Internal Ex-Post Evaluation for Grant Aid Project

conducted by Malawi Office: November 2020

Country Name	The Project for Introduction of Clean Energy by Solar Electricity Generation System
Republic of Malawi	

I. Project Outline

Background	About 99% of Malawi's power was provided by hydropower. When the water level was low in the dry season, there was a shortage of power, with the total available capacity of 288 MW against the maximum demand of 347 MW (2010). Therefore, diversification of energy sources was an issue, and renewable energy, including solar power generation, was expected to support its introduction as an energy source that would realize a stable supply of power while suppressing greenhouse gas emissions.				
Objectives of the Project	To increase power generation capacity diversify power sources and raise awareness of people of Malawi on the use of renewable energy by procurement of photovoltaic (PV) system and related equipment in the Project Site as well as technical assistance for capacity building of technical personnel, and thereby contributing to demonstration of Japan's initiatives for promoting collaborative efforts by both developed and developing countries against climate change.				
Contents of the Project	1. Project Site: Kamuzu International Airport 2. Japanese side (1) 830 kWp grid-connected PV generation system (PV modules, watt hour meter, junction box, collecting box, power conditioner, transformer, 11kV switchgear, cables, data management and monitoring system, display board and others) and PV system spare parts and maintenance tools * The generation capacity was increased from the originally planned 450 kW by procuring additional PV modules and related equipment. (2) Technical assistance (soft component): Training on grid connected PV system including basic knowledge, inspection and maintenance, and emergency response 3. Malawi side: Securing and clearing of land, construction of related facilities such as fences, gates, roads and drainage, obtaining power and water distribution lines to the site, providing telephone trunk to the Main Distribution Frame, providing general furniture, obtaining power generation license, etc.				
Project Period	E/N Date	February 17, 2010	Completion Date	September 13, 2013 (Completion of Soft Component)	
	G/A Date	February 17, 2010			
Project Cost	E/N Grant Limit / G/A Grant Limit: 660 million yen, Actual Grant Amount: 647 million yen				
Executing Agency	Airport Developments Limited (ADL)				
Contracted Agencies	Main Contractor(s): Nishizawa Limited Main Consultant(s): Nippon Koei Co., Ltd. Agent: Crown Agents Ltd.				

II. Result of the Evaluation

< Constraints on Evaluation >

As the executing agency was busy with response to the COVID-19 epidemic, it was difficult to collect additional information for clarification of the initial answers provided by them. Therefore, we could not clarify the detailed factors behind the trends in the indicator values.

< Special Perspectives Considered in the Ex-Post Evaluation >

The ex-ante evaluation sheet of this project set 2012 as the target year for the quantitative effects indicators, explaining that year 2012 as "3 years after project completion." However, that it seems to be a mistake considering that the planned project period was from February 2010 to December 2011. Since the actual project completion was September 2013, we set 2016 as the target year for this ex-post evaluation.

1 Relevance

<Consistency with the Development Policy of Malawi at the Time of Ex-Ante Evaluation>

At the time of ex-ante evaluation, the project was consistent with the "National Energy Policy" (2003), which aimed to reduce the proportion of biomass energy (especially firewood and charcoal) to 50% by 2020 while increasing renewable energy from 0.2% to 7%.

<Consistency with the Development Needs of Malawi at the Time of Ex-Ante Evaluation >

At the time of ex-ante evaluation, there was a need for the development of renewable energy, including solar power generation, as mentioned in "Background" above.

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

The government of Japan introduced a scheme of "Program Grant Aid for Environment and Climate Change" in 2008 to support developing countries that lack implementation capacity and funds for balancing between a reduction of CO2 emission and economic growth to promote global efforts against climate change effectively. The project was implemented under this scheme as a mitigation measure through the introduction of clean energy.

<Evaluation Result>

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

2 Effectiveness/Impact

<Effectiveness>

The project's objective, namely, "to increase power generation capacity, diversify power sources, and raise awareness of people of Malawi on the use of renewable energy," has been achieved. Regarding the quantitative effects, the power generation volume at transmission end (Indicator 1), the estimated reduction of CO2 emission (Indicator 2), and the estimated reduction of electricity cost for the airport facilities (Indicator 3) were all achieved above the target in 2016, the target year. After that, the figures show a slight downward trend with time, reportedly as the solar panels have become dirty despite daily cleaning and as the power generation is lowered while some

components are under repair. Even so, the facility has been functioning and able to generate more than the airport's energy requirement, which is 500 kWp while the facility generates 831 kWp. The excess energy is channeled to the national grid.

