was within the planned budget, the project period exceeded its original plan because of two additional procurements of solar PV equipment. Therefore, efficiency of the project is fair. Quantitative indicators of the project's objective including electric power generation, diesel displacement, and reduction of carbon dioxide (CO_2) surpassed their targets at the time of the ex-post evaluation. In addition, at the project sites where the solar PV systems were installed, building users showed their increased awareness on solar and renewable energy. Ministry of Environment and Energy (MEE) and State Electric Company (STELCO) successfully installed their domestic solar PV systems using the knowledge and experiences from the project. The data and knowledge of the project were also utilized in the implementation of subsequent solar PV projects by other donors in Maldives. Thus, the project produced most of the expected effects. Therefore, the effectiveness and impact of the project are high. No major problems have been observed in the institutional, technical and financial aspects of operation and maintenance of the PV systems. Therefore, sustainability of the project effects is high.

In light of the above, this project is evaluated to be highly satisfactory.

1. Project Description



Project Location
(Source: Ministry of Foreign Affairs, Japan)

Solar PV Panels on the President Office

1.1 Background

In Maldives, electricity is supplied by two state-run utility companies. One is STELCO that serves 27 islands including Malé, the capital island of Maldives. Another is FENAKA (initials from *Fen Narudhamaa Karant*, meaning water, sewage and electricity in *Dhivehi*[1]) that covers 149 outer atolls. Electricity demand in Malé was already high as the island was densely populated at the time the project planning. Rapid population growth was also expected in Hulumalé, an artificial island constructed as a commuter town about 15-minute ferry ride northeast of Malé. Further boost of electricity demand was expected there. On the other hand, remote atolls where electrification was promoted rapidly suffered from high cost of electricity generation because unit cost of generation increased as a scale and capacity of generation became smaller. In Maldives, almost all the energy sources were imported, thus electrification of the country meant increased expenditure on fuel import and more pressure on the national budget.

Many islands and atolls of Maldives rise little more than one meter above mean sea level, which makes the country extremely vulnerable to sea-level rise caused by climate change. The government of Maldives stressed the importance of reducing emission of greenhouse gases and was actively involved in international efforts by ratifying UN Framework Convention on Climate Change and Kyoto Protocol and becoming a member of Cool Earth Partnership[2] which was established by the government of Japan.

In response to the above situation, the government of Maldives made a request to the government of Japan to conduct The Feasibility Study for Application of Photovoltaic Power on Malé and Hulumalé Islands (January to November, 2009). This study was conducted as a Technical Cooperation Project on Development Planning for introduction of solar PV system in Malé and Hulumalé with an aim to stabilize power supply and promote the use of renewable energy in the mid to long term. Based on the feasibility study, five sites were identified in Malé as potential project sites for the project. The feasibility study also identified the needs of technical transfer of operation and maintenance skills to STELCO staff because they had few technicians with sufficient experiences in operating and maintaining PV system.

1.2 Project Outline

The objective of this project was to improve the power generating capacity, diversify energy supply sources, and build awareness among the citizens on renewable energy through

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1 Official Language of Maldives

2 Cool Earth Partnership is a financial mechanism to assist developing countries that are working to contribute to climate stability. It was presented by then Japanese prime minister Fukuda at Davos Forum in January 2008. It is part of the Cool Earth Promotion Programme that was proposed to implement Cool Earth 50 (Japan's initiative on climate change to cut the global emission by half by 2050.)

installation of solar PV equipment at five sites in Malé and Hulumalé and training of technicians, thereby contributing to promote joint efforts of Japan and Maldives to address climate change.

<Grant Aid Project>

E/N Grant Limit or G/A Grant Amount / Actual Grant Amount	1,000 million yen / 1,000 million yen
Exchange of Notes Date (/Grant Agreement Date)	March, 2010 / March, 2010
Implementing Agency	Ministry of Environment and Energy (MEE) (Ministry of Housing, Transportation and Environment until May 2012) / State Electric Company Limited (STELCO)
Project Completion Date	March, 2014
Main Contractor(s)	Toyota Tsusho Corporation (Japan)
Main Consultant(s)	Yachiyo Engineering Co., Ltd. (Japan) / Shikoku Electric Power Co., Inc. (Japan)
Procurement Agent	Japan International Cooperation System (JICS)
Outline Design	<JICA Feasibility Study> Application of Photovoltaic Power on Malé and Hulumaléé Islands in the Republic of Maldives (January to November, 2009)
Related Projects	<Projects by Other Donors> Solar PV projects are carried out by United Nations Industrial Development Organization (UNIDO), United Nations Development Programme (UNDP) & Global Environmental Facility (GEF), German Agency for International Cooperation (GIZ), World Bank, Asian Development Bank (ADB) etc. See main text for the details.

2. Outline of the Evaluation Study

2.1 External Evaluator

Makiko Soma, Global Link Management Inc.

2.2 Duration of Evaluation Study

Duration of the Study: October, 2015 - August, 2016

Duration of the Field Study: December 7-17, 2015, March 4-8, 2016

2.3 Constraints during the Evaluation Study

There was remaining fund from the first bidding of the project because the price of solar

battery panels[3] dropped sharply after the feasibility study. In order to consume the entire amount, the project fund was stretched to conduct two additional biddings[4]. Thus, the project period was extended significantly. The solar battery panels procured in the third bidding was installed in 2014, only one and a half years after the project completion at the ex-post evaluation. It should be noted that it might be too early to evaluate the sustainability of the installed solar PV systems considering most ex-post evaluations are conducted three years after project completion.

