

Country Name	Project for Introduction of Clean Energy by Solar Electricity Generation System
Kingdom of Cambodia	

I. Project Outline

Background	Power demand in Cambodia rapidly increased year by year from early 2000. During 5-year period from 2008, the power demand increased by 21% yearly, and the installed capacity increased by 2.1 times from 187 MW to 385 MW. The gross generation amount was 1,484 GWh against 1,664 GWh of power consumption amount in 2008. The shortage was imported from neighboring countries. Besides, in power generations, renewable energy was 51 GWh accounted for merely 3%. In Phnom Penh city, the peak demand in 2008 was estimated to be 240 MW, and for that the main power sources were thermal power generation plants in Cambodia and in Vietnam. With regard to rural household electrification, 20% of households could access to electricity in 2009. The government of Cambodia set an electrification target as 70% by the year 2030 through the grid-connection and introduction of renewable energy technologies using solar power, biomass and mini-hydro.			
Objectives of the Project	To enhance power generation capacity, diversify energy sources and increase awareness among the people and policy makers of Cambodia on utilization of renewable energy by procuring equipment for solar power generation and training for technical experts at the Phum Prek Water Treatment Plant in Phnom Penh, thereby contributing to demonstration of Japan’s initiatives to promote efforts among both developed and developing countries against climate change.			
Contents of the Project	1. Project Site: Phum Prek Water Treatment Plant, Phnom Penh 2. Japanese side: 1) procurement and installation of grid-connected photovoltaic (PV) system for 488 kWp (PV modules, power connection boxes, power collection boxes, power conditioners, transformers, external lightning strike protection facilities, data management and monitoring systems, power generation display devices, switchboards, etc.), 2) technical assistance (soft component of grant aid) for training on basic knowledge about interconnecting PV generating system and its operation and maintenance (O&M) including preventive inspection and emergency response and revisions of the O&M manuals) 3. Cambodian side: site for installation of PV system, logistical arrangements and clearances			
Project Period	E/N Date	March 18, 2010	Completion Date	June 20, 2013 (Delivery date of procured equipment)
	G/A Date	March 18, 2010		
Project Cost	E/N Grant Limit / G/A Grant Limit: 720 million yen, Actual Grant Amount: 717 million yen			
Executing Agency	Phnom Penh Water Supply Authority (PPWSA) ¹			
Contracted Agencies	Main Contractor: Marubeni Corporation Main Consultant: NEWJEC Inc. Agent: Japan International Cooperation System			

II. Result of the Evaluation

< Special Perspectives Considered in the Ex-Post Evaluation >

- The ex-ante evaluation set the target of the increase in power generation and reduction of electricity cost in 2015, three years after the project completion in 2012. However, since the project completed with two years delay in 2014, the target year was postponed for two years to be 2017. Therefore, this ex-post evaluation verified the achievement of the project objectives between 2014 and 2017.
- The ex-ante evaluation set the rising of Cambodian people's awareness of utilization of renewable energy as one of the qualitative effects by the project. However, in order to specifically verify the contribution of the project, the ex-post evaluation assessed how the PV power generation system installed by the project in PPWSA contributed to awareness raising of the people who utilize the PV power.

1 Relevance

<Consistency with the Development Policy of Cambodia at the Time of Ex-Ante and Ex-Post Evaluation>

The project has been consistent with Cambodian development policies, as promoting the introduction of renewable clean energy has been prioritized in the "National Strategic Development Plan 2006-2010" at the time of ex-ante evaluation and the "National Strategic Development Plan 2014-2018" at the time of ex-post evaluation. The "National Strategic Development Plan 2014-2018" also places a priority on further expansion of the capacity of low-cost and hi-tech electricity production, especially from new and clean energy sources.

<Consistency with the Development Needs of Cambodia at the Time of Ex-Ante and Ex-Post Evaluation>

While the major power source of electricity in Cambodia is hydro which is renewable energy, dependency on thermal generation which emits CO₂ by burning coal is increasing in recent years. Therefore, the project has been consistent with the needs of Cambodia for increasing power generation and diversifying energy sources by introducing renewable clean energy.

