Lao People's Democratic Republic

FY2017 Ex-Post Evaluation of Japanese Grant Aid Project

"Mini-Hydropower Development Project"

External Evaluator: Toru Shimada, ADAMIS Ltd.

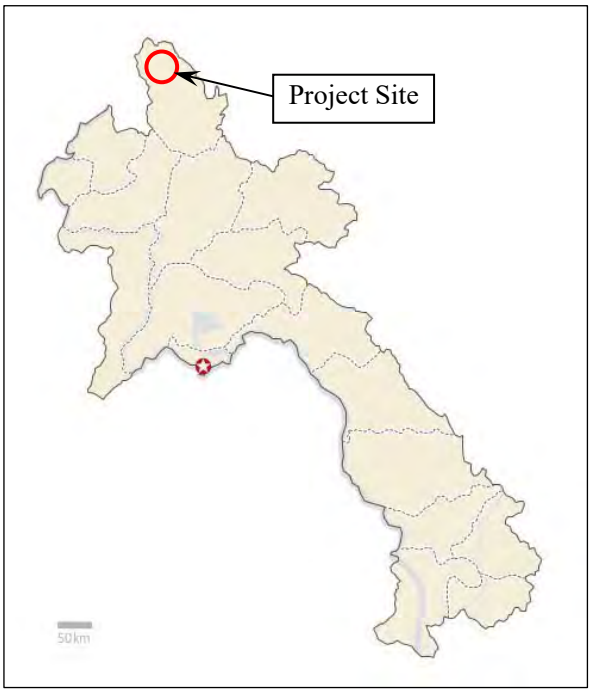
Hiromitsu Takao, Aviation Systems Consultants Co., Ltd.

0. Summary

The project aimed at promoting utilization of renewable energy, contributing to reduction of greenhouse gas emission, and promoting electrification in rural areas by constructing a mini-hydropower plant and distribution networks in Gnod Ou District, Phongsaly Province, thereby contributing to the socio-economic development of Laos. The 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. With regards to efficiency of the project, the project cost exceeded the plan although the project period was within the plan. Therefore, efficiency of the project is fair. Qualitative effects of the project are observed, but achievement of operational indicators, such as plant factor and generation of hydropower plant are below the targets. Therefore, effectiveness and impacts of the project are fair. With regards to operation and maintenance of facilities, some minor problems have been observed in terms of the institutional aspect, technical aspect, financial aspect and current status. Therefore, sustainability of the project effects is fair.

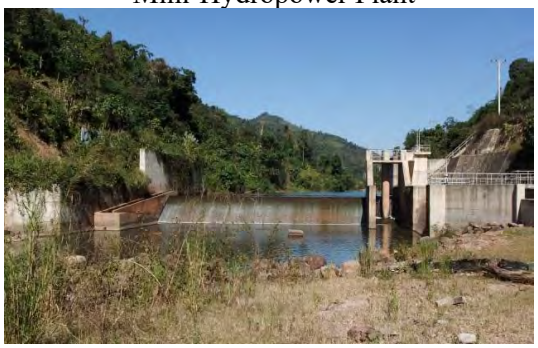
In light of the above, this project is evaluated to be partially satisfactory.

1. Project Description



Project Location

Mini-Hydropower Plant



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1.1 Background

Lao People's Democratic Republic (hereinafter referred to as "Lao PDR") is an inland country affected by the tropical monsoon, and its potential of hydropower development is estimated to be more than 26,000 MW[1]. The Government of Lao PDR has planned power development with the practical use of the high hydropower potential through the positive introduction of independent power plants. The national electrification ratio of Lao PDR had consequently been increasing from 36% in 2000 to 73% in 2010. By region, the electrification ratio became as high as 96% in the Central Region including the capital in 2010 but remained as low as 59% in the Northern Region. The Government of Lao PDR showed a policy to actively promote rural electrification from the viewpoint of reducing the internal disparities between urban and rural areas and poverty reduction in the remote areas, and set targets to improve the national electrification ratio to 80% by 2015 and to 90% by 2020 in *The Seventh Five-year National Socio-Economic Development Plan (2011-2015).*

One of issues on the future rural electrification was financial issue. Most of the power in villages near the border was imported, and the import tariff was relatively expensive. The power price was more expensive than electricity tariff to consumer in Lao PDR. Therefore, reduction of volume and/or tariff of import power have been required. In addition, there was technical issues, i.e. low reliability of power supply through long distance distribution networks and insufficient technical and management capabilities of off-grid electrification.

Phongsaly Province, the target area of the project is located in the northernmost of Lao PDR, its electrification ratio was the lowest in the country, and electrification of remote areas had not been progressed. This is because there were only Nam Ngai mini-hydropower plant (1,200 kW) and Mai hybrid power plant (mini-hydropower 110 kW + solar power 40 kW) in Phongsaly Province, which could not generate sufficient power, it is difficult to maintain reliability of supply and of appropriate voltage of power generated in the country through long distance 22kV distribution networks from national power grid, and import power from China is expensive.

In order to solve such conditions, the Government of Lao PDR requested Government of Japan for Japan's Grand Aid to construct a mini-hydropower plant and to extend distribution networks to the surrounding un-electrified villages in Gnod Ou District, Phongsaly Province.

1.2 Project Outline

The objective of the project is to promote utilization of renewable energy, to contribute to reduction of greenhouse gas emission, and to promote electrification in rural areas by

[1] *Current Status and Future Trend of Laos Energy and Power* by Inoue, Asakura and Sasaki, posted on website of the Institute of Energy Economics, Japan in October 2003 http://eneken.ieej.or.jp/data/pdf/749.pdf (accessed 2018-6-11)

constructing a mini-hydropower plant and distribution networks in Gnod Ou District, Phongsaly Province, thereby contributing to the socio-economic development of the country.