3. Results of the Evaluation (Overall Rating: A[5])

3.1 Relevance (Rating: ③[6])

3.1.1 Relevance to the Development Plan of Maldives

Securing reliable energy supplies and promotion the utilization of renewable energy were prioritized in The Seventh National Development Plan (2006-2010) at the time of the project planning. The above development plan was not renewed at the time of the ex-post evaluation. The priorities remained the same in the Progressive Party's manifest (entered into force on November, 2013) where the President of Maldives serves as the party leader.

The policy of Maldives' energy sector, National Energy Policy and Strategy (2010) has been effective since the project planning until the ex-post evaluation. This strategy aimed at stabilizing energy supply and promoting the use of renewable energy. The government of Maldives formulated the Scaling-up Renewable Energy in Low Income Countries Investment Program (SREP-IP) (2013-2017) along the above sectoral strategy. SREP-IP intends to leverage the financing of the World Bank, ADB, and Islamic Development Bank (IDB) to generate a total of 30 megawatts (MW) of renewable energy by the end of 2017. The main objectives of SREP-IP include the following: 1) creating an enabling environment for the growth of a reliable and sustainable energy sector, 2) providing electricity to every inhabited island at a reasonable rate, 3) reducing over-reliance of the energy sector and the national economy on fossil fuels through the diversification of energy supplies, 4) improving energy efficiency and conserving energy, 5) encouraging the adoption of low-carbon technologies, 6) promotion of renewable energy, and 7) engaging private sector in the development of energy sector. Under SREP-IP, two major programs are planned and implemented. One is the Accelerating Sustainable Private

[3] Packaged cells of panel designed to absorb the sun's rays as a source of energy to get voltage and current for generating electricity. They are also called solar battery module, solar panel, or solar module etc.

[4] This project belongs to the Japan's Programme Gant Aid for Environment and Climate Change. The projects under this programme are required to use procurement agent services. In the services, unbiased non-profit organizations who have professional knowledge and skills in international procurement serve as procurement agents to provide services including management and supervision on overall processes of selection and procurement of goods and services as well as fund management. The procurement agent should have high expertise to carry out procurement in a fair and transparent manner to ensure the efficient and smooth implementation the projects. (Source: website of Japan International Cooperation System, accessed on April 11, 2016. http://www.jics.or.jp/soshiki/about.html)

[5] A: Highly satisfactory, B: Satisfactory, C: Partially satisfactory, D: Unsatisfactory

[6] ③: High, ② Fair, ① Low

Investment in Renewable Energy (ASPIRE) that encourages private investment for the integration of solar and waste power generation. Another program is the Preparing Outer Islands for Sustainable Energy Development (POISED) that aims to promote the use of renewable energy on outer atolls using funds of the government of Maldives and foreign donors.

In short, renewable energy promotion has been a key priority of the government of Maldives and energy sector policy of the Maldives both at times of planning and ex-post evaluation. Thus, the project has been consistent with the development policy and energy sector policy of the Maldives.

3.1.2 Relevance to the Development Needs of Maldives

The demand for electricity was increasing as the population was rapidly growing on Malé island at the time of the project planning. The demand became especially prominent after the tsunami disaster in December 2004 because many victims emigrated to Malé from their home islands. However, shortage of lands prevented further expansion of electric power facilities in Malé. Almost all the country's electricity generation depended on imported diesel fuel in Maldives and the steep rise in fuel prices around 2004 worsened financial situation of STELCO. This became a serious issue of national energy security. In addition, Maldives has been one of the most vulnerable countries to sea level rise induced by climate change. Thus, it was necessary to lessen dependence on diesel fuel to reduce emissions of greenhouse gases.

At the time of the ex-post evaluation, population concentration to Malé island is continuing and electricity demand is steadily increasing. Energy security remains to be an important issue in Maldives. Also, Maldives continues its effort to reduce greenhouse gas emissions by lessening dependence on fossil fuel because it is still important to address climate change. Therefore, both at times of the project planning and the ex-post evaluation, there have been great needs for energy security and promoting renewable energy use to reduce greenhouse gases in Maldives.

3.1.3 Relevance to Japan’s ODA Policy

In June, 2008, Maldives expressed its support for Japanese government’s initiative, the Cool Earth Promotion Programme and established the Cool Earth Partnership with Japan. The program was proposed to promote the long-term plan, Cool Earth 50 to prevent global warming. In response to this, Japan’s Country Assistance Policy for Maldives（June, 2009）listed supports in the field of climate change as a top priority. This justifies the Project’s consistency with Japan's aid policy.

This project has been highly relevant to the country’s development plan and development needs, as well as Japan’s ODA policy. Therefore, its relevance is high.

3.2 Efficiency (Rating: ②)

3.2.1 Project Outputs

The project's original plan was to install solar PV equipment with total capacity of 395 kWp at five sites in Malé. However, as mentioned above, due to the price plunge of solar panels in the market, the project fund was not fully consumed at the initial bidding. This resulted in two additional biddings and procurements of PV equipment. As a result, process of bidding and procurement for installation was repeated three times. The total capacity of the procured solar PV equipment reached 740 kWp, approximately 1.9 times the initial target and was installed at 12 sites including Hulumalé. The site-specific output capacity of the three phases (the first, second and third biddings and procurements will be referred to as Phase 1, Phase 2, and Phase 3, respectively) of installation is shown in Table 1.