<Consistency with Japan's ODA Policy at the Time of Ex-Ante Evaluation>

The project was consistent with the Japan's ODA policy for Cambodia at the time of ex-ante evaluation. In the "Country Assistance Program for Cambodia 2002", support for development of economic infrastructure and countermeasures against global issues were prioritized in order to realize sustainable economic growth and stable society in the country. In addition, the project was implemented under the scheme of "Program Grant Aid for Environment and Climate Change", which the government of Japan newly introduced in 2008 in order to support developing countries with willingness to contributing to mitigation of climate change but with lack of capacity and fund to balance between their economic growth and greenhouse gas reduction.

<Evaluation Result>

In light of the above, the relevance of the project is high.

¹ A state treatment and business unit under the supervision of the Ministry of Industry, Mines and Energy (MIME), responsible for water treatment and supply to satisfy the demand of the population in Phnom Penh (Source: website of PPWSA, 2017; the sub-decree No.14 ANKr.BK, 2004).

2 Effectiveness/Impact

<Effectiveness>

The project has achieved its objectives by enhancing power generation capacity and diversifying energy sources through the installation and operation of solar power generation system in Phum Prek Water Treatment Plant. The power generation amount at transmission end (Indicator 1) largely exceeded the target value of 652 MWh/year because the number of PV modules procured by the project was 3,624 sets (777kWp) which was larger than the original plan of 2,328 sets (488kWp) due to lower cost of the modules compared to the original budget. As a result, CO₂ reduction (Indicator 2) and electricity cost savings (Indicator 3) have been achieved by largely exceeding the targets.

Two technical staff of PPWSA, who participated in the soft component training programs, are currently engaged in operation and maintenance (O&M) of the PV system installed by the project. The total number of the training participants was 13, because the project invited technical staff not only from PPWSA but also from EDC² and MIME in order to further ensure the transfer of O&M techniques for solar system.

Awareness raising on renewable energy was limited to the officials and staff of PPWSA, EDC and MIME involved in the project since the power generated by the PV system has been used only in Phum Prek Water Treatment Plant.

<Impact>

Along with the Japanese government's actions of the Joint Crediting Mechanism (JCM)³ widely applied in Cambodia, by introducing the first grid-connected PV system over 500 kW in Phnom Penh, the project shows the Japan's contribution to promote efforts among developed and developing countries against climate change. There was no resettlement and land acquisition caused by the project. No negative impact on natural environment has been observed.

<Evaluation Result>

In light of the above, the effect of the project has been observed mostly as planned. Therefore, the effectiveness/impact of the project is high.

Table 1: Quantitative Effects of the Project

Indicators \ Year	Baseline 2012 baseline year	Target 2015 3 years after completion	Actual 2014 completion year	Actual 2015 1 year after completion	Actual 2016 2 years after completion
Indicator 1: Power generation at sending end (MWh/year)	0	652	1,091	1,132	1,087
Indicator 2: CO ₂ reduction amount (ton/year) ¹⁾	0	402	974	1,662	1,115
Indicator 3: Annual savings of electricity cost of PPWSA by the PV power generation (million Riel/year) ²⁾	0	507	786	815	783
Supplemental information 1: Number of PV modules working	0	2,328	3,624	3,624	3,624
Supplemental information 2: Power generation capacity (kWp)	0	488 ³⁾	777	777	777

Source: Preparatory Survey Report (2011), data provided by PPWSA at the time of ex-post evaluation (2017)

1): CO₂ reduction by power generation by PV system is calculated by the following formula: (generation amount) x (estimated CO₂ emission by fuel burning + estimated CO₂ emission by plant operation)

2): The annual savings of electricity cost is calculated by the following formula: (power generation amount at sending end) x (average electricity tariff charged by EDC). The average electricity tariff used in the calculation is 776.8 Riel/kWh for the target value of 2015, and 720 Riel/kWh for the actual value in 3 years of 2014, 2015 and 2016.

3): 210 Wp x 2,328 PV panels = 488 kWp

3 Efficiency

Outputs (the number of PV modules) were produced exceeding the plan (the ratio against the plan: 155%). Although the project cost was within the plan (the ratio against the plan: 99%), the project period exceeded the plan (the ratio against the plan: 171%) since the additional time was required for the procurement of additional PV panels. Therefore, efficiency of the project is fair.