Grant Limit / Actual Grant Amount	JPY 1,775 million / JPY 1,772 million
Exchange of Notes Date /Grant Agreement Date	March 2013 / March 2013
Executing Agency	Ministry of Energy and Mines
Project Completion	February 2015
Main Contractor	Hazama Ando Corporation
Main Consultant	Tokyo Electric Power Service Co., Ltd.
Basic Design	August 2012 - March 2013
Related Projects	Technical Cooperation: "The Master Plan Study on Small Hydropower in Northern Laos" (JICA, 2003-2005) Other international organizations, aid organizations etc.: "Greater Mekong Subregion Northern Power Transmission Project" (Asian Development Bank, 2011-2015), "Lao Rural Electrification Phase II Project", (The World Bank, 2010-2013)

2. Outline of the Evaluation Study

2.1 External Evaluator

Toru Shimada, ADAMIS Ltd.

Hiromitsu Takao, Aviation Systems Consultants Co., Ltd.

2.2 Duration of Evaluation Study

This ex-post evaluation study was conducted with the following schedule.

Duration of the Study: September, 2017 - October, 2018

Duration of the Field Study: January 7 - January 31 and April 1 - April 10, 2018

3. Results of the Evaluation (Overall Rating: C[2])

3.1 Relevance (Rating: ③[3])

3.1.1 Consistency with the Development Plan of Lao PDR

The Seventh Five-year National Socio-Economic Development Plan (2011-2015) in place at

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

[3] ③: High, ②: Fair, ①: Low

the time of planning the project stated, as approaches of the energy sector, “Expansion of lines to meet the twin objectives of supplying electricity domestically for country’s development, and export.”, “become battery of ASEAN”. The same plan also set a target of expansion of rural electrification.

The Eighth Five-year National Socio-economic Development Plan (2016-2020) in place at the time of the ex-post evaluation states, as activities for energy integration, “focus on the development and utilization of clean and environmentally friendly energy”, “expand electricity coverage to rural remote and hard-to-access areas, leading to at least 90% of the total number of families in the country having access to electricity by 2020”.

Since both *the Seventh National Socio-economic Development Plan* and *the Eighth National Socio-economic Development Plan* aimed at rural electrification as mentioned above, the project has been consistent with the national development plans.

3.1.2 Consistency with the Development Needs of Lao PDR

At the time of planning, there were only two small power plants in the project target area, i.e. Phongsaly Province. Import power was supplied in Gnod Ou district from China through a substation near the border with China, and distributed to the villages through 22 kV distribution lines along the provincial road. However, other villages away from the distribution lines were not electrified. Under such circumstances electrification ratio of Phongsaly Province was only 23% in the first half of year 2012, the lowest among all provinces in Lao PDR. The Government of Lao PDR set targets to improve the household electrification ratio of Phongsaly Province to 60% by 2015 and to 70-80% by 2020. Furthermore, expensive power was imported from China at 9.2 US¢/kWh, so that reduction of import power cost and volume was one of issues of the energy sector.

At the time of ex-post evaluation, electrification ratio of Phongsaly Province was 59.04% (in November 2017), and that of Lao PDR was 93.82%, still the lowest among all provinces in Lao PDR.

Table 1 shows volume of power import from China (MWh) and average price (US¢/kWh). Volume of import power from China increased as demand increased in Phongsaly Province. The average price of the import power is on a downward trend with increase of import volume, but it is approximately twice as high as the lowest unit price of household electricity (up to 25 kWh, LAK 355 per kWh).

Table 1: Volume and Average Price of Power Imported from China

Year	2014	2015	2016	2017
Import volume (MWh)	8,261	10,119	11,385	11,129
Average price (US¢/kWh)	9.41	9.25	8.73	8.59

Source: Documents provided by Electricite du Laos (hereinafter referred to as “EdL”)

Therefore, the project has been consistent with the development needs of the target area, in terms of increasing electrification ratio of Phongsaly Province.

3.1.3 Consistency with Japan's ODA Policy

Japan's Country Assistance Policy for Lao PDR (April 2012) in place at the time of planning the project stated to extend Japan's assistance to "rectifying disparities in access to electric power within Lao PDR and enhancing power export through expanding electric power in safe and stable manner" in Development of Economic and Social Infrastructure that was one of the priority areas, and *Rolling Plan for Lao People's Democratic Republic* annexed to the Country Assistance Policy placed energy sector in "Power Development Program" and stated to provide assistance for improvement of the capacity of administering electricity enterprises, development of government-owned power generation facilities and main transmission networks, and development of facilities for rural electrification in order to expand stable, sustainable and efficient power supply. Also, the Government of Japan declared a policy to support realization of the green growth of developing countries by utilizing Japan's superior techniques in the field of renewable energy (micro hydropower, solar power and so on) in the JFY2012 budget. Therefore, the project was consistent with Japan's assistance policy for Lao PDR and policy to support realization of the green growth at the time of planning the project.

As described above, the country's socio-economic development plans at the times of planning the project and ex-post evaluation aim at increase of electrification ratio, development needs is high in Phongsaly Province because of the lowest electrification ratio in the country, and Japan's ODA policy aimed at rectifying disparities in access to electric power within Lao PDR. Therefore, 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

This project is to construct a mini-hydropower plant and distribution networks in Gnod Ou District, Phongsaly Province, and planned and actual outputs of the project are summarized in Tables 2 and 3. Major changes were exclusion of the distribution networks in the Northeast area and an increase of the effective head in order to resolve shortage of power output.