Table 1 Output Capacity of Electricity Generation at 12 Sites

	Sites (11 sites in Malé, 1 site in Hulumalé)	Output Capacity (kWp)	Total Output Capacity (kWp)
Phase 1	1) STELCO Building	45	395
	2) Maldives Center for Social Education (Social Center)	100	
	3) Thaajuddeen School	130	
	4) New Secondary School (Hiriya school)	100	
	5) The President Office	20	
Phase 2	6) Velaanaage Building	40	280
	7) Giyaasudheen School	80	
	8) Kalaafaanu School	85	
	9) Central Administrative Building (University)	40	
	10) Faculty of Health Science-FHS (University)	35	
Phase 3	11) Ministry of Finance and Treasury	20	65
	12) Hulumalé Hospital	45	
		Total	**740**

Sources: JICA documents, response to questionnaire from STELCO

As a soft component of the Project, trainings were conducted on fundamental knowledge, operation and maintenance and emergency response procedures of solar PV systems during the first and second phases. Input for the trainings was 11.5 man-months, which was same as the plan.

MEE and STELCO were expected to provide necessary support for procurement and smooth implementation of the project. Although detailed responsibilities were not mentioned in the project plan, MEE and STELCO carried out the following.

<MEE>

- Processed exemption of customs duty for procured materials
- Assigned one project manager and two coordinators for the project
- Provided an office space
- Paid consumption tax charged during the project amounting to 119,234.91 MRV[7]

<STELCO>

Monitored power network during PV systems installation in Phase 1.

3.2.2 Project Inputs

3.2.2.1 Project Cost

The project cost was same as the budget. The procurement agent services were employed, thus all of the project fund was granted to the government of Maldives and no reversal was made at the project completion. Total project cost of the Japanese side was 1,000 million yen, same as the Grant Limit, therefore the consumption rate was exactly 100%. The evaluation was made only on Japanese side budget because the budget and expenditure of the Maldivian side for the project were unknown.

3.2.2.2 Project Period

The project period was significantly longer than planned. The planned period was 19 months from April 2010 to October 2011. Instead, the project was 49 month-long from March 25, 2010 to April 30, 2014, which was 254% of the planned period. The delay, as mentioned earlier, was due to additional biddings and procurements in order to consume the entire project fund.

The first installation period ended on February 8, 2012. It was 22.4 month-long and 118% of the planned period. According to the procurement agent and the documents provided by JICA, delivery of the equipment from Japan was delayed about three months due to the Great East Japan Earthquake that occurred on March 11, 2011. This extension can be considered unavoidable and still minimal considering the significance of the earthquake disaster.

While the duration of the entire project was 2.5 times longer than the plan, the produced output was almost twice the original plan. Also, the number of sites has increased from 5 to 12, 2.4 times the initial plan. The phase 1 was extended by 18%, which is considered unavoidable and minimal. The project would have certainly exceeded the planned period even without the influences of the earthquake. Nonetheless, the above circumstances can justify that the extension of the project was mostly proportionate to the outputs increase. Interviews with STELCO confirmed that the extension was officially agreed by both Japanese and Maldivian sides.

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[7] Maldivian Rufiyaa, currency of Maldives. 1 MVR≒7.37 Japanese yen (at OANDA rate in April, 2016).

Although the project cost was within the plan, the project period exceeded the plan. Therefore, efficiency of the project is fair.

3.3 Effectiveness[8] (Rating:③)

3.3.1 Quantitative Effects (Operation and Effect Indicators)

For quantitative indicators 1) to 3), the evaluation was made on the inter-annual changes from the year of installation until the ex-post evaluation for each of the three phases. As indicated in Tables 2 to 4, Phase 1 to 3 largely achieved the expected targets. Phase 2 showed a little downturn between 2013 and 2015 and slightly missed the target in 2015 because the solar cell panels on the roof-top of Administrative Building of the National University were covered by plastic sheets during the construction of the adjacent building from late 2013 to early 2015. The construction was completed and power generation has recovered at the time of the ex-post evaluation, therefore, the annual target is likely to be achieved in 2016.

Table 2 Electricity supplied, Diesel saved, CO_2 Reduced of Phase 1

	Baseline	Target	Actual	Actual	Actual
	2010	2014	2013	2014	2015
	Base Year	3 years after completion	1 year after completion	2 years after completion (Note 1)	3 years after completion
1)Electricity supplied (kWh/day)	0	1202.4	1601.30 (133%) (Note: 2)	1606.41 (134%)	1618.91 (135%)
2)Diesel saved (ℓ/day)	0	312.62	416.40 (133%)	417.67 (134%)	420.92 (135%)
3)CO_2 Reduced (kg/day)	0	819	1090.90 (133%)	1094.30 (134%)	1102.80 (135%)

Sources: : JICA documents and data provided by STELCO

Note 1: Target year (2014) was set as three years after completion, but due to 3-month delay, 2014 was two years after completion.

Note 2: The percentage shows ratios against the target.

Table 3 Electricity supplied, Diesel saved, CO_2 Reduced of Phase 2

	Baseline	Target	Actual	Actual	Actual
	2011	2014	2013	2014	2015
	Base Year	1 years after completion	Year of completion	1 year after completion	2 years after completion
1)Electricity supplied (kWh/day)	0	930.1	1088.20 (117%)	974.63 (105%)	895.41 (96%)
2)Diesel saved (ℓ/day)	0	241.8	282.93 (117%)	253.40 (105%)	232.81 (96%)
3)CO_2 Reduced (kg/day)	0	633.5	741.30 (117%)	663.92 (105%)	609.95 (96%)

Sources: JICA documents and data provided by STELCO

[8] Sub-rating for Effectiveness is to be put with consideration of Impact.

