Local Government Unit of Puerto Galera

Republic of the Philippines

Pilot Survey for Disseminating SME Technologies for Developing Non-Electrified Communities by Micro-Hydropower

Summary Report

May, 2016

Japan International Cooperation Agency

Kita Machinery Co., Ltd.

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1. Background

Infrastructural development is imperative in Asia. The Philippines is not an exception. The Medium-term Philippine Development Plan for 2010-2016 under the Aquino administration pursues infrastructural development through public-private partnerships (PPP) to boost the country's economic growth and to achieve social development. In reality, however, the plan has been hindered by dire public finances.

(1) Electric power supply and electrification

Continued increase in power consumption is expected in the Philippines in keeping with its demographic growth. For this reason, harnessing new sources of power is one of the country's highest priorities, along with making the existing power supply more reliable. Any oil price hike significantly affects this oil-poor economy that depends largely on imports from the Middle East.

The government of the Philippines is trying to develop alternative energies to oil and to boost the country's energy self-sufficiency. The vigorous efforts in the development of renewable energy have resulted in a 21% share of hydropower and a 12% combined share of solar, wind, biomass, and geothermal power generation.

Unfortunately, all major hydropower plants (which represent 69% of the hydropower capacity) are concentrated in Luzon. More than 7,000 other islands in the country are left behind because of the difficulty in constructing large-scale hydropower plants. Geological constraints also preclude network extension for power transmission and distribution. Some areas remain without access to electricity even today.

As an alternative to reliance on power grid extension, off-grid power sources are being introduced to supply power to these areas with small-scale renewable sources of energy, such as micro-hydropower and photovoltaic power generation. The development of micro-hydropower is spearheaded by the National Power Corporation Small Power Utilities Group (NPC-SPUG), the country's utility company, along with the Department of Energy (DOE) as an administrative agency that develops energy plans and regulates the power sector in the Philippines. The National Electrification Administration (NEA) under the DOE's jurisdiction also is driving electrification of remote areas with micro-hydropower.

(2) Water supply

Besides power supply, other infrastructural development is trammeled by the fact that residents of small barangays are scattered across the islands.

Although 83% of the population has access to safe drinking water, over half of the national territory has greatly limited access to water supply. In each of the provincial cities and municipalities in the Philippines, a Water District (WD) operates and maintains a water supply system as a local corporate entity under the competent Local Water Utilities Administration (LWUA). Officially, the LWUA extends loans and provides managerial and technical assistance to these WDs to encourage development of provincial water supplies and their sound management. Unfortunately, the water quality is often compromised as many small-scale water supply systems managed by WDs carry untreated water from deep wells.

(3) Transportation

Motorized tricycle taxis are a popular means of cheap short-distance transportation in the Philippines. Exhaust fumes from their poorly designed engines and mufflers contain not only a large amount of carbon dioxide, but also other air pollutants like nitrogen oxides (NOx), sulfur oxides (SOx), and particulate matter (PM). Motorized tricycles account for over half of the total vehicles, and thus greatly influence energy consumption and the environmental load in the Philippines.

Against this background, the DOE has launched a project to introduce electric tricycles as a part of their efforts to ensure stable energy supply and efficient energy use in the transportation sector. The project aims to put 100,000 electric tricycles on roads by 2016.

2. Outline of the Pilot Survey for Disseminating SME Technologies

(1) Purpose

This project was intended to offer a solution to challenges faced on islands and in mountainous regions through a pilot survey conducted in Oriental Mindoro to validate the effectiveness of a system built around small hydro-generators that integrates a water purifier, an electric tricycle, and LED lighting. The system was designed to supply power to areas that had no access to electricity, as well as to provide improved sanitation and better means of transportation. Including a small hydro-generator as the main component, the system has:

- Component A: Small hydro-generators (crossflow model and screw model)
- Component B: A small water purifier
- Component C: LED lighting
- Component D: An electric tricycle

Attention was paid to the following potential benefits from this system in the pilot survey.

- Power supply to non-electrified areas
- Supply of drinking water to residents around the demonstration site
- Improved nighttime security by LED lighting in the demonstration site
- Improved transportation access for local residents and reduced environmental load provided by an electric tricycle introduced to the demonstration site

- Vitalized community with an increasing number of tourists coming to the demonstration site

(2) Activities

1) Component A: Small hydro-generator (crossflow model and screw model)

a) Field study and design

A field study was conducted at Tamaraw Falls to figure out what specifications are needed for the water turbine generators to be installed there. In addition to the installation site for the generator, the water intake site was also checked to roughly measure the head and flow of the water. The study confirmed a flow of more than 40 l/s except for during the dry season when the flow is diminished and the head is more than 36 m.

Installation methods for a crossflow generator were considered for the intended installation site downstream of Tamaraw Falls while ensuring that the water outlet will be above the water level of the river. Based on the measurement results of the flow and head, the following specifications were applied to the crossflow generator.

- Effective head: 10–30 m
- Flow: 20–40 l/s

Installation of a screw generator was planned before the water intake of the crossflow generator in order to ensure sufficient flow speed. In consideration of the following issues, complete waterproofing was chosen for the generator unit instead of simplified waterproofing as initially planned.

- The screw generator for this pilot survey is usually installed in a place with minor changes in the water level. Hence, waterproofing of the standard model is simplified. However, the intended installation site experiences major changes in the water level due to squalls.
- It is difficult to evacuate the generator to a higher spot in time in response to a sudden change in the water level caused by a squall. The risk of the submersion of the generator cannot be excluded.
- Total waterproofing of the generator can ensure continued operation of the generator even during squalls.

In order to supply power from the generators to their components, wiring routs were considered and the specifications (e.g., wire sizes) were determined for satisfying allowable voltage drop and other technical requirements. Cables were selected with due consideration to the distance and topography from the generators to the distribution board. Figure 2-1 presents the wire connection between respective components.