Table 2: Comparison of Project Outputs

Item	Planned	Actual
Generation Type	Run-Off-River Type	Run-Off-River Type
Maximum Discharge	7.02 m^3/s	7.02 m^3/s
Effective Head	8.8 m	8.92 m

Installed Capacity	450 kW	450 kW
Diversion Weir	H4.5 m, L41.1 m	H4.5 m, L37.6 m
Intake	W4.2 m, H3.3 m, L16.8 m	W5.2 m, H3.0 m, L18.0 m
Setting Basin	W10.7 m, H3.5 m, L31.2 m	W13.2 m, H3.5 m, L31.8 m
Headrace	W2.0 m, H2.5 m, L680.5 m	W2.0 m, H2.5 m, L695.0 m
Head Tank	W5.0 m, H6.2 m, L32.7 m	W10.4 m, H7.0 m, L33.5 m
Penstock	D1.2 m, L5.2 m, 3 units	D1.2 m, L5.1 m, 3 units
Powerhouse	W8.9 m, L14.0 m, H6.7 m	W8.9 m, L14.0 m, H8.4 m
Water Turbine and Generator	Submersible Pump Turbine: 3 units 173.5 kW, 600 rpm	Submersible Pump Turbine: 3 units 173.5 kW, 600 rpm
Generator	Vertical Shaft Three Phase Synchronous Generator: 3 units 166.7 kVA, 600 rpm	Vertical Shaft Three Phase Synchronous Generator: 3 units 166.7 kVA, 600 rpm
Controller	Start & stop Operation of the Plant; Protection Stop Control; Voltage, Current, Output Observation; Automatic Synchronizer; Protection Relay; Isolated Operation Detecting Device	Start & stop Operation of the Plant; Protection Stop Control; Voltage, Current, Output Observation; Automatic Synchronizer; Protection Relay; Isolated Operation Detecting Device
Main Transformer	Oil Self Cooling Three Phase Transformer; Rated Capacity: 500 kVA; Voltage: 22 kV/440 V	Oil Self Cooling Three Phase Transformer; Rated Capacity: 500 kVA; Voltage: 22 kV/440 V
Switch Gear	Three Phase Switchgear with Fuse; Transformer for Instrument; Current Transformer for Instrument; Arrester	Three Phase Switchgear with Fuse; Transformer for Instrument; Current Transformer for Instrument; Arrester
22kV Distribution Lines	Three Phase Bare ACSR; 12 m Reinforced Concrete Pole; Northeast Area: 76.3 km, West Area: 47.5 km	Three Phase Bare ACSR; 12 m Reinforced Concrete Pole; West Area: 51.9 km
400V Distribution Lines	Three Phase 4 lines Insulated ACSR; 8 m Reinforced Concrete Pole; Northeast Area: 10.0 km West Area: 6.1 km	Three Phase 4 lines Insulated ACSR; 8 m Reinforced Concrete Pole; West Area: 6.0 km
Transformers (22 kV/400 V)	Northeast Area: 13 units West Area: 10 units	West Area: 10 units

Table 3: Comparison of Project Outputs (Soft Component)

Planned	Actual
Establishment of Provincial-Rural Electrification Fund in Phongsaly Province (hereinafter referred to as "P-REF"). (P-REF management manual is prepared. P-REF is established. P-REF officers properly have capability for financial management.)	・Final draft of P-REF management manual was proposed. ・P-REF was established about 17 months after the end of the soft component (August 1, 2016). ・PDEM could understand incompletely the details of P-REF balance of payment.
Selection/Procurement of Special Purpose Organization (hereinafter referred to as "SPO") for Operation and Maintenance	・A draft of criteria for SPO selection were prepared. ・Licensing of the SPO was given about two months

(hereinafter referred to as "O&M"). (Criteria for SPO selection are prepared. License is issued to a selected SPO.	after the end of the soft component (May 22, 2015).
Establishment of O&M Monitoring System. (Provincial Department of Energy and Mines of Phongsaly Province (hereinafter referred to as "PDEM") staff acquires sufficient knowledge and skills of designing and plant structures for monitoring/supervising "O&M" activities. O&M manual is prepared. PDEM staff is capable in monitoring/supervising activities for the plant.)	・Basic training for mini-hydro power plant and On the Job Training (hereinafter referred to as "OJT") were conducted. ・O&M manual (for civil structure) was produced in English Language. No O&M manuals for the plant and Lao Language version were not produced.

It was agreed, as a design change during the detailed design, to exclude the distribution networks in the Northeast area from the project scope so as to deal with increase of the project cost due to the depreciation of Japanese Yen (from JPY 80.41 per US$ to JPY 99.80 per US$ at the times of outline design and detailed design respectively) and to construct them by the Laotian side.

Background and reason of the increase of the effective head in order to resolve shortage of power output are described below.

The designed output of the mini-hydropower plant is 450kW (150kW x 3 units). During the commissioning tests in February 2015, 152kW of one unit operation was confirmed. However, it was not possible to confirm output of simultaneous 3 units operation due to shortage of water volume. After that, as a result of more than one year operations, it was confirmed that the maximum output at simultaneous 3 units operations was only 400-407kW even in water rich period during the rainy season, and countermeasures to increase the output was required. As a countermeasure, removal of the submersible weir and increasing crest elevation of the spillway of the head tank were proposed by using calculation and observation. The countermeasure was executed in April 2016, followed by output confirmation tests. It was not possible to confirm the output for simultaneous 3 units operations, because it was the dry season, but the output of one unit was 165kW, which was 13kW more than the output before the countermeasure. This result is almost same as expected in the calculation, and it was considered that 450kW would be almost achieved by simultaneous 3 units operation.

There is little difference between the planned and actual outputs of the mini-hydropower plant, but achievement rate for 22kV distribution lines, 400V distribution lines and transformers were 41.9%, 56.6% and 43.5%, respectively due to the exclusion of the distribution network in the Northeast area.