Table 4 Electricity supplied, Diesel saved, CO_2 Reduced of Phase 3

	Baseline	Target	Actual	Actual
	2013	2015	2014	2015
	Base Year	1 year after completion	Year of completion	1 year after completion
1)Electricity supplied（kWh/day）	0	215.4	250.37 (116%)	280.54 (130%)
2)Diesel saved（ℓ/day）	0	59.0	68.47 (116%)	76.80 (130%)
3)CO_2 Reduced（kg/day）	0	154.5	179.39 (116%)	201.22 (130%)

Sources: JICA documents and data provided by STELCO

For the quantitative effect 4) Diversification of Energy, breakdown of the energy supply sources was set as an indicator. As shown in Table 5[9], dependence on diesel fuel was reduced while the proportion of jet fuel[10] increased. This still indicates a very high dependence on imported fuel overall. Supply of solar PV energy was 0.07% of the total energy supply in 2010, and increased by ten-fold to 0.7% in 2013 and twenty-fold to 1.4% in 2014. The project installed solar PV systems with capacity of 740 kWp. This accounts for almost 20% of the total solar PV electricity generation in the entire Maldives (4 MWp) at the time of the ex-post evaluation (December, 2015), showing a certain contribution of the project to the increased proportion of solar-derived energy.

Table 5 Proportion of Energy Supply Sources

Unit: %

	2010（Actual）	2011（Actual）	2012（Actual）	2013（Actual）	2014（Actual）
Diesel	81.2	83.4	82.9	62.1	57.6
Gasoline	9.1	8.8	9.5	8.6	6.6
LPG	3.3	3.3	2.9	2.5	2.0
Solar PV	**0.07**	**0.07**	**0.06**	**0.7**	**1.4**
Kerosene	0.06	0.09	0.07	No data	No data
Jet fuel	5.7	4.3	5.5	26.7	33.4

Sources: Data provided by MEE

Note: No baseline or target set for this indicator. The sum of the ratio would not be 100% as each figure is rounded to one decimal place.

9 Table 5 includes jet fuel and other energies that are not intended for electricity generation. Thus it should be noted that the dependency on diesel and the ratio of renewable energy supply in the table do not exactly explain the trends of the energy used for electricity generation.

10 Fuel used for jet engine of the aircrafts. It is obtained by refining the natural crude oil.

3.3.2 Qualitative Effects

For the soft component of the Project, expected outputs 1) to 5) identified in the Soft Component Plan were largely achieved by the end of the project and the effects are still observed at the time of the ex-post evaluation as shown in Table 6. (See 3.5 Sustainability for details.) Under the Output 4), the Renewable Energy Development Fund (RED fund) was established as planned and the rough outline of the fund usage, i.e., businesses and projects development as well as research and development on renewable energy, was identified. However, specific activity plan or financial plan was not yet prepared. In order to materialize the contents of the above memorandum, MEE should prepare an activity plan and budget to come up with a financial plan. The Output 5) Facilitation of Smooth Communication between MEE and STELCO seems to be largely achieved. It is difficult to objectively evaluate the smoothness of communication, but the two agencies have obviously gained more opportunities for close communication by working together during the project implementation. Also, STELCO regularly reports the operation and maintenance status of the solar PV systems to MEE based on the Operation and Management (O&M) Agreement signed between the two agencies during the project. Such monthly exchange should have increased their communication opportunities.

Table 6 Achievements of Soft Components

Expected Output (2010)	Achievements at Ex-Post Evaluation (2015)
1) Manual of the PV system is drafted	Maintenance manual of the installed PV systems has been utilized.
2) Basic structure of PV system is understood by the trainees and O&M of the PV system is carried out in a sustainable manner	Patrol inspections are carried out along the manual at time of the ex-post evaluation.
3) O&M records are well kept and reported, and the necessary expenditures are made in line with the budget identified in the O&M Agreement	In all 12 sites, records on power generation and problems in operations are reported monthly from STELCO to MEE. Monthly maintenance costs are spent as budgeted in the O&M Agreement.
4) Renewable energy fund (RED fund) is established and the income generated by the Project's PV systems is pooled in the fund	The RED fund was established and funds are transferred to MEE from STELCO regularly (every month).
5) Communication and information sharing between the owner of the equipment (MEE) and manager (STELCO) become smooth through increased communication opportunities	MEE and STELCO are communicating better than the time before the project through implementation of the project, monitoring report based on the O&M Agreement, and managing the RED fund.

Sources: Interview with STELCO and MEE

3.4 Impacts

3.4.1 Intended Impacts

Two qualitative effects of the project were expected at the time of planning. One is raising awareness of the public on renewable energy promotion of utilization and the other is presenting Japan's initiative in addressing climate change. They are considered and evaluated as *impacts* rather than *effectiveness* of the project in this report for two reasons. First, it would take some time until these effects can be felt after achieving the project objective. Second, they are considered as *impacts* based on their causal relationship with the output of the project.

(1) Raising Awareness of the Public on Promotion of Utilization of Renewable Energy

The solar PV systems were installed on the rooftops of public buildings. The 12 sites were strategically selected to attract attention of the public. The sites include the busiest places in Malé such as the President's Office and Velaanaage building, the highest building in Maldives, and public schools. At every site, a display board was installed near the ground floor entrance to show the amounts of the power generated, diesel fuel saved, and CO_2 reduced by the solar PV systems mounted on the rooftop. At STELCO head office, a display board was installed next to a bill payment window, catching attention of the visitors and customers waiting to pay the bill. According to STELCO staff, right after the installation, many people showed interests and asked questions about the information shown on the display board. Such strategic site selection and installation of easy-to-understand display have certainly aroused people's interests on solar PV and possibly on renewable energy.