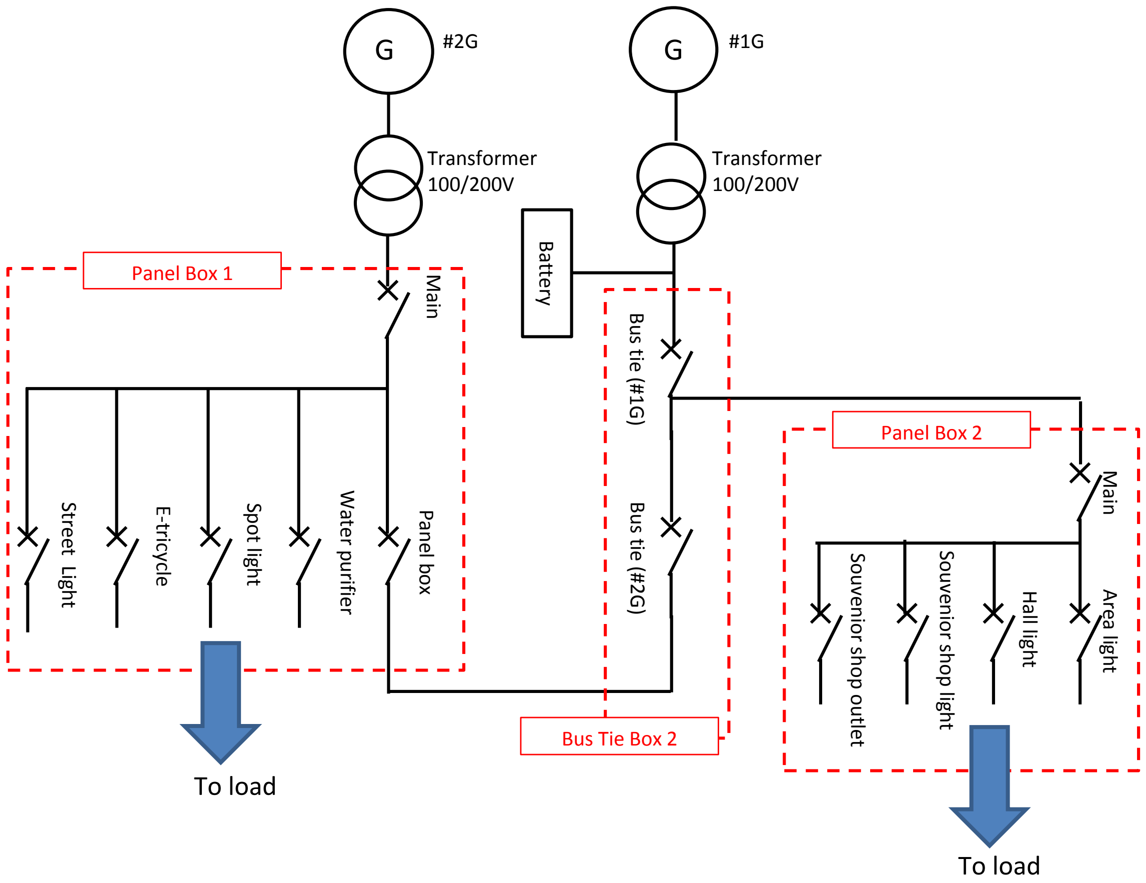

Figure 2-1 Connection diagram

b) License

According to the prior confirmation, no special procedures were necessary for installing water turbine generators and other components as explained below.

(Licensing)

Consultation with the DOE regarding the licensing requirement for installation of hydropower equipment confirmed that there are no licensing requirements for the installation of water turbine generators of the intended scale not involving sale of the generated power.

(Environmental impact assessment)

Consultation with the city of Puerto Galera and the Department of Environment and Natural Resources (DENR) as a concerned agency found that this project does not require environmental impact assessment. The necessary Certificate of Non-Coverage (CNC) was obtained after submitting the required documents to the DENR.

(Water rights)

Consultation with the National Irrigation Administration (NIA) and the waterworks department of Puerto Galera confirmed that water rights do not need to be obtained for the water turbine generators and small water purifier.

c) Procurement and transportation

A local contractor was given specifications for the procurement of locally available materials for foundation work, such as reinforcement bars, cement, and wiring. Chemical anchors, anti-rust paint, and other materials that need to meet strict quality requirements were purchased in Japan and provided to the local contractor.

The import and local transportation took place in the following manner:

2015.1.8	Departure from the port of Tokushima
2015.1.19	Arrival at the port of Manila
2015.2.24	Materials and equipment were transported to the warehouse managed by ISHIDA PHILIPPINES TUBE
2015.4.10	The crossflow generator was transported to the project site
2015.5.8	The remaining materials and equipment were transported to the project site

d) Installation

Civil engineering and other foundation work for the equipment needed to be completed before the rainy season. Keeping this in mind, a coordination meeting was organized with the local contractor to agree on details, including installation spots, dimensions, and arrangement of reinforcement bars. The civil engineering work began in March 2014 and was completed in April 2014. The progress was monitored periodically by a hired supervisor.

The installation was carried out in May 2015. Operation tests were conducted after the installation to measure the frequency, voltage, and current of generated power, which demonstrated that the power was generated properly. A flow regulator was prepared because the flow was exceptionally low during the operation tests.

The instruction manuals obtained from manufacturers were compiled for the person in charge to perform maintenance and inspection of installed equipment. A workshop was organized after drafting the maintenance manual, which explained the frequency of regular inspections, checked items, and tips for troubleshooting. In the drafting process, attention was paid to facilitate visual understanding of the operating procedure by including photos and illustrations of equipment on the site.

2) Component B: Water purifier

a) Field study and design

Intake of the raw water for the purifier was prepared at the top of Tamaraw Falls. The natural flow of water can be captured by the water intake pipe installed in the channel at the top of the waterfall and introduced to the purifier. This saves power consumption by eliminating the need for a water intake pump.