With regard to the soft component, final draft of P-REF management manual was proposed for establishment of P-REF, but P-REF had not been established; a draft of criteria for SPO selection were prepared and advices were made for selection/procurement of SPO, but selection/

procurement has not been completed; and basic training for mini-hydro power plant and OJT were conducted, and O&M manual for civil structure in English was produced for establishment of O&M monitoring system, but O&M manuals for the plant and Lao Language version had not been produced; by the end of the soft component.[4]

3.2.2 Project Inputs

3.2.2.1 Project Cost

Table 4 summarizes planned and actual cost of the project. The cost borne by Japanese side was within the planned amount, but it was exceeded essentially considering the reduction of the output. By the way, the project cost excluding the distribution networks in the Northeast area was estimated to be JPY 1,560 million at the time of planning, and the actual cost exceeded it by 13%. The cost borne by Laotian side was estimated to be JPY 3 million at the time of planning, and the actual cost was not available from Institute of Renewable Energy Promotion, Ministry of Energy and Mines (hereinafter referred to as "IREP"). Therefore, the total project cost was not available, and comparison was made on the cost borne by Japanese side.

Table 4: Comparison of the Project Cost

Item	Planned	Actual
Cost borne by Japanese Government	JPY 1,775 million	JPY 1,772 million
Cost borne by Laotian Government	JPY 3 million	(Not available)
Total	JPY 1,778 million	(Not available)

Source: Documents provided by JICA

3.2.2.2 Project Period

The planned project period was 23 months (April 2013 - February 2015). The actual project period was 23 months, from April 2013 to February 2015, as planned (100%)[5].

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

3.3 Effectiveness and Impacts[6] (Rating: ②)

3.3.1 Effectiveness

[4] According to the consultant, "With regard to that the Lao version was not produced, there were no concepts equivalent to the technical terms on the manual in the Lao language. Therefore, there would be risks of erroneous operation, which might cause serious safety issue, due to mistranslation." and "With regard to the manual for plant, there was a judgment that substitution by training etc. using the manufacturer's manual was appropriate from a safety standpoint."

[5] The distribution network in the Northeast area was agreed to be constructed by Laotian side. However, it was completed, by the time of the field study, only 3 out of 13 villages due to delay of development of access road to the villages.

[6] Sub-rating for Effectiveness is to be put with consideration of Impacts.

3.3.1.1 Quantitative Effects (Operation and Effect Indicators)

Table 5 summarizes achievements of quantitative effects (operation and effect indicators). The actual value for 2017 is 2.8 years after the project completion, and can be regarded as equivalent to the target value (3 years after completion).

Table 5: Achievement of Quantitative Effects

	Baseline	Target	Actual		
	2012	2018	2015	2016	2017
		3 Years After Completion	Completion Year	1 Year After Completion	2 Years After Completion
Maximum output of Mini-hydropower Plant (kW)	0	450	407	NA	About 430
Plant factor*[1] (%)	0	79.6	NA	NA	43.4
Generation of Mini-hydropower Plant and reduction of power import (MWh/year)	0	3,141	1,631	2,089	1,714
Household Electrification ratio in Gnod Ou district (%)	32	60	51.27	58.26	58.86

Source: Installed capacity provided by SPO, other data provided by EdL

Notes: *[1] Plant factor = (Generation of mini-hydropower plant per year)/(Installed capacity x 24 x 365)

The achievement rate for plant factor and generation of mini-hydropower plant per year was only 54.6%. According to the executing agency, main reasons for less achievement are as follows. The effective head is reduced due to raising downstream water level in rainy season because of sedimentation of soil in downstream of the power station. Frequent stop of power generation due to faulty alarm of the main transformer could not be repaired until October 2017. Operations of the generator(s) should be stopped due to troubles of the EdL's power distribution network.

Figure 1 shows monthly generation of the mini-hydropower plant. It indicates that generation in October to December was greater than that in the rainy season when water is rich (from May to October) in any year. This confirms that the effective head was reduced in rainy season. Generation in June to September 2017 is lower than the same period of other years. It is considered to be because of faulty alarm of the main transformer. According to the contractor's *Monthly Progress Report*, the monthly average water level at the powerhouse in 2014 was high in July at 739.71m and low in December at 738.47m, and they are 1.81-0.57 m higher than 737.90 m of outlet level described in *The Preparatory Survey for Mini-Hydropower Development Project in Lao PDR Final Report*. It is assumed that a landslide of the downstream right bank, after the detailed design and before commencement of works, caused

raise of water level. Therefore, it is considered to be necessary to decrease the water level of downstream in rainy season in order to achieve target values of the plant factor and generation of the plant.