Interviews with the building users were conducted on their awareness on renewable energy use. At each site, at least one person was interviewed except the site at STELCO (11 people from 11 sites in total). The interviews found that all 11 people knew the presence of the installed solar PV systems. They also understood that promoting renewable energy use through solar PV energy generation was an action against climate change. Ten out of the 11 respondents said they never saw a solar panel before the project. The interviews were conducted to only 11 people, thus the result cannot be statistically significant to represent the entire nationals. However, this project has at least helped to sensitized the interviewees and possibly other building users on renewable energy to some extent by making them familiarized with solar PV.

As mentioned above, strategic site selection for effective promotion and installation of easy-to understand display boards showing the status of power generation enabled the project to contribute to making the Maldivian citizens more aware of renewable energy to a certain extent. Meanwhile, the project planned or conducted no activities on awareness raising although it was intended as a qualitative effect of the project. MEE stated that they carried out some public relation activities for the project originally. However, they did not have the records and reports

that showed the results or details of such activities. Workshops and seminars should have been held at each site within the framework of the project to enhance understanding of the public on how PV panels generate electricity and contribute to reduction of fossil fuel consumption.

(2) Presentation of Japan's Initiative in Addressing Climate Change

No indicators were set for this effect at the planning stage. Therefore, its evaluation was conducted by setting the following three indicators: a) Installation of solar PV systems by the government of Maldives after the project, b) Utilization of Japanese PV technology in the PV systems mentioned above, and c) Advantages of this project in comparison to renewable energy projects by other donors.

a) Installation of solar PV systems by the government of Maldives after the project

MEE installed a 25kWp solar PV system in 2014 on its building after the project. MEE carried out all steps from planning, procurement, and designing using its own budget. Installation work was outsourced to a domestic company of Maldives. Though it was a small scale system, MEE reported it was the first PV system fully funded and established solely by Maldivians. MEE staff also acknowledged that the knowledge and experience gained from the project were very useful for installation of the PV system. STELCO also installed their PV systems in three atolls in 2015. The total power generation capacity of the three sites is 120 kWp for grid-tied PV system[11] and 240 kWp for stand-alone PV system with batteries[12]. STELCO staff also revealed in the interview that they utilized the technical knowledge learned from the project for establishing the above PV systems. These examples of MEE and STELCO indicate that this project contributed to installation of country-led PV systems.

b) Utilization of Japanese PV Technology

The solar panels and inverters of the above PV systems installed by MEE and STELCO were made in China and Germany respectively. Therefore, the project did not contribute to dissemination of Japanese technology and products. In Maldives, the solar panels from Germany or China are widely spread because of their cost competitiveness. Although both MEE and STELCO acknowledged that the quality of Japanese solar PV equipment is better than those of other countries, higher price seemed to be the reason why Japan-made equipment was not chosen.

c) Advantages of the project in comparison to renewable energy projects by other donors

Strengths of the project compared with similar projects are: 1) large power generation capacity, 2) intensiveness of the technical trainings on operation and maintenance, 3) high quality of solar panels with highly presentable installation work, and 4) effective showcasing of the PV systems

[11] An electricity generating solar PV system that is connected to the utility grid. The PV systems deployed in the project are all this grid-tied system.

[12] A system where the generated electricity is charged in the batteries. The project did not use this system.

by strategic site selection. Many projects and programs for promotion of renewable energy were conducted by various donors as shown in Table 7. Generation capacity of this project (740 kWp) has been the largest as of December 2015, at the time of the ex-post evaluation. Also, in-depth trainings were conducted to cover the topics from basic skills of solar PV system to actual maintenance in this project. According to STELCO technicians, these trainings were more intense than any other PV related trainings they had ever received and they recognized the trainings as a very important experience. In addition, the solar PV systems were installed in the most visible locations in Malé and Hulumalé for awareness raising of the Maldivian people and effective exhibition while most of other foreign donors' projects took place on remote atolls.

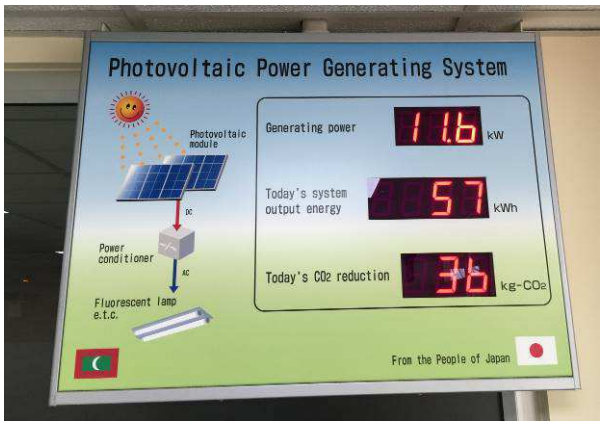
Table 7 Major Renewable Energy Projects by Other Donors in Maldives