The water of Tamaraw Falls was sampled for a quality test at the waterworks bureau of Batangas in order to ensure that it would be potable after treatment. The test found that the water can become potable after disinfection and sterilization, albeit with a slightly high potential of hydrogen. The water was classified as AA river water[1] according to the Philippine National Standard for Drinking Water 2007.

The treated water was designated as drinking water in the barangay of Villaflor rather than in tourist facilities of Tamaraw Falls as the barangay, which does not have a purified water supply, can benefit more from safe drinking water.

Required specifications for the purifier were extracted by discussing the challenges to ensuring that it can be employed more extensively in the water supply system. Namely:

- Avoid higher manufacturing costs
- Assess the needed amount of treated water
- Adopt a switchboard design to enable local repair
- Employ components that can be procured in the Philippines
- Ensure proper treatment of swollen flow of muddy water

For more extensive application of the small water purifier for drinking water in the future, necessary specifications were discussed to address the above requirements. The initial specifications required manual operations to inject chemical additives for disinfection or to convey water. The specifications were modified to perform these tasks automatically by adding sensors and controllers. As a result, semiautomatic operation of the purifier was ensured with the new specifications (manual washing of the purified water tank). The modification introduced an automatic drinking water feed system that responds to a reduced level of water inside the tank so that operation can continue unattended.

b) Procurement and transportation

The equipment was procured in Japan and transported to the Philippines in the same shipment as the water turbine generators.

[1] AA river means river carrying water with quality that complies with the Philippine National Standard for Drinking Water (PNSDW) after a certain disinfection and sterilization process.

c) Installation

The equipment was transported and installed at the project site in May 2015. Concurrently with the installation, the assembly method of the equipment was explained to the local person in charge of repair. After the installation, the pump and other components were started up to make sure they operate properly. For proper maintenance and management, a workshop was organized for the people in charge of operation and maintenance.

3) Component C: LED lighting

a) Field study and design

Places for installing lights were determined after consultation with the city of Puerto Galera and the barangay of Villaflor to find out where the greatest need for lighting was.

・ Street lights for safe passage and safety around Tamaraw Falls
・ Spotlights for better night view of Tamaraw Falls
・ Barbeque area for extended business hours

In response to these needs, specifications for electric wiring and lighting devices were considered after discussing the necessary lighting intensity, wiring route that does not interfere with the public, and ways to minimize voltage drop.

b) Procurement and transportation

The equipment was procured in Japan and transported to the Philippines in the same shipment as the water turbine generators.

c) Installation

In May 2015, foundation work was carried out followed by installation of lighting poles and LED lamps. After their installation, the lamps were checked to make sure they light up properly.

4) Component D: Electric tricycle

a) Field study and design

Normally, electric tricycles are designed for urban transportation. In this project, an electric tricycle is employed under unintended conditions involving travel over ups and downs on winding roads around the site. We consulted the manufacturer, BEMAC, regarding the unique driving conditions and necessary specifications. The discussion and desk research proved that their electric tricycles can be used in the project site.

In order to verify the desk research, a prototype electric tricycle owned by BEET Philippines, a subsidiary of BEMAC, was borrowed for a test run from the government building to Tamaraw Falls. The tricycle was able to handle the mountainous road, proving that it is possible to deploy the electric tricycles.

According to the initial specifications, the charger for the electric tricycles was supposed to be installed separately. Instead, a built-in charger was adopted to prevent theft and simplify the construction work on the site.

b) Procurement and transportation

The equipment was procured in Japan and transported to the Philippines in the same shipment as the water turbine generators.

c) Installation

Thanks to the built-in charger of the electric tricycle, only a power socket needed to be installed on the site. Proper charging was confirmed after the installation in May 2015.

5) Establishment of organization for operation and maintenance

The construction and operation of respective components for this project are relatively simple. However, they demand regular maintenance and replacement of supplies. For sustainable system operation after introducing these components, it is necessary to set up a maintenance and management organization with an established operation procedure, as well as to finance the operation, maintenance, and management. Necessary measures are discussed here.

a) Organization

Maintenance and management of the water purifier as one of the components employed in this project are necessary to continuously supply safe drinking water with due consideration to public health. This survey revealed that the barangay of Villaflor, despite a vague concern over drinking water, did not have a water supply system and the residents had little knowledge on how to maintain the quality of drinking water. A maintenance and management organization consisting only of residents of the barangay would require a lot of time for them to acquire the requisite knowledge. There is a concern as to their ability to sustain the maintenance system. Meanwhile, the city of Puerto Galera has a designated department for operating and managing water supply systems with knowledge on water quality control.

Operation and maintenance of water turbine generators and the electric tricycle require electrical expertise. The city of Puerto Galera has a department dealing with electricity that is staffed with electricians. There are also maintenance crews for vehicles owned by the city. Proper project implementation is deemed possible if the city takes charge of the maintenance of the generators and the tricycle.

For the above reasons, the survey team proposed that the city establish an organization led by the city rather than the barangay in order to maintain and manage the small hydro-generators and all other components. After the consultation, the city of Puerto Galera adopted the proposal from the team to establish a maintenance and management organization led by the city.

Five people in charge were deployed to the project site. Lines of communication were defined respectively for regular operation and maintenance, and for troubleshooting the components. Two engineers from the city were assigned for troubleshooting the components.