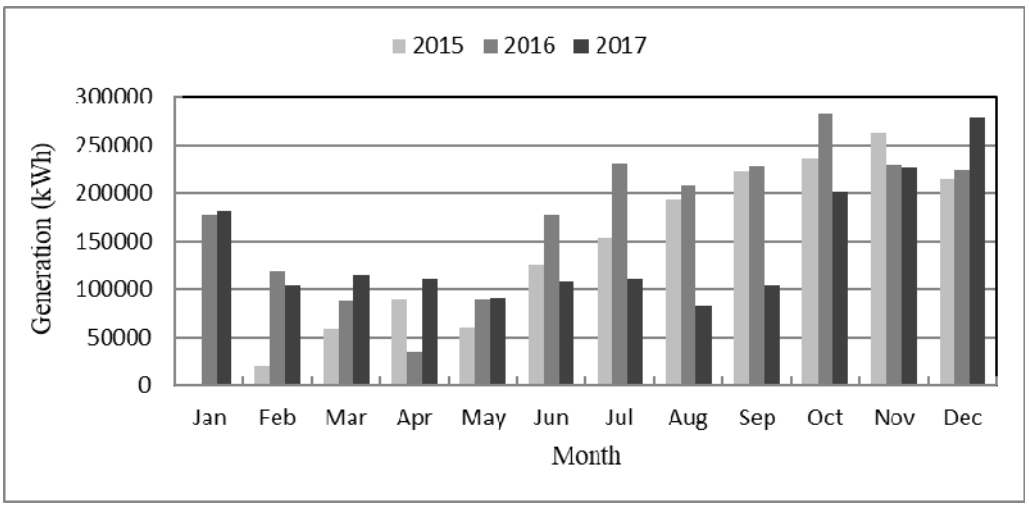

Figure 1: Monthly Generation of Mini-hydropower Plant

The power generated by the plant has been effectively used in Gnod Ou District, and saved approximately US$ 2.89 million on import cost from China for about 3 years.

Achievement of household electrification ratio in Gnod Ou District is 98.1% of the target, although only 3 out of 13 villages in the Northeast area have been electrified by the Laotian side. It is considered to be because the target was set as same as that for Phongsaly Province in 2015 and electrification has been progressed in other areas in Gnod Ou District.

As a reference indicator, number of electrified households in the West area, the target area of Japanese assistance, at the end of 2017 was 627, and exceeded the expected number of households in the preparatory survey (581) by 8%. Number of electrified households in the Northeast area, which was excluded from the Japanese assistance, was 185, and remained at only 29% of the expected number of households in the planning stage (641).

3.3.1.2 Qualitative Effects (Other Effects)

(1) Strengthening of Stable Power Supply

At the time of planning, it was understood that installation of a power plant at the ending point of system grid would contribute to transmission and distribution loss reductions as well as strengthen stable power supply to the adjacent areas, because Gnod Ou District would continue to be located at an end of Lao national power grid.

Interviews of 13 persons[7] including staff of PDEM, District Department of Energy and Mines

[7] PDEM: 1 (male), DDEM: 4 (3 (male), 1 (female)), EdL (Phongsaly): 2 (male), EdL (Gnod Ou): 2 (male), residents:

(hereinafter referred to as "DDEM"), provincial and district offices of EdL, and residents of Ou Tai, where electricity had been supplied even before the project, were conducted during the field study. As results of the interviews, 12 out of 13 persons answered positive opinions, such as easier to live due to reduction of power outages, keeping food safely and effective utilization of night time, and all of staff of PDEM, DDEM and EdL answered that voltage stability has been enhanced.

Therefore, it is considered that number of power outages was reduced and voltage stability was enhanced in the adjacent areas by the project.

(2) Promotion of Renewable Energy Development

At the time of planning, it was considered that the project would contribute to promotion of renewable energy development in Phongsaly Province, because the minihydropower plant was one of renewable energy utilizing domestic resources. In addition, it was expected that renewable energy development would be accelerated by utilizing fund of P-REF.

In addition to the project, Nam Ou 5 and Nam Ou 6 hydropower plants (total 420 MW) are in operation in Phongsaly Province, but power generated by these plants has been sent to a substation in OudomXay Province and has almost no effect on power suppled in Gnod Ou District. Nam Ngay hydropower plant (1.2 MW) and Mai hybrid plant (0.15 MW) operated at the time of planning the project have been stopped operations.

Therefore the project itself has promoted renewable energy development in Phongsaly Province. Apart from the project, there is no prominent promotion of renewable energy development in Phongsaly Province.

P-REF fund has been mainly used for operating cost (such as travel and meeting) of P-REF, and cost for construction of a small roof structure for operator's quarters, but not used for promotion of renewable energy development. It is considered to be premature to expect promotion of renewable energy development in Phongsaly Province by utilizing P-REF.

3.3.2 Impacts

3.3.2.1 Intended Impacts

(1) Reduction of Emission of Greenhouse Gas in China

At the time of planning, it was predicted that 3,141 MWh/year of power import would be reduced after completion of the project[8], since the project was planned to provide electricity to the areas where electricity from China was supplied through 35 kV/22 kV distribution lines. Therefore, it was expected that emission of greenhouse gas would be reduced by 3,367 tCO_2 per year in China.

4(2 (male), 2 (female)) (With regard to interviewees, each organization selected appropriate staff after recognizing main purpose of the survey. Residents were selected in the area out of the project considering gender balance.

[8] Source: Documents provided by JICA

An average reduction of emission of greenhouse gas by the project per year can be re-calculated at the time of the ex-post evaluation by using the same equation used in the planning stage as follows:

0.9873 tCO_2/MWh x 1,916.5 MWh x 1.1 (distribution loss rate) = 2,081 tCO_2

(1,916.5 MWh is average generation of the mini-hydropower plant (reduction of power import from China) for three years.)

This is 62% of the amount expected in the planning stage due to the less generation per year than the plan.

(2) Improvement of Rural Economy

At the time of planning, it was expected that the promotion of rural electrification and stable power supplies by the project would activate local industries and change lifestyle of residents that would lead to better living.

With regards to change of local economy, livelihoods, social services and living conditions of residents, interviews of 26 persons[9] including a staff of Department of Planning and Investment of Phongsaly Province, a staff of Office of Planning and Investment of Gnod Ou District, and residents, including shop owners, of the villages, where distribution networks were constructed, were conducted during the field study. As results of interviews, all persons answered that there were positive changes in local economy and livelihoods, such as reduction of using fire, comfort of living and increase in income. In social services and living conditions of residents, all persons also answered that there were positive changes, such as utilization of television and refrigerator, reduction of cooking time and labor and possibility of night work and/or study.