Donor	UNIDO	UNDP／GEF	GSEP[13]/ Government of Japan (GoJ)	GIZ	World Bank
Project Name	Renewable Energy Based Economic Development	Renewable Energy Technology Development and Application Project	Dhiffusi Solar-Ice Project/ The Project for Provision of a Solar Power Generation System to Dhiffushi	Support for Climate Neutrality Strategy of the Maldives	Clean Energy for Climate Mitigation Project
Project Site	Raa Atoll Faninu and Baa Atoll Goidhoo	Alif Dhaalu Atoll Mandhoo	Kaafu Atoll Diffushi	Raa Atoll Ungoofaru, Dhaalu Atoll Kuduhuvadhoo	Thinadhoo
Project Cost	0.27 Million USD	Not known	Grassroots Grant Aid: 361,254USD)	3 Million Euro	2.6 Million USD
Project Period	Not known	2005 - 2008	2014 - 2015	2011 - 2015	2012 - 2014
Generation Capacity	5kW(solar), 3.5kW（wind）	12.8kW(solar)	40kW(solar)	328kW(solar)	558kW(solar)
Purpose/ Characteristics	Promotion of renewable energy etc.	Promotion of renewable energy and sea water desalination.	Promotion of renewable energy and provision of ice-maker for fishery	Capacity development on devising comprehensive strategies for renewable energy promotion.	Promotion of renewable energy and capacity development of public sector

Sources: Prepared by the author based on the data and information provided by MEE and STELCO

[13] Global Sustainable Electricity Partnership.

As mentioned in (1), MEE and STELCO are using the solar PV systems installed by the project to advertise their solar PV promotion to Maldivians and to visitors from overseas. High-quality Japanese solar PV systems are attracting people's attention at visible places in Malé and Hulumalé. Also, the photos and data of the project's PV system were used for the handouts and presentation materials of MEE and STELCO. These publicity opportunities contributed to showing Japanese initiative on promotion of solar PV power generation as part of the measures against climate change.



Display Board Showing Power Generation etc.
(Entrance of Ministry of Finance)

MEE's Self-Financed Solar Panels
(Building of MEE)

3.4.1 Other Impacts

(1) Impacts on the Natural Environment

MEE confirmed that there were no negative impacts on natural environment by the project.

(2) Land Acquisition and Resettlement

Installation of the equipment was done inside the existing public facilities. Therefore, MEE confirmed that there was no resettlement or land acquisition by the project.

(3) Unintended Positive/Negative Impact

As mentioned in the section of relevance, the government of Maldives was implementing two programs called ASPIRE and POISED with assistance of ADB and the World Bank respectively under the umbrella of the SREP-IP (2012-2017) as shown in Table 8. In these programs, some of the site-specific power generation data from the project was used as a benchmark. This also shows the project's certain contribution to Maldives' promotion of PV energy.

Table 8 Program of Renewable Energy led by Government of Maldives

Program	Project Amount	Donor	Solar PV Generation Target	Outline
Accelerating Sustainable Private Investments in Renewable Energy (ASPIRE)	About 69.5 million USD	World Bank etc.	20 MW until 2019 in and around Malé	Promotion of private sector investment for renewable energy in and around Malé
Preparing Outer Islands for Sustainable Energy Development Program (POISED)	About 62 million USD	ADB, European Investment Bank, IDB etc.	21 MW in all inhabited isolated atolls by 2019	Promotion of government investment and donor supported renewable energy introduction to isolated atolls

Sources: Interview with implementing agencies, JICA documents

This project has largely achieved its objectives. Therefore, effectiveness and impact of the project are high.

3.5 Sustainability (Rating: ③)

3.5.1 Institutional Aspects of Operation and Maintenance

The name of MEE was formerly Ministry of Housing, Transportation and Environment (MHTE). In May 2012 MHTE was restructured to be MEE. The same minister took over the positon and no change was made on organizational structure and decision making processes within the organization. In STELCO, a division called Distribution Unit is in charge of monitoring and maintenance of the solar PV systems. In the unit, 15 staff (all male) underwent the trainings conducted by the project. Fourteen out of the 15 staff were technicians or engineers. At the time of the ex-post evaluation, one of the 15 technicians has resigned but the tasks were taken over by the successor.

As shown in Figure 1, the ex-post evaluation finds that STELCO staff are conducting the maintenance work along the O&M Agreement signed under output 5) of the soft component. MEE, as an owner of the PV equipment, watches over the maintenance works by STELCO through monthly reports. Generated electricity of the PV systems is also managed in the RED fund in line with the O&M Agreement. The details of the management of the RED fund will be described in 3.5.3.

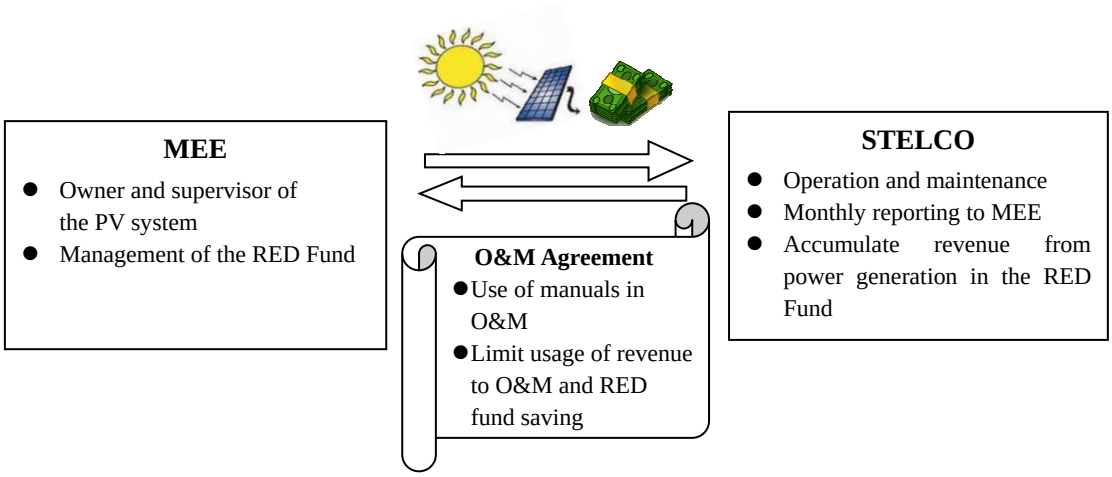


Figure 1 Operation and Maintenance Structure of the PV System

Source: Prepared by the author

It should be noted that Maldives Energy Authority (MEA) was at the final stage of revising policies on net-metering[14] and legal system development related to renewable energy in March, 2016 at the time of the ex-post evaluation. Therefore, O&M Agreement has been in the process of being updated in order to reflect the new policies on power purchasing price.