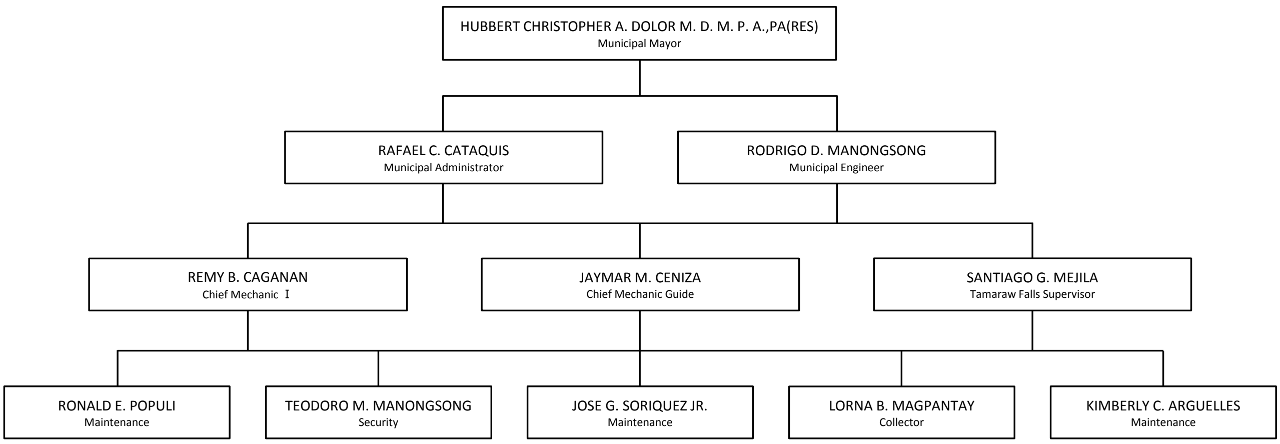

Figure 2-2 Organization chart

b) Revenue and expenditure

In addition to routine operational checks and cleaning, it is necessary to regularly replace parts and replenish supplies. Components used in this project require the following maintenance, replacement parts and supplies.

- Screw hydro-generator

  Replace bearings, gaskets, O-rings, and so forth every year.

- Crossflow hydro-generator

  Replace bearings after every 20,000 hours of operation (roughly two years).

- Water purifier

Replenish polyaluminum chloride (PAC) as coagulant and chlorine for sterilization. Daily consumption amounts to around 40 grams of the coagulant and 200 grams of the sterilizing agent.

- Electric tricycle

  With normal charge and discharge cycles, the battery needs to be replaced roughly every seven years.

The city of Puerto Galera plans to allocate part of entrance fee revenue from tourists visiting the falls to cover the expenses for regular operation, maintenance, and part replacement.

6) Demonstrative test

a) Operation test of hydro-generator

In the test run, the crossflow hydro-generator was checked to ensure proper operation and stable output without vibration, overheating, or any other abnormalities. In response to discovering that the flow of the falls drops below the initially envisaged level, a new flow regulator was prepared to ensure stable operation even with the reduced flow. Anticipated power output is presented in the following table.

In addition, the screw hydro-generator and the control panel were checked to make sure they operate normally while the crossflow hydro-generator is operating.

These two water turbine generators have simple structures. It was verified that their operating methods were simple enough for local people in charge to operate and maintain them.

Table 2-1 Calculation of annual generated power

Operational conditions		
Flow regulator	Flow rate	Operation period
Large regulator	10 l/s	seven months of operating during the dry season from November to May
Small regulator	20 l/s	three months of operating during the rainy season from June to October
No regulator	40 l/s	two months of operating during the rainy season from June to October

	Dry season	Rainy season
Power output (kWh)	3,629	12,139

Total annual power output **15,768 kWh** (capacity factor of 36%)

b) Operation test of water purifier

The quality of water met the standards according to the examination conducted after installation of the purifier.

Table 2-2 Result of water examination

Parameter	PNSDW Standard		Result		
	Acceptance Criteria (Maximum Level)		Before Purification	After Purification	
Turbidity	5	NTU	0.48	0.10	Passed
Color	5	TCU	<1	<1	Passed
pH at 25°C	6.8-8.5	-	8.25	8.08	Passed
Sulfate	250	mg/L	<5	<5	Passed
Chloride	250	mg/L	5.16	10.32	Passed
Total Dissolved Solids	500	mg/L	144	168	Passed
Iron	1	mg/L	0.0298	not detected	Passed
Manganese	0.4	mg/L	0.0112	not detected	Passed
Cadmium	0.003	mg/L	not detected	not detected	Passed
Lead	0.01	mg/L	not detected	not detected	Passed
Arsenic	0.01	mg/L	0.005	0.005	Passed

Table 2-3 Result of water examination (Bacteriological examination)

Parameter	PNSDW Standard	Result			
	Acceptance Criteria	Before Purified		After Purified	
Total Coliform	Less than 1.1	More than 8.0	Failed	Less than 1.1	Passed
Fecal Coliform	Less than 1.1	More than 8.0	Failed	Less than 1.1	Passed
Heterotrophic Plate Count	Less than 500 CFU/ml	More than 6,500 CFU/ml	Failed	2 CFU/ml	Passed

The survey team has established a method for maintaining the right quality of treated water with the local people in charge by confirming how to adjust the amount of injected agents and operate the purifier during the visit in June 2015. Since then, the treated water has been used by residents of the barangay of Villaflor. During another visit in October 2015, the survey team verified the operation by the local people in charge and found no problems. Residual chlorine concentration was also measured to ensure that the treated water is sufficiently sterilized, and no problems were identified. Thereafter, a daily report was kept to monitor the operation.

	Example			
Water purifier				
How long was the water purifier operated?	2 hours			
Start time of operation	5:00 PM			
Did you do back wash?	Yes			
Finish time of back wash	5:30 PM			
Residual amount of Chlorine before beginning of operating	4L			
Residual amount of PAC before beginning of operating	4L			
Did you make chlorine?	Yes			
Did you make PAC?	No			
Residual chlorine concentration	0.1			
How many plastic containers filled with purified water were transported to barangay in one day?	20			

Figure 2-3 Form for daily water purifier report

c) Operation test of electric tricycle

As mentioned before, the purpose of introducing electric tricycles was to improve traffic environments in major cities like Manila and these tricycles are generally designed for traveling over relatively flat roads. A test run was conducted to ensure that such a tricycle would be able to travel over rugged terrain like the site of this project.