Since everybody gave positive answers on change of livelihood and living conditions, it is considered that livelihood of the residents were improved by the project as planned. In addition, some residents have a buying motivation for a rice mill machine and/or a weaving machine. The project contributes to activation of local industries.

3.3.2.2 Other Positive and Negative Impacts

(1) Impacts on the Natural Environment

According to the environmental management plan in *Gnod Ou Mini-Hydro Power Project Initial Environment Examination 28 December, 2012 Chareun and Associates Co.Ltd* (hereinafter referred to as "IEE"), it was planned to minimize impacts on natural conditions by watering for mitigating air pollution, construction of a temporary sedimentation pond for

[9] Department of Planning and Investment of Phongsaly Province: 1 (male), Office of Planning and Investment Gnod Ou District: 2 (male), shop owners: 2 (female), residents: 21 (12 (male), 9 (female)) (With regard to interviewees, each organization selected appropriate staff after recognizing main purpose of the survey. Shop owners and residents were significantly selected from rural communities closest to Ou Tai, where distribution networks were laid, considering gender balance.)

mitigating water pollution, etc.

It was not possible to confirm whether various mitigation measures described in the IEE were actually implemented and/or whether the natural environment was kept within environmental standards. According to DDEM, there were no adverse impacts on environmental and no complaints from the residents. According to the contractor's monthly progress report of December 2014 (earthworks were almost finished by that time), water quality of that month conformed to environmental standards as shown in Table 6.

Table 6 Results of Water Testing in December 2014

Item	Location	Dec. 15	Dec. 31	Standard	Judgement
Power of Hydrogen	Upstream	7.5	7.5	6.6-9.5 (EU)	○
	Downstream	7.5	7.5		○
Dissolved Oxygen (mg/l)	Upstream	6.0	7.0	>5 (Japan)	○
	Downstream	6.0	7.0		○

Source: Monthly Progress Report No.14 (December 2014)

Therefore, although it was no possible to obtain an evidence, such as environmental monitoring reports, it is thought to minimize the environmental pollution by construction of the plant, according to response from DDEM and the result of water testing at the time of near completion of earthworks by contractor.

(2) Resettlement and Land Acquisition

There was a need of compensation of crops on the Government land (0.8 ha), and it was planned to compensate in accordance to *JICA Guidelines for Environmental and Social Considerations* and Laws of Lao.

According to the IEE, stake holders meetings were held in September and December 2012. Acquisition of land was not necessary, however the IEE estimated amount of compensation for loss of livelihood (loss of crop production/income for three years) of the rice fields of 2.66 ha (13 families) that would be subject to occasional flooding, and a corn garden of 0.8 ha that would be affected by construction of penstock in accordance with *Technical Guidance on Compensation and Resettlement of People Affected by Development Projects (Decree 192/MONRE)*. According to hearing from IREP, compensation was made by provision of alternative land instead of monetary form. According to hearing from DDEM, the compensation was adequate and there was no complaint from people affected by the project.

It was not able to confirm details of the compensation of crops, etc., but it is thought to be properly implemented.

There are some positive qualitative effects, such as reduction of number of power outages, improvement of voltage stability and promotion of introducing renewable energy in area around

the project, but for the achievement rates of quantitative effects, installed capacity and plant factor in 2017 was 54.6%. Therefore, effectiveness of the project is fair. Improvement of livelihood of residents and activation of local industries were found in qualitative effects, but reduction of greenhouse gas was 62% of the amount expected in the planning stage. Therefore, impacts of the project is fair. There were no notable unintended positive/negative impacts.

In light of the above, this project has achieved its objectives to some extent. Therefore effectiveness and impacts of the project are fair.

3.4 Sustainability (Rating: ②)

3.4.1 Institutional / Organizational Aspect of Operation and Maintenance

It was considered in the planning stage that the mini-hydropower plant would be owned by PDEM and operated and maintained (plant operation, inspection and maintenance, replacement of spare parts and business management) by SPO. However, the contract between PDEM and SPO requires SPO to conduct operation, maintenance and management of the dam and monitoring, record and report of generation, but does not require to conduct periodic inspection and replacement of spare parts. It specifies that SPO shall solve any problems of the plant jointly with PDEM, however SPO has not conducted periodic inspection and replacement of parts. There were changes in organization that is introduction of inspection by DDEM and no involvement of IREP in P-REF management.

In regard to manpower, staff in Rural Electrification Division of IREP increased from 4 persons at the time of planning to 5 persons, and staff in Energy Division of PDEM increased from 10 persons to 12 persons. Staff in Energy Division of DDEM and in SPO were 3 and 3 persons (including 2 engineers) respectively.

DDEM has been inspecting the plant twice a month and reporting to PDEM monthly. SPO is required to submit monthly reports to PDEM and IREP, but the report was not submitted sometimes. It is undesirable in management of P-REF that monitoring and audit of P-REF account by Provincial Department of Finance (hereinafter referred to as “PDOF”) have not been made and that PDEM does not fully understand details of the balance of P-REF.

Ownership of the distribution networks were transferred to EdL, and EdL operates and maintains them together with other distribution networks as planned.

Therefore, in regard to institutional aspect of operation and maintenance of the mini-hydropower plant developed by the project, it has concerns for fund management.

3.4.2 Technical Aspect of Operation and Maintenance

It was considered in the planning stage that an organization that had sufficient technical and financial capability would be selected as SPO and that PDEM, which would monitor SPO, needed strengthen its capacity through a soft component of the project although it had

foundation for monitoring SPO through experiences of management of operation and maintenance of existing Nam Ngay hydropower plant and Mai hybrid plant in the province.