As seen above, the project should not have problems in the institutional aspects of operation and maintenance.

3.5.2 Technical Aspects of Operation and Maintenance

STELCO is in charge of operation and maintenance of the PV systems installed by the project. The status of technical aspects of operation and maintenance at STELCO's is as follows. Technical level of the 15 technicians at STELCO's Distribution Unit is considered sufficient at the time of the ex-post evaluation. This is because they acquired enough knowledge and skills to conduct the operation and maintenance of the current PV system through the trainings conducted by the project. STELCO is conducting periodic inspection every six months. During the inspection, young staff are trained through On the Job Training (OJT) on maintenance work. Although no additional trainings on operation and maintenance were conducted by external agencies etc. after the project, STELCO has not encountered problems in maintaining the current PV system with the skills and techniques acquired through the project. STELCO technicians are following the manuals developed by the project to do the maintenance work because the O&M Agreement mandates the use of these manuals in their maintenance work.

The technical level of STELCO staff is sufficient, technical guidance within the organization are adequately conducted, and the manuals are developed and utilized for O&M work. Therefore, no particular problems are found in the technical aspect of operation and maintenance.

[14] A grant mechanism that credits solar PV **system** owners for the electricity they add to the grid by setting power purchasing prices by law. It is usually intended for promotion of renewable energy.

3.5.3 Financial Aspects of Operation and Maintenance

The RED fund was established by MEE in order to accumulate the revenue from solar PV power generation. Memorandum of Agreement and Articles of Incorporation were also formulated for the management of the fund.

Records of MEE and STELCO reveal that the revenue from PV power generation has been enough to cover the maintenance cost the records also show that the maintenance cost is disbursed as identified in the O&M Agreement. Therefore, there is a sufficient financial source for operating and maintaining the solar PV systems deployed in the project. After subtracting the maintenance cost from the revenue, STELCO sends the remaining balance to the RED fund every month.

Table 9 Balance of RED Fund

Unit: MVR

	2012 (Oct to Dec)	2013 (Jan to Dec)	2014 (Jan to Dec)	2015 (Jan to Aug)
Revenue from PV power generation	191,166	2,219,977	2,392,423	1,530,922
O&M Cost	41,647	1,069,325	980,552	544,885
Balance of the above sent to MEE from STELCO	149,519	1,150,652	1,411,871	986,037

Sources: Provided by STELCO

STELCO's administrative performance was not possible to evaluate because they did not disclose their financial statements. However, STELCO finance division revealed that the general and administrative expenses of the organization had been 6 to 8 % of their total revenue. From 2010 to 2015, regular maintenance work was done using this allocated budget. In the same period, STELCO also allocated 18 to 20 % of the total revenue as maintenance expense that covers occasional and large scale repair and maintenance. In 2016, allocation for general administrative and maintenance expenses are expected to be almost the same as past years. Also, in case STELCO's revenues could not cover the cost of power generation, Ministry of Finance (MoF) would provide subsidies to compensate the negative balance. Therefore, although financial statements were not available, there has been stable allocation for general administrative and maintenance expenses in the past six years. Also, STELCO is a 100% government funded company and there is a mechanism of compensation from the MoF, thus, STELCO is unlikely to have an immediate financial problem.

From the above, the financial sources are secured for operating and maintaining the solar PV systems deployed in the project, thus, there is no particular problems in the financial aspects.

3.5.4 Current Status of Operation and Maintenance

No major problems were reported on the operation and maintenance of the following equipment at the 12 sites by the time of the ex-post evaluation except some slight problems with telecommunication and computer system of the measuring devices.

1) Solar cell panel
2) Installation stand
3) Junction box, Collector box
4) Power conditioner
5) Transformer
6) Power generation display device etc.
7) Measuring device
8) Power distribution material
9) Spare parts
10) Tools for maintenance and test equipment

The computer system of the measuring devices has the following malfunctions:

- Failure of telecommunication line: Communication line failure is reported between a personal computer (PC) for monitoring at Social Center to STELCO. STELCO is not able to receive data from Social Center and a staff is making a regular visit to check the operational status. STELCO has asked the service provider to fix the problem but the same problem reoccurred. STELCO plans to request a periodic check to the service provider.
- Problem with software: A software installed to STELCO's computer for remote monitoring and data uploading at the 12 sites encounters occasional errors. The errors can be solved when the program is restarted but the STELCO staff may not be able to handle the problems when they have to install the software to new PCs or some serious problems occur. STELCO communicated with the distributor for a possible solution before it develops into a serious problem.
- Minor problems of PC: PC was installed for monitoring and sending the data of the generated electricity to STELCO at each site. Operation of some PCs becomes occasionally unstable. STELCO is planning to contact a distributor in Maldives to conduct tune-up for the PCs.

The above minor issues would not directly affect the power generating performance and sustainability of the solar PV systems and STELCO has a plan to address these issues. Overall, the solar PV systems at 12 sites are operational and well maintained without a serious problem.