After a round trip between the barangay of Villaflor and the city office of Puerto Galera (approximately 30 km in total), two out of the five battery indicator lamps remained lit. The result of this test run demonstrated that a round trip with six passengers consumes battery power corresponding to three lamps from the fully charged level. The person in charge from the city verified that the vehicle was able to be driven without any operational problems.

The electric tricycle was designated mainly for transporting treated water to the barangay and as a free public taxi for traveling between the barangay, the falls, and the city office of Puerto Galera.

d) Operation test of LED lighting

According to the measurements, the street light consumes 0.32 kW of power to produce necessary illuminance of 10 lx, as designed.

(3) Information of Product/Technology to be Provided

1) Component A-1: Screw hydro-generator

- The propeller turbine of the generator is installed in the flowing water. More than one unit can be installed in parallel according to the width of the channel to increase the output.
- The equipment can generate power even with a little head and little flow. The installation requires simple construction with almost no civil engineering work. Output regulation with the inverter eliminates the need for a device for adjusting the flow, and thereby simplifies the maintenance.

2) Component A-2: Crossflow hydro-generator

- A crossflow turbine was adopted to generate power with low flow and medium head. In order to simplify the structure, the turbine and the generator are coupled by a single shaft to eliminate the need for belt coupling.
- A power generation system can be constructed with, e.g., the main unit of the generator, a reservoir with a capacity of around 1 m^3, and PCV water conduit pipes with an inner diameter of 125 mm or greater. Using these widely available general-purpose materials minimizes the cost of system construction.
- Power generation with extremely low flow (8 l/s, or 1/10 of the maximum flow) is made possible with the use of a flow regulator.

3) Component B: Water purifier

- This rapid filtering purifier can supply two kinds of agents—namely, coagulant and chlorine. The excellent sterilization performance ensures safe water quality.
- The rapid filtering system for this project employs a smaller filter with the same specifications as filters employed in purification plants all over Japan. The smaller filter can perform sterilization and introduce agents, achieving the same performance as the larger ones. Clean water can be produced with a simple installation, which minimizes the running cost of the purification system.
- The self-cleaning filter keeps itself clean for long use.
- The operating power consumption is as low as 650 W.

4) Component C: LED lighting

- The bright LED lamps have a long service life of 60,000 hours (about 16 years).
- Compared to conventional mercury lamps, the LED lamps save energy by roughly 75% and last much longer. They do not need maintenance and attract fewer bugs.

5) Component D: Electric Tricycle

- The vehicle can travel practical travel distance by adopting a lithium-ion battery to provide a lighter tricycle while ensuring a strong body for rugged road conditions.
- The vehicle control unit regulates the motor current according to the road and running conditions to extend the travel distance.

(4) Counterpart Organization

Municipality of Puerto Galera, Oriental Mindoro, Philippines

(5) Target Area and Beneficiaries

Tamaraw Falls, Barangay Villaflor, Municipality of Puerto Galera, Oriental Mindoro, Philippines