Regarding the qualitative effects, the effects of the soft component have been partially reflected in the O&M of the facility, particularly in terms of one of the trained staff still practicing what he had learned and the manuals being utilized (see "Sustainability" below for more information on O&M). Public awareness activities about the solar power generation by the PV system have been conducted - ADL receives visits from schools and interest groups at least once every two months. So far, 24 solar users and 240 non-users have shown interest in the facility after getting some awareness of its effectiveness.

<Impact>

The expected impact of this project, namely, "Contribution to a demonstration of Japan's initiatives for promoting collaborative efforts by both developed and developing countries against climate change," has not manifested. However, there has been a positive impact related to gender. The PV solar panels require daily cleaning. Since this task can also easily be done by women, ADL hired 50% of its cleaning personnel in the form of women. Guarding services (especially during the day) have also accommodated women. Through the project, therefore, the welfare of women has been uplifted.

Besides, unexpected positive impacts brought by the project include the following. (a) Public Relations for the Kamuzu International Airport has improved as it receives a good number of interest groups that come to learn and appreciate how the facility works. (b) For ADL, which now has the mandate to plan and manage the developments of other airports in Malawi, the facility is serving as a model power back up. ADL will endeavor to ensure that future airports or other existing airports should have a similar facility as power backup. No adverse impacts have been observed.

<Evaluation Result>

Therefore, the effectiveness/impact of the project is high.

Quantitative Effects

Indicators	Baseline 2009 Baseline Year	Target 2016(1) 3 Years after Completion	Actual 2016 3 Years after Completion	Actual 2017 4 Years after Completion	Actual 2018 5 Years after Completion	Actual 2019 6 Years after Completion	Actual 2020 (-March) 7 Years after Completion
Indicator1: Power generation volume at transmission end (MWh/year)	0	661.0	1,292.6	1,149.5	1,121.6	1,053.0	258.7
Indicator 2: Estimated reduction of CO2 emission (ton/year)(2)	0	367.0	406.5	361.9	352.7	331.9	89.9
Indicator 3: Reduced electricity cost for the airport facilities (equivalent million yen/year)(3)	0	1.78	8.44	5.91	6.39	4.05	N.A.

Source: Ex-ante Evaluation Report; ADL

Note: (1) The target values were calculated as follows.

<Indicator 1> The estimated average power output was calculated by average irradiation (kWh/m^2-day) x system efficiency (0.7) x output of PV (kWp) = 5.7 x 0.7 x 456.3 = 1,810.0 kWh/day = 661.0 MWh/year.

<Indicator 2> The annual CO2 emission reduction was calculated by emission reduction unit x Annual power output = 0.555 kg-CO2/kWh × 661.0 x 10^3 kWh/year = 366,855 kg-CO2/year ≈ 367 ton/year.

<Indicator 3> The reduced electricity cost was calculated by unit electricity tariff (Category Scale III) × annual energy output

= 4.0923 MWK/kWh × 661.0 x 10^3 kWh/year = 2.70501x10^6 MWK/year ≈ 1.78 million yen/kWh (1 MWK = 0.658 yen). * MWK: Malawian Kwacha

(2) For the actual values of Indicator 2, ADL indicated that it used the same calculation method as the one used for the target value. However, it appears that a different coefficient (0.314) was used than the coefficient used to calculate the target value (0.555).

(3) The original data was provided by ADL based on credit notes from Electricity Supply Commission of Malawi (ESCOM) in Malawian Kwacha. The evaluator converted the amount to Japanese yen using the following exchange rates: 0.157 yen (2016), 0.155 yen (2017), 0.157 yen (2018), and 0.151 yen (2019).

3 Efficiency

While the project cost was within the plan, the project period significantly exceeded the plan (ratio against the plan: 98% and 191%, respectively). The project implementation was delayed as there were serious economic problems in Malawi between 2011 and 2012 such as low supply of foreign currency, and serious fuel shortages. Due to that, government operations, including those for this project, were brought almost a standstill. Therefore, the efficiency of the project is fair.

4 Sustainability

<Institutional/Organizational Aspect>

The ADL's O&M structure[1] for the PV system installed by this project is robust enough, and ADL reported that they have a sufficient number of people to carry out the operation. However, some issues for the future have been observed, although they have not undermined the sustainability so far. First, under the soft component, this project trained technical staff from the Department of Civil Aviation (DCA) and ADL to handle O&M issues of the facility so that the DCA staff could provide technical support and cooperation on the switchgear and transformer. However, such an arrangement did not materialize since, according to the actual institutional arrangement, it is ADL that is primarily involved in the operation of the facility, and DCA does not take a frontline role in handling the facility. Second, when ADL wants to buy spare parts directly from manufacturers, they are told that the manufacturers only deal with certified dealers, and a third party like

[1] The O&M team has two groups, namely (a) Electrical (four staff members) (b) Refrigeration (two staff members). Besides, there are eight cleaners. The two teams work hand in hand. The two team reports to the Technical Team (three staff members), headed by the Engineering Manager, who in turn reports to management.