No major problems have been observed in the institutional, technical and financial aspects of the operation and maintenance system. Therefore, sustainability of the project effects is high.

4. Conclusion, Lessons Learned and Recommendations

4.1 Conclusion

The objective of this project was to improve the power generating capacity, diversify energy supply sources, and build awareness among the citizens on renewable energy through installation of PV equipment at five sites in Malé and Hulumalé and training of technicians, thereby contributing. to promote joint efforts of Japan and Maldives to address climate change.

The project has been highly relevant to development policies and development needs of Maldives both at times of the project planning and the ex-post evaluation. The project was consistent with Japanese ODA policy toward Maldives at the time of its planning stage. Therefore, its relevance is high. Although the project cost was within the planned budget, the project period exceeded its original plan because of two additional procurements of solar PV equipment. Therefore, efficiency of the project is fair. Quantitative indicators of the project's objective including electric power generation, diesel displacement, and reduction of CO_2 surpassed their targets at the time of the ex-post evaluation. In addition, at the project sites where the solar PV systems were installed, building users showed their increased awareness on solar and renewable energy. MEE and STELCO successfully installed their domestic solar PV systems using the knowledge and experiences from the project. The data and knowledge of the project were also utilized in the implementation of subsequent solar PV projects by other donors in Maldives. Thus, the project produced most of the expected effects. Therefore, the effectiveness and impact of the project are high. No major problems have been observed in the institutional, technical and financial aspects of operation and maintenance of the PV systems. Therefore, sustainability of the project effects is high.

In light of the above, this project is evaluated to be highly satisfactory.

4.2 Recommendations

4.2.1 Recommendations to the Implementing Agencies

・MEE and STELCO should update the O&M Agreement as soon as MEA officially revises the policies on feed-in tariff.

・MEE should prepare concrete financial and activities plans for utilization of the RED fund to promote renewable energy and its R&D activities projects as well as research and development on renewable energy.

・STELCO should make sure to prevent any technical deficiency in telecommunication for the monitoring PC at Social Center through periodic monitoring by the provider. Regarding the software of the monitoring PC, STELCO should keep communicating with the distributor to fix

its malfunction. For the malfunctions of the PCs at each site, STELCO should also contact the distributor for tune-up to improve the unstable operations.

4.2.2 Recommendations to JICA

None.

4.3 Lessons Learned

（1） Importance of Using Solar PV System sites as an Environmental Education Material for Awareness Raising of the Public and Promotion of the project.

Two qualitative effects were set for the project at the planning stage. One was raising awareness among the public of promoting the use of renewable energy and the other was presenting Japan's initiative in addressing climate change. However, there were no activities implemented to directly contribute to these effects except the exhibition effects of the solar PV systems. MEE stated that they carried out video making and other public awareness building activities. However, the evaluator was not able to obtain the records and reports of such activities. Thus, the consequences of MEE’s activities remain unknown. For these qualitative effects, the concrete activity plans and verifiable indicators should have been set in the project design. For example, the project plan could have included activities such as an exposure to mass media i.e., newspaper and TV, environmental education at schools using the education materials and promotional video explaining the mechanism of power generation of solar PV, and public relations events by collaborating with local private companies to advertise Japanese PV products. Through these promotional activities, the project could have further contributed to raise awareness of Maldivian citizens on renewable energy and to advertising Japan’s assistance. It would also be important to conduct questionnaire survey for the participants to examine the effects of such campaign and promotional activities.

Solar PV system is an environment-friendly facility that can serve as an environmental education material. When a similar project is implemented in the future, solar PV system should be utilized to the maximum to sensitize both children and adults on environment and energy conservation and to familiarize them with Japanese assistance, technology, and products.

（2） Securing O&M Budget and Motivating the Implementing Agencies for Sustainable Maintenance of the Solar PV System

The solar PV systems installed by the project are maintained by STELCO and MEE in a good condition even after the project. Many factors contributed to such sustainable maintenance: sufficient trainings provided by the project, availability of capable staff at STECO, and high prioritization of solar PV introduction both at MEE and STELCO. There are, among others, two unique factors that contributed to the satisfactory maintenance status of the solar PV systems.

First, establishment of the RED fund succeeded in securing financial source of the operation and maintenance. Second, strategic site selection enabled the solar PV systems to catch people's attention and to motivate STELCO and MEE to maintain the equipment in a good condition. The details are elaborated as follows.

<Contributing Factor 1: Revenue from PV Power Generation to Cover the Maintenance Cost>

In this project, Japan and Maldives sides agreed that the revenue from power generation of the PV systems would be calculated using the metered data. The calculated revenue was expected to cover the maintenance cost. This enabled STELCO to secure budget for maintenance monthly. After subtracting the maintenance cost from the revenue, the remaining balance is sent to the RED fund as set forth in the O&M Agreement signed between MEE and STELCO. Such way of securing maintenance cost would be useful for other renewable energy promotion projects.

<Contributing Factor 2: Installation of Solar PV systems at Prominent Locations>

The solar PV systems were installed at busy, prominent locations such as the President's Office and Velaanaage Building, the highest building in Maldives, to attract people's attention. The PV systems are also a popular destination for important guests to MEE. These situations might have put STELCO and MEE under some pressure, which in turn motivated them to maintain the equipment in a good condition. STELCO uses the photos and data of the solar PV systems for presentation materials at foreign conferences and investors' forums etc. Selecting strategic locations to catch people's attention would be useful not only for promotion and exhibition purposes but also for motivating the implementing agencies to maintain the equipment in a good condition.