(6) Duration

November 2013 to July 2016

(3) Progress Schedule

Task	Person(s) in charge	Period (FY 2013 – FY 2016)
Consultation with the local government	Kosumi, Koyama, Tsuji, Kuwahara, Aki, Fujisawa, Aquino	
Field survey and measurement	Kosumi, Koyama, Tsuji, Kuwahara, Aki, Fujisawa, Aquino	
Data collection from target sites	Kosumi, Koyama, Tsuji, Kuwahara, Aki, Fujisawa, Aquino	
Negotiation with a contractor (local) and hired individuals	Kosumi, Koyama, Tsuji, Kuwahara, Aki, Fujisawa, Aquino	
Discussion of survey methods for candidate sites	Kosumi, Koyama, Kuwahara, Aki, Fujisawa	
Scheduling of field survey	Kosumi, Koyama, Kuwahara, Aki, Fujisawa	
Field survey and measurement (Round 2)	Koyama, Kuwahara, Aki, Fujisawa, Aquino	
Meeting with the local contractor	Koyama, Kuwahara, Aki, Fujisawa, Aquino	
Collection of information on the area	Koyama, Kuwahara, Aki, Fujisawa, Aquino	
Discussion of installation procedure for hydro-generators	Koyama, Kuwahara, Aki, Fujisawa, Aquino	
Preparation of an organization for sustainable operation	Koyama, Kuwahara, Aki, Fujisawa, Aquino	
Consultation and decision on a method for supplying power to non-electrified villages	Koyama, Kuwahara, Aki, Fujisawa, Aquino	
Signing contracts with a contractor (local) and hired individuals	Koyama, Kuwahara, Aki, Fujisawa, Aquino	
Detailed design of hydropower equipment	Kosumi, Koyama, Kuwahara, Aki, Fujisawa, Aquino	
Discussion of system configuration (e.g., hydropower, purification, EV, and lighting)	Kosumi, Koyama, Kuwahara, Aki, Fujisawa, Aquino	
Discussion of procedure for hydropower installation	Kosumi, Koyama, Kuwahara, Aki, Fujisawa, Aquino	
Report of results of designing the hydropower installation and system	Koyama, Kita, Kuwahara, Aquino	
Consultation regarding process and procedure for construction on the site (local government)	Koyama, Kita, Kuwahara, Aki, Fujita, Aquino	
Collection of information related to material procurement and transportation	Koyama, Kita, Kuwahara, Aki, Fujita, Aquino	
Meeting with the local contractor regarding the construction plan and safety plan	Koyama, Kita, Kuwahara, Aki, Fujita, Aquino	
Decision on specifications for distribution equipment and its detailed design	Koyama, Kita, Kuwahara, Aki, Fujita, Aquino	
Fabrication of water turbine generators and related components	Kosumi, Koyama, Kita, Kuwahara, Aki, Fujita, Aquino	
Procurement of the water purifier, EV, and lighting equipment	Kosumi, Koyama, Kita, Kuwahara, Aki, Fujita, Aquino	
Preparation and shipment of components	Kosumi, Koyama, Kita	
Hosting project counterpart in Japan (Takamatsu and Tokushima)	Kosumi, Koyama, Kita, Kanamura	
Procurement of materials and equipment for power distribution and preparation for the construction to install the equipment	Kuwahara	
Preparation for procurement of materials and equipment for civil engineering work for hydropower installation	Kuwahara	
Decision on the organization for sustainable maintenance and operation, and discussion of fee collection system	Kuwahara, Sekiguchi	
Acceptance of components shipped from Japan	Koyama, Sato, Kanamura, Aki, Aquino	1, 1_2
Procurement of materials and equipment for civil engineering work and preparation for the construction	Koyama, Kanamura, Aquino	2
Management of civil engineering work	Kosumi, Koyama, Kanamura	
Installation of head-driven water turbine generators	Koyama, Kanamura, Aquino	3
Installation of water turbine generators, water purifier, EV, and lighting	Kosumi, Koyama, Sato, Aki	4
Operation of water turbine generators, water purifier, EV, and lighting for their adjustment	Kosumi, Koyama, Sato, Aki, Fujita	5
Workshop on the operation of the introduced system	Kosumi, Koyama, Sato, Kanamura, Aki, Fujita	6
Examination and supervision of fee collection and O&M	Kosumi, Koyama, Kanamura, Aki, Fujita	7, 7_2, 7_3
Ceremony for commencement of operation	Koyama, Kita, Kanamura	8
Operation test of hydropower installation and data collection	Koyama, Aki, Fujita	9, 9_2
Interview survey regarding the use of purifier, EV, and lighting	Koyama, Kanamura, Aki, Fujita	10, 10_2
Examination of activities for disseminating technologies	Koyama, Kanamura, Kuwahara	11, 11_2
~~Roll-out seminar (Manila) → Consultation regarding roll-out activities~~	~~Koyama, Kanamura, Aki~~	
Compilation and analysis of operation data, and evaluation and supervision of operation test	Koyama, Aki, Fujita	
Analysis of the results from hearing survey regarding the use of water purifier, etc., and discussion for their improved use	Koyama, Kanamura, Aki, Fujita	
Evaluation of operation test	Koyama, Aki, Fujita	
Report of operation test results of hydropower installation and the system	Koyama, Kanamura, Aki, Fujita	12
Monitoring of fee collection and O&M	Koyama, Kanamura, Aki, Fujita	13, 13_2, 13_3
Consultation for the dissemination of technologies (further business expansion)	Tsuji, Koyama, Kanamura, Kuwahara	14, 14_2
Briefing and consultation regarding correction of the draft final report	Tsuji, Koyama, Kanamura, Kuwahara, Aki, Fujita	15
Correction of the draft final report and drafting of the final report	Tsuji, Koyama, Kanamura, Kuwahara, Aki, Fujita	
Preparation of the final report	Tsuji, Koyama, Kanamura, Kuwahara, Aki, Fujita	
Debriefing and submission of the final report	Tsuji, Koyama, Kanamura, Kuwahara, Aki, Fujita	
Debriefing for the target village	Koyama, Kanamura, Kuwahara, Aki, Fujita	16

Legend: Local task (planned); Local task (actual); Period of task carried out in Japan (planned); Period of task carried out in Japan (actual)

Figure 2-4 Progress schedule

(4) Manning Schedule

Survey Period: FY 2013 – FY 2016

	Assignment	Name	Affiliation		Man/Month Total MM	Days
Tasks at project site	Project chief	Noriko Tsuji	Kita Machinery Co., Ltd.	Plan	0.40	12
				Scheduled	0.47	14
				Actual	0.00	0
	Project chief	Takahiko Kosumi	Kita Machinery Co., Ltd.	Plan	2.00	60
				Scheduled	0.00	0
				Actual	0.43	13
	Supervision of generator installation	Tsuyoshi Koyama	Kita Machinery Co., Ltd.	Plan	3.80	114
				Scheduled	0.47	14
				Actual	4.00	120
	Supervision of water pipe installation	Kazuya Sato	Kita Machinery Co., Ltd.	Plan	1.00	30
				Scheduled	0.00	0
				Actual	0.47	14
	Assistance in supervision of installation	Kensaku Tsuji	Kita Machinery Co., Ltd.	Plan	0.80	24
				Actual	0.43	13
	Assistance in supervision of installation	Shinichi Kita	Kita Machinery Co., Ltd.	Plan	1.80	54
				Scheduled	0.00	0
				Actual	1.13	34
	Procurement management (charging system assistant)	Tomoko Kanamura	Kita Machinery Co., Ltd.	Plan	0.00	0
				Scheduled	0.47	14
				Actual	2.10	63
	(Chief advisor (Effective outsourcing) for business model, development, and roll-out)	Kenichi Kuwahara	Shikoku Electric Power Company	Plan	2.73	82
				Scheduled	0.30	9
				Actual	2.27	68
	(Effective outsourcing) Operation and management of small hydro-generators	Toshio Aki	Shikoku Electric Power Company	Plan	4.37	131
				Scheduled	0.00	0
				Actual	1.97	59
	(Effective outsourcing) Optimal power use	Yoshitetsu Fujisawa	Shikoku Electric Power Company	Plan	1.00	30
				Scheduled	0.00	0
				Actual	0.77	23
	(Effective outsourcing) Optimal power use	Tomohisa Fujita	Shikoku Electric Power Company	Plan	1.57	47
				Scheduled	0.00	0
				Actual	1.13	34
	(Effective outsourcing) Power quality, and social and environmental consideration	Ruben Aquino	INGÉROSEC Corporation	Plan	1.50	45
				Scheduled	0.00	0
				Actual	2.03	61
	(Effective outsourcing) Organization and sustainable operation	Remi Sekiguchi	ICAN (Local NGO)	Plan	1.00	30
				Scheduled	0.00	0
				Actual	1.00	30
	Total MM in the Philippines (planned)				21.97	