ADL is not one of them. Also, there are some components of the equipment which ADL personnel are forbidden to touch. These restrictions make ADL helpless and entirely dependent on the consultants, which attracts costs when problems occur. This will create a problem of eternal dependency on the consultants, and ADL will not be able to stand alone in the future.

<Technical Aspect>

The current members of the O&M team of ADL can operate the facility and manage and analyze the data such as CO2 emission, solar radiation, and energy generation. However, the departure of two of the three officers trained by the project poses another problem for the future if the remaining staff members leave, as the other members of the current O&M team do not have the opportunity to be trained.[2] In addition, there are some more technical issues over spare parts and repair works, although they have not much affected the operation of the facility so far. First, due to the evolution of technology, the market no longer has spare parts for the model that was installed by this project. Although ADL has been able to manage O&M so far with the spare parts provided by this project, there is a fear that in the future, all spares may not be available. Second, some components of the equipment are labeled in Japanese, and all instructions of such components are in Japanese. This makes it impossible for ADL staff or outsourced technicians from Malawi to conduct O&M. Third, for some parts that need replacement, ADL personnel are requested to invite consultants alone to come and fit them (i.e., ADL's technicians are forbidden to touch these parts). However, ADL cannot know how many Man Hours with how many technicians will be required to fix a particular problem.

<Financial Aspect>

ADL sets aside MKW5 million annually for all O&M as well as maintenance activities of the facility. So far, it has barely managed to keep the facility running. As it ages, however, the amount may not be enough as we expect more breakdowns entailing higher costs (including the cost for travel, accommodation, and allowances to be paid to invite consultants for repair works). The amount will have to be adjusted upwards.

<Current Status of Operation and Maintenance>

Although not all operators were trained as planned, the PV power system has been operated and maintained to the level that can continue power generation. The facility is inspected three times a day (morning, noon, and evening). If they notice something unusual, the relevant team is deployed to work on it. The PV system components are in good condition except for the following: among the nine inverters (power conditioners), one broke down, was replaced by a spare, and is currently operating again; another power conditioner will be repaired in the near future, according to ADL.

All spare parts and consumables are well kept and utilized. ADL has replaced eight solar panels from a stock of solar panels that were left by the project. However, the emerging problem of spare parts mentioned above poses a threat to future maintenance of the equipment.

<Evaluation Result>

In light of the above, some problems have been observed in terms of the institutional, technical, and financial aspects of the executing agency. Therefore, the sustainability of the project effect is fair.

5 Summary of the Evaluation

The project achieved the objective of increasing power generation capacity, diversifying power sources, and raising awareness of people of Malawi on the use of renewable energy, with the grid-interconnected PV system installed at the Kamuzu International Airport. Regarding the sustainability, some problems are found in the institutional, technical, and financial aspects of the O&M of the PV system such as the dependence on consultants, unavailability of some spare parts, and the decreasing number of trained personnel, which might lead to the degradation of the facility in the long-term. However, the solid O&M structure has enabled ADL to operate and maintain the facility in good condition. As for the efficiency, the project period significantly exceeded the plan. Considering all of the above points, this project is evaluated to be satisfactory.

III. Recommendations & Lessons Learned

Recommendations to the Executing Agency:

1) ADL is recommended to facilitate easier access to and maintenance of the equipment by allowing ADL personnel unfettered access to repair any part of the equipment within their competency. This will assist in reducing time leading to repair of a component as they will not have to wait for consultants to find convenient time to come and carry out repairs.

2) ADL is recommended to retain the staff member who received training in this project to the O&M of the project facility. Also, it is desirable that ADL request cooperation from DCA to augment the technology transfer with the DCA staff trained under this project.

Lessons Learned for JICA:

1) It is needed to confirm parts procurement conditions during the detailed planning survey stage and to confirm language of the manual and labels during equipment inspection whether in English or any others that can be understood locally.

2) In future projects to procure solar electricity generation equipment, the O&M personnel's accessibility to any parts of the equipment should be confirmed before procurement.

3) When a soft component is to include training for personnel from other organizations than the O&M agency, JICA should make sure that such personnel will be actually involved in O&M in the practical institutional setting.

[2] The transfer of knowledge and skills on O&M of the facility has not been smooth because the only remaining member who was trained was not trained in Training of Trainers. As a result of this, the new staff has mastered the art of operating and maintaining the facility through manuals left by the project and previous experience from elsewhere. However, there is no way to be sure that the technology they are using is sufficient in the medium to long term.

PV modules (the solar panels)

Power conditioners in the energy conversion room

Display board indicating the energy amount being generated by the facility