At the time of the field study, all of the trainees who received trainings in the soft component, worked for PDEM and DDEM. Operators of SPO are university graduates and received trainings in the soft components. However, the company selected as SPO had no experience of O&M of a power plant, but had only experience of O&M of power distribution networks (including transformers). Their technical capability of operation, maintenance and management of the power plant is limited. The SPO have been relied on an external volunteer when a technical trouble occurred, and it took quite a while to take countermeasures including coordination with PDEM.

The O&M manual prepared by the supplier were kept in PDEM, and there was no O&M manual in the plant. DDEM has been conducting inspection of the mini-hydropower plant and dam twice a month. However, there is no checklist and/or handbook for inspection. In the planning stage, it was understood "Aside from an operation manual, which will be prepared by a supplier of the equipment, more simplified but useful O&M manual is needed for plant operators to carry out daily patrol, periodical inspection, O&M recordings, O&M activities before/during/after floods, troubleshooting in abnormal situations, and communication with the substation near the border, etc.", and "Japanese Consultant will prepare a draft of O&M manuals in Lao language using figures, photos and illustration in order for operators to easily understand." in the soft component. However, O&M manual for the plant, which can be understood easily by the operators, was not prepared, and only O&M Manual for Civil Structures in English was prepared. In addition, PDEM staff did not recognize existence of that manual, when the evaluation team asked PDEM in the field study, although the consultant proposed Laotian side to translate the O&M manual for civil structure into Lao language and its formal utilization, at the completion of the soft component. The absence or non-utilization of such manuals should be resolved as soon as possible in order to implement appropriate operation and maintenance continuously.

It is considered, despite conduct of the soft component, that technical capabilities of SPO and PDEM are inadequate from the facts that SPO does not have an expert who can respond to troubles, and that frequent faulty alarm of the main transformer had been left for a long time.

Therefore, there is a technical concern in operation and maintenance of the plant.

With regard to operation and maintenance of the distribution networks, it was understood in the planning stage that technical level of EdL was sufficient to manage the distribution networks because it provided power supply in the country including rural areas, and EdL branch in Phongsaly operated power transmission and distribution business including operation, maintenance and management of the existing substation (35/22kV) for power import from China, 22kv and 400V distribution lines, metering, collection of electricity fees, etc.

EdL branch in Phongsaly answered to a questionnaire "The distribution networks were constructed by the Japanese side with the same specifications as other distribution networks. Therefore, there is no particular problem in operation and maintenance of the distribution networks." However, the road along the 22 kV distribution lines is a rough dirt road, so that it is considered that inspect work is not easy.

Taken together, there are technical concerns in operation, maintenance and management of the facilities and equipment constructed by the project.

3.4.3 Financial Aspect of Operation and Maintenance

For the mini-hydropower plant, it was planned in the planning stage to establish P-REF for management of the fund for the future overall and replacement of the plant.

Financial conditions of P-REF was reviewed in this ex-post evaluation. As a result, Table 7 shows balance of P-REF. P-REF has been receiving a half of income from sales of power to EdL in US Dollar and another half in Lao Kip. SPO deducts SPO's expenses (operation and management cost), receives 40% of the net profit as O&M charge, and transfers 60% of the net profit to P-REF account.

Table 7: Balance of P-REF (Unit: LAK)

	2015	2016	2017
Power Sale Income	634,290,613	547,198,332	461,546,799
Cost of SPO	154,175,000	152,510,000	139,200,000
O&M Charge	191,807,020	156,988,841	128,939,533
Income to P-REF	288,308,593	239,200,124	193,407,266
P-REF Expenditure	0	22,122,090	146,142,139
Balance of P-REF	288,308,593	217,078,034	47,265,127

(Unit: US$)

	2015	2016	2017
Power Sale Income	51,911	67,893	55,711
Cost of SPO	0	0	0
O&M Charge	20,764	27,157	22,284
Income to P-REF	31,146	40,736	33,427
P-REF Expenditure	0	0	0
Balance of P-REF	31,146	40,736	33,427

Source: Data provided by PDEM

Total income from the sales of power to EdL at the end of 2017 was approximately US$ 350 thousand, and 60% of the net profit after deducting SPO's operation and management cost of about US$ 60 thousand was transferred to P-REF. The fund remained in P-REF as at the end of 2017 was approximately US$ 174 thousand. This is nearly equal to only 1.2 years of the amount estimated in the preparatory survey. This is because the total generation was only 61% of the planned volume and the total amount paid to SPO (cost of SPO + O&M charge) was approximately 30% more than the estimated amount of LAK 379 million per year in the

preparatory survey.

As described in section 3.3.1.1, the power sale income will stay less than the planned amount, if the problem of decrease of effective head in the rainy season is not solved. In addition, increase of P-REF expenditures is envisaged for procurement of new spare parts, increase of troubles by aging and periodic overhaul. Therefore, P-REF should be managed carefully.

It was recognized in the planning stage that "Most of income of EdL is from sale of power in the country, and most of expenditure is for import of power and buying power from independent power producer. Income and expenditure steadily are increased as the power demand increase. During 2008 to 2011 EdL run a loss only in 2011, main reason for the loss was the fact that power generation sector was spun off into a separate company in December 2010 and that fund was flown out for power purchase."

Table 8 summarizes profit and loss of EdL (consolidated balance including power generation company).

Table 8: Profit and Loss of EdL (Unit: Million LAK)

	2014	2015	2016
Operating Income	3,276,662	3,695,640	4,273,879
Operating Expenditure	2,963,655	4,018,523	4,664,194
Operation Profit	313,007	-322,883	-390,315
Non-operating profit	10,788	350,747	-339,287
Net profit	323,795	27,864	-729,598

Source: Data provided by EdL

Profit had a surplus in 2014, but a deficit in 2015 and 2016. Net profit had a surplus due to make up for a loss by non-operation profit in 2015, but a deficit in 2016. Main reason for deficits were negative spread between a price of power purchase from independent power producer and sales price to customers, and import of electricity from foreign country in dry-season.