Plan: As of 2013.11.8
Scheduled: As of 2015.11.2
Actual: As of 2016.3.5

Commencement ceremony of operation
Roll-out seminar (Manila)

	Assignment	Name	Affiliation		Man/Month Total MM	Days
Tasks in Japan	Project chief	Takahiko Kosumi	Kita Machinery Co., Ltd.	Plan	2.50	50
				Scheduled	0.00	0
				Actual	2.50	50
	Supervision of generator installation	Tsuyoshi Koyama	Kita Machinery Co., Ltd.	Plan	2.50	50
				Scheduled	0.00	0
				Actual	2.50	50
	Assistance in supervision of installation	Shinichi Kita	Kita Machinery Co., Ltd.	Plan	0.50	10
				Scheduled	0.00	0
				Actual	0.50	10
	Chief advisor (Effective outsourcing) for business model, development, and roll-out	Kenichi Kuwahara	Shikoku Electric Power Company	Plan	1.35	27
				Scheduled	1.70	34
				Actual	2.05	41
	(Effective outsourcing) Supervision of operation of small hydro-generators	Toshio Aki	Shikoku Electric Power Company	Plan	1.60	32
				Scheduled	0.50	10
				Actual	2.05	41
	(Effective outsourcing) Optimal power use	Yoshitetsu Fujisawa	Shikoku Electric Power Company	Plan	0.40	8
				Scheduled	0.00	0
				Actual	0.40	8
	(Effective outsourcing) Optimal power use	Tomohisa Fujita	Shikoku Electric Power Company	Plan	1.20	24
				Scheduled	0.00	0
				Actual	1.20	24
	(Effective outsourcing) Power quality, and social and environmental consideration	Ruben Aquino	INGÉROSEC Corporation	Plan	0.80	16
				Scheduled	0.00	0
				Actual	0.80	16
	(Effective outsourcing) Power quality, and social and environmental consideration	Remi Sekiguchi	*ICAN (Local NGO)	Plan	0.00	0
				Scheduled	0.00	0
				Actual	0.80	16
	Total MM in Japan (planned)				10.85	

Activities for receiving equipment in Japan

Plan: As of 2013.11.8
Actual: As of 2016.3.5

Figure 2-5 Manning schedule

(5) Implementation System

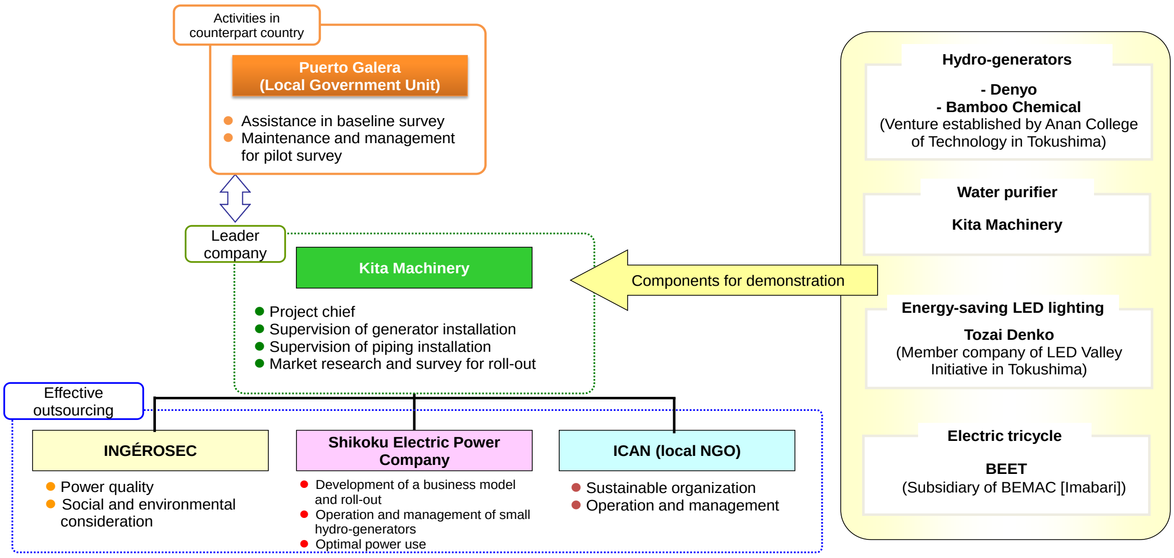

Figure 2-6 Implementation system

3. Achievement of the Survey

(1) Outputs and Outcomes of the Survey

1) Power supply to a non-electrified area

Water turbine generators were installed for supplying off-grid power to the Tamaraw Falls area. Continuous operation with reduced water flow and the resulting wider application of crossflow hydro-generators were achieved by mounting a flow regulator.

The generator with the right flow regulator for the dry season and rainy season in the Philippines is expected to achieve an annual power output of 15,768 kWh. The relatively low capacity factor of 36% is associated with the longer period in which power needs to be generated with drought water level.

The operation schedule of each component was considered. Provided that there is sufficient flow, all components can be operated simultaneously. The scheduling only needs to take into account the period when the flow is diminished. Figure 3-1 presents the schedule developed while taking the needs of each component into account.