4 Sustainability

<Institutional Aspect>

A solar power generation maintenance team was organized in PPWSA during the project, and there was no significant institutional change since then. The number of team members has been five including two staff members attended the soft component training of the project and other three members assigned after the project. According to the questionnaire survey and interviews with PPWSA, the number of team members is sufficient for proper operation and maintenance of the system. There is no prospect of changing the institutional structure of PPWSA in the near future.

Table 2. Number of Staff of PPWSA

Year	2014	2015	2016
Total number of staff of PPWSA	851	920	1,030
Number of staff in charge of O&M of the PV system installed by the project	5	5	5

Source: PPWSA

<Technical Aspect>

The internal annual training program on SOP (Standard Operation Procedures) of the PV generation system was conducted for

² EDC: Electricite du Cambodge

³ A system to cooperate with developing countries for reducing greenhouse gas emissions, in which the result of reduction is assessed as contribution by both partner countries and Japan. (Source: website of the Ministry of Foreign Affairs of Japan)

PPWSA's technical staff in 2015 and 2016. The training was a 4-day program invited 18 electrical engineers and technicians and 2 operators of the system. Trainer of the program was the chief of Electrical Section of PPWSA. Although he was not involved in the project, the trainer received the comprehensive training on PV system in India. Materials for the training were prepared based on the training materials and manuals provided by the project. The O&M manuals prepared by the project has been the main documents and fully utilized by the maintenance team for their daily works and occasional trouble shootings.

<Financial Aspect>

PPWSA has prepared sufficient annual operational budget for O&M of the system. The major part of the budget has been for equipment and spare parts susceptible to damage. However, after the project completion in 2014, no parts and modules has been replaced or repaired. Therefore, apart from the staff salary, no other expense has been paid for the system since then. In case a reasonably large damage and/or parts replacement takes place, the other budget category could be devoted for repair works by getting an approval of the Director General of PPWSA.

<Current Status of Operation and Maintenance>

According to the interview with the technical staff of PPWSA, they have been strictly following the daily, weekly, monthly and annually maintenance plans prepared by the project. As for the annual maintenance plan, PPWSA has made some modifications by adding a few items to be checked such as electric cables and protection relays.

<Evaluation Result>

In light of the above, no problem has been observed in terms of the institutional, technical and financial aspects of the implementing agency. Therefore, the sustainability of the project effect is high.

5 Summary of the Evaluation

The project has achieved its objectives by enhancing power generation capacity, diversifying energy sources through the procurement and installation of solar power generation system and technical training for O&M staff of the system. However, awareness raising on renewable energy was limited to the officials directly involved in the project. The PV system installed has been well functioning and generating electricity without any problems. As for efficiency, the project period exceeded the plan. Considering all of the above points, this project is evaluated to be highly satisfactory.

III. Recommendations & Lessons Learned

Recommendations to Executing Agency:

- Although the project was highly successful, awareness raising on renewable energy was limited within the project related agencies namely PPWSA, EDC and Ministry of Mines and Energy (MME) (former MIME). In order to disseminate the project demonstration effects wider, it is recommended EDC and PPWSA to publicize the social and technical effects of the solar generation system in the Phum Prek Water Treatment Plant, and organize seminars, workshops and visitors' tours to the site for learning.
- Dissemination of the PV generation model introduced by the project in other provincial waterworks or water treatment plants of PPWSA has not been observed. It is recommended for the Ministry of Industry and Handicraft (MIH) (former MIME) and PPWSA to introduce the benefits of PV system including cost saving of electricity, and to promote the dissemination of PV system to other provincial waterworks and development partners.

Lessons Learned for JICA:

- The Phum Prek Water Treatment Plant where the solar power generation system was installed by this project has being renovated to improve water supply capacity by JICA's grant aid. Also, the institutional capacity of the executing agency of this project was strengthened by the technical cooperation project. PPWSA has enhanced operation capacity of water supply service through JICA's cooperation, which has been attributing to the steady implementation of this project. In addition, the project has been successful in installing solar power generation system at water treatment plant managed by PPWSA that can be appropriately and effectively utilized. The appropriate selection leads to strengthening of power generation capacity and diversification of energy sources, contributing to efficient management and the sustainable operation and management even after project implementation. In light of the above, it is important to select the executing agency and the installation site relevant to the project along with referring to past support results when formulating similar projects.



Solar panels on the roof of Phum Prek Water Treatment Plant



Computer Management System