Taken together, there is financial concern in operation and maintenance of the facilities and equipment developed in the project.

3.4.4 Status of Operation and Maintenance

The following problems were observed at the time of the field study.

- Frequent shutdown due to the faulty alarm of the main transformer in simultaneous 3 units operations had been left for a long time, but according to the SPO's operators it was remedied by replacing a thermometer with its spare in September 2017.
- Data logger was broken in June 2016, and has been unusable. A quotation from the supplier was expensive as JPY 910,000 for only investigation of the cause. Therefore, the data logger has not been repaired, and operators have been recording operating status in handwriting. Possibility of purchasing similar product from third country was being

considered at the time of field study.

- Concrete blocks for river bed protection were washed out by the flood, and rearranged at the end of the defect liability period. However, the concrete blocks were washed out as shown in Figure 2 again after two months (in September 2016), and have not been repaired yet. Repair by using P-REF has been considered at the time of field study.

Figure 2: Washed out Concrete Blocks

- With regard to the distribution networks, one pole of 22 kV distribution line constructed by Japanese side is inclined as shown in Figure 3. It may not be in a critical situation, but it is necessary to pay attention to the expansion of inclination during periodic inspections.

Figure 3: Slanting Pole

These situations of operation and maintenance are undesirable. Although it is noteworthy that countermeasures by using P-REF were being considered, there is a concern when and how it will be done. It is necessary for ensuring execution of the countermeasures to undertake technical improvement as soon as possible.

Taken together, there are problems in operation and maintenance of the facilities and equipment developed in the project.

The field study made clear the following facts; audit of P-REF account by PDOF have not been made; there were no expert who can respond to troubles in SPO; there was no O&M manual at the plant; and there was no checklist for periodic inspections by DDEM; it will be not possible to earn power sale income as planned, if the decrease of effective head in the rainy season is not solved; and the broken data logger and washed out concrete blocks for river bed protection have been left for a few years.

In light of the above, some minor problems have been observed in terms of the institutional aspect, technical aspect, financial aspect and current status. Therefore sustainability of the project effects is fair.

4. Conclusion, Lessons Learned and Recommendations

4.1 Conclusion

The project aimed at promoting utilization of renewable energy, contributing to reduction of greenhouse gas emission, and promoting electrification in rural areas by constructing a mini-hydropower plant and distribution networks in Gnod Ou District, Phongsaly Province, thereby contributing to the socio-economic development of the country. The 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. With regards to efficiency of the project, the project cost exceeded the plan although the project period was within the plan. Therefore, efficiency of the project is fair. Qualitative effects of the project are observed, but achievement of operational indicators, such as plant factor and generation of mini-hydropower plant are below the targets. Therefore, effectiveness and impacts of the project are fair. With regards to operation and maintenance of facilities, some minor problems have been observed in terms of the institutional aspect, technical aspect, financial aspect and current status. Therefore, sustainability of the project effects is fair.

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

4.2 Recommendations

4.2.1 Recommendations to the Executing Agency

(1) Recommendations to PDEM

PDEM should implement, without delay, repair or replacement of the data logger and restoration/improvement of the concrete blocks for river bed protection. In addition, PDEM should develop, as soon as possible, an O&M manual in Lao language for operators of mini-hydropower plant and inspection manual/checklist for DDEM staff by referring to the O&M manual for the plant prepared by the manufacture. PDEM should make SPO hire a part-time expert, prepare periodic inspection and maintenance plans urgently, and conduct periodic inspection and maintenance according to the plans.

It is preferable to confirm the rise in water level of the downstream during the rainy season, to consider possibility of lowering the water level, to confirm financial validity of countermeasures, and to take appropriate measures.

(2) Recommendations to PDOF

P-REF is important for securing funds for operation and maintenance in the future including procuring spare parts and rehabilitation of the plant after 25 years. P-REF should be managed more carefully under the present circumstances, in which income is lower than the plan. Therefore, PDOF should audit cash flow of P-REF in the past, and then conduct regular audits thereafter.

(3) Recommendations to EdL

The slanting pole in Figure 3 was found out along the way to interview of villagers, and all poles constructed by the project were not checked. Because such a condition was observed in less than three years after the end of the defect liability period of the distribution networks in June 2015, other poles should be check. It is not desirable to increase tension of the cable due to the slanting pole. Therefore, EdL should regularly inspect the poles, follow-up slanting conditions, and take appropriate measures if inclination increases.

4.2.2 Recommendations to JICA

JICA Laos Office should monitor implementation of the above-mentioned recommendations by the executing agency, and provide advices as necessary.

4.3 Lessons Learned

Establishment of Appropriate Executing Organization

The preparatory survey of the project found that while the Ministry of Energy and Mines had a lot of experiences of power development projects, organization of IREP was insufficient. However, IREP was responsible for the implementation of the project, and it was not possible to organize sufficient participation and cooperation of other departments such as Department of Energy Business, which had the experience of selection of and contract with SPO. The weakness of the executing organization is one of the factors that caused some problems for operation and maintenance. When planning and implementing a project, it is necessary to establish a system that can effectively utilize overall capacity of the executing agency as necessary, after checking the organization and technical capacity of the department(s) that actually handle the project.

IREP told in the field study that the project was positioned as the pilot project for establishing a fund to cover the operation and maintenance costs. However, such descriptions were not in the preparatory survey reports or documents from JICA. When establishing a project organization, it is necessary to discuss and have a common understanding between JICA and executing agency during the preparatory survey, and to record the results in the minutes of discussions.