	Hour																									
	6		7		8		9		10		11		12		13		14		15		16		17		18	
#2G (small socket)	Generation																		Generation (also at night)							
#2G (large socket)																	Generation									
Total power output (kW)	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	2.3	2.3	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
Electric tricycle (3 or more charge indicator lamps: 0.6 kW)	Barangay → Falls						Charge						Falls → PG city office → Falls or Falls → Barangay → Falls				Charge								Falls → Barangay	
Charge indicator lamp	4	4	4	4	4	4	4	4	4	4	4	5	5	5	2	2	2	2	3	3	3	3	3	4	4	4
Water purifier (0.4kW)			Operation										Operation											Backwash		
LED (0.3kW)	Light																								Light (also at night)	
Total load (kW)	0.3	0.3	0.4	0.4	0.4	0.4	0.6	0.6	0.6	0.6	0.6	0.6	0.4	0.4	0.4	0.4	1.2	1.2	0.6	0.6	0.6	0.6	0.6	0.4	0.3	0.3
Business hours at the falls			Business hours																							

Figure 3-1 Operation schedule of each component

2) Supply of safe drinking water

A water purifier was installed at the falls to supply drinking water that meets the Filipino standards for residents of the local barangay for improved sanitation and better living environments. The daily supply of water ranges between 360 and 500 liters. The newly installed water turbine generator produces enough power to run the water purifier.

3) Enhanced security due to installed LED lighting

The newly installed LED lighting attracted tourists during the night, and this visibly discouraged crimes. As a matter of fact, about four cases of theft occurring every year have been brought down to zero ever since the lights were installed. The security around Tamaraw Falls has been enhanced.

4) An increased number of tourists owing to the LED lighting

An interview with the local people in charge revealed that many people visit to see the illuminated falls at night. At the moment, tourists cannot enter the resort with access to the falls because the city authorities have not extended the business hours. A significant growth in the number of visitors can be expected from the extension of the business hours, which will translate into increased revenue from the entrance fee.

5) Improved transport access owing to the electric tricycle

The electric tricycle from this project is used between the barangay, Tamaraw Falls, and the city office of Puerto Galera to provide more convenient means of transportation for residents of the barangay, whose option used to be limited to share taxis called *jeepneys*. The battery of the tricycle is charged by the water turbine generators for free rides to help save expenditures of local residents. The tricycle can save 10,000 pesos (about 26,000 yen) annually compared to the scenario where 100 passengers travel to the city office by paying 100 pesos per person for each *jeepney* ride.

6) Validation of the system

The survey found that remote barangays need more infrastructure for power and water supply, as well as better transportation. The purifier and electric tricycle introduced in this project can be operated with the relatively low power produced by micro hydro-generators which have capacities on the order of several kilo watts.

The water turbine generators introduced in this project not only require little effort in terms of maintenance and operation, but also generate power with a wide range of flow levels when aided by a flow regulator.

The system integrating these water turbine generators, purifier, and electric tricycle can be applied to a small stream of water and the range can even be expanded by devising the right operation method for each component while taking the respective power consumption into account.

(2) Self-reliant and Continual Activities to be Conducted by Counterpart Organization

Interviews at the project site and the city of Puerto Galera verified that the tasks assigned for operation, inspection, cleaning, and other maintenance work, as well as the communication line are clearly defined.

According to the verification, records of operation and maintenance were kept daily using the designated form and were duly archived. The maintenance and management of equipment were properly conducted by the designated organization.

Self-reliant and sustainable: the system is expected to be operated in a sustainable and self-reliant manner as the city of Puerto Galera can cover necessary maintenance and management costs with the revenue from the entrance fee to the falls.

4. Future Prospects

(1) Impact and Effect on the Development Issues through Business Development of the Product/Technology in the Surveyed Country

Given the country's precipitous mountains and rainy weather conditions, there are suitable places for micro hydropower generation all over the Philippines. Moreover, mountainous tribes actually live in these places without access to the electricity, safe drinking water, and viable means of transportation they need. For this reason, this pilot survey was necessary.

At the moment, the following impacts can be expected from the pilot survey to address the challenges to community development.

1) Power supply to non-electrified areas

In this pilot survey, small water turbine generators were employed to supply power to public facilities around a falls, which is expected to attract more tourists as the business hours of the facilities can be extended and safe water can be provided. LED lighting can extend the hours of the trail to the falls, which are illuminated at night, offering a completely different experience than during the day. The attraction will lead to a greater number of visitors and a corresponding increase in revenue from the entrance fee. Nearby shops can also expect growth in revenue.

Street lights will help prevent car accidents during the night. Visits by tourists at night will also discourage and prevent crimes.

2) Enhanced sanitation with simplified drinking water purification system

Safe drinking water is freely distributed to the local barangay in addition to its availability at the falls in order to provide better services to tourists. Earlier, residents used to rely on well water or spring water from mountains. The practice often caused diarrhea among infants and sometimes typhoid even among adults. These problems will be resolved thanks to the safe water supply.

(2) Lessons Learned and Recommendations following the Survey

In this pilot survey, micro-hydropower generators and other components were planned, installed, operated, maintained, and managed over a period of three years. The technological transfer from the Japanese survey team was made throughout the entire process with an eye to encouraging the self-reliance of the local stakeholders led by the city of Puerto Galera.

During these three years, there were troubles like diminished power output associated with drought-level flow and replacement of components due to a lightning strike. However, the emphasis was given to making sure that the city, as the project counterpart, always led the troubleshooting efforts.

The equipment was handed over after the pilot survey, while ensuring proper maintenance and management over a long period and effective application of acquired knowledge in order for the local counterpart to take the initiative.

- Regular operation and maintenance needs to be properly spearheaded by the organization established for that purpose.
- Entrance fee revenue from tourists needs to be properly managed to cover the operation and repair costs.
- All troubleshooting needs to be carried out according to the assigned roles in the maintenance and management manual.
- All irregular replacement and repair work needs to be properly led by the mayor.
- Filipino counterparts should consult Kita Machinery regarding any troubles they cannot resolve locally.
- It is expected that Filipino counterparts help disseminate the technologies to other areas of the country through additional model projects.

Kita Machinery as a Japanese counterpart is expected to improve the specifications of necessary components and offer lower prices as they pursue business expansion based on lessons learned from this pilot survey. The valuable information from this project will be shared with the city of Puerto Galera in order for both counterparts to build lasting rapport through further joint efforts.

ATTACHMENT: OUTLINE OF THE SURVEY