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Assessment of the Potential of Off-Grid microHydro in an Irrigation Canal in Lower Magsaysay, Kuya, Maramag, Bukidnon to Power Streetlights

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ABSTRACT

This study is about the assessment of a potential microhydro system in an irrigation canal in Lower Magsaysay, Kuya, Maramag, Bukidnon to power streetlights. The assessment showed that the microhydro have enough potential just to power streetlights. The microhydro system designed utilizes cross flow turbine of 6 kW power output and generator with power rating of 6 kW. The microhydro, based on design specifications, can generate maximum power output of 6 kW, which is enough to power streetlights that can cover longer distance based on the guidelines set by the Department of Energy on road lighting. The microhydro turbine and generator have an estimated cost of Php 81,129.00 and the street light system at Php 308,844.00. Realization of these systems can greatly help the residents in the area in terms of accessibility, safety and security.

Keywords: micro hydro power plant, renewable energy, irrigation canal

INTRODUCTION

The need to discover and use safe, cost-effective and sustainable sources of electricity is very much timely, relevant and practical especially for countries like the Philippines, with limited fossil fuel reserves. Reliable new sources of energy are needed as energy costs continue to rise which also leads to the rise of CO_2 level in the atmosphere. Hydroelectric power generation is considered as an effective means of generating clean renewable energy that will continue to be a feasible addition to energy demands. Innovations particularly in the local level like harvesting potential energy from sources we didn't care to utilize is what we need. Rice field irrigation has potential for hydropower generation, this could be utilized by diverting the irrigation water.

On the other hand, well-lit roads and environment particularly at night, provides safety and security to communities and businesses. However, street lighting system is costly in terms of installation, maintenance, and power consumption. In rural areas, most of the farm roads do not have road way lighting systems, which also links to increasing crime rate and accidents due to the absence of lighting. Providing lighting system can greatly affect the way of living in rural areas. The cost of street lighting system can be significantly reduced to only installation and maintenance when own power generating system will be utilized, in this case, the microhydro.

The use of renewable energy would be of great help to decrease the demand from the grid. Utilities are concern in the reduction of emissions from traditional power plants by using renewable energy and to reduce the high cost of supplying electricity to remote areas (Al-Ammar, 2011). Development of more Small Hydropower Plants gives significant contribution to address electricity demand with a positive environmental impact (Paish, 2002).

Water will still be available for agricultural irrigation and other purposes after diverting and utilizing it to generate electrical power (Hanmandl, 2006). In Japan, early example of generating electricity by using irrigation water is the Momura microHydro power. Water from lakes and rivers through the Man-made irrigation systems for growing rice were utilized for electricity generation (Suwa, 2009).

In Philippines, the very first microHydro project was at the Lateral B Canal of Magat River Integrated Irrigation System (MARIIS) in Barangay San Marcos in San Mateo, Isabela. The project was Funded through a grant from the Japan International Cooperation Agency (JICA), and is jointly undertaken by DA-attached agency NIA and the Department of Energy (DOE) in 2014 (Diega, 2014).
There are several papers that presents simple method for Micro Hydro Power (MHP) plant design, Zema, et al., (2016) proposed a method using simple models with reduced input parameters in the initial design stage, this method

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was verified in an existing irrigation system in Calabria, Italy; while Butera, et al., (2015) tested a methodology in Piedmont Region in the United States of America, this method shows the description of irrigation network and identification of higher hydropower potential, it also determines the actual combination between irrigation and hydroelectric usage and hydropower development scenarios.

OBJECTIVES

The main objective of the study is to assess the potential of Off-Grid microHydro in an irrigation canal to power streetlights in Lower Magsaysay, Kuya, Maramag, Bukidnon;

Specific Objectives:

1. Gather data for the design considerations of the microHydro plant;
2. Give the specifications of the turbine and generator for the microHydro plant;
3. Determine the technical potential of a microHydro plant;
4. Design a street lighting system; and
5. Determine the basic cost of the turbine, generator and street lighting system for the microhydro plant in an irrigation canal in Lower Magsaysay, Kuya, Maramag, Bukidnon.

METHODOLOGY

Data gathering: The data gathered included the historical and present data of water level, water flow, discharge, head measurement and the area details;
Calculations: Calculations were made to determine if the resource is capable of producing enough energy since the concept of hydro plant is utilizing the flowing mass of the water from higher elevation or the kinetic energy, which turns the turbine that is directly coupled to a generator to produce electrical energy;

Simulation using the Cross Flow Design Software: Data gathered and calculated were simulated in the software. The technical potential of a renewable energy system was determined by considering the head loss, turbine, and generator specifications through Cross Flow Design Software;

Designing the Street Lights: The number of streetlights were based on the power capacity potential of the microhydro;

Costing: The installation cost of the turbine and generator of the microhydro power plant and the street lighting was determined and since the development of the microhydro does not provide sale of the power output, only descriptive benefits can be assessed from the microhydro and the street lighting system.

RESULTS AND DISCUSSION

Data for the design considerations of microHydro plant

The data shows that the discharge of the water from the canal averages 0.4775 m^3/s.

Cross Flow Turbine Design

After the data are sufficient, the researcher decided to use Cross Flow Turbine for the microhydro. The technical drawing generated from the software can easily be fabricated in local machine shops. The Cross Flow Turbine to be fabricated has the technical specifications shown in Table 1.

Generator Specifications

Since the power output of the turbine is found to be at 6 kW, it is safe to use a 6 kW generator. From the Cross Flow Turbine specifications, the generator speed can be found by using the equation:

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Substituting the values results to approximately 1800 rpm for the generator speed. The summary of the generator specifications is shown in Table 2.

Microhydro Power Plant Design

The design of the microhydro power plant is shown in Figure 1 and Figure 2.

Table 1

Cross Flow Turbine Specification

Parameter	Value
Head	5 m
Flow Rate	0.19 m^3/s
Runner Diameter	230 mm
Runner Length	410 mm
Turbine RPM	399 rpm
Power	6 kW
Turbine Pulley	36 in
Generator Pulley	8 in

Table 1

Generator Specifications

Parameter	Value
Brand/Supplier	Yunkun Qianwei
Power	6 kW
Generator RPM	1800 rpm
Frequency	60 Hz
Voltage	230 V
Current	21.8 A
Number of Phase	Single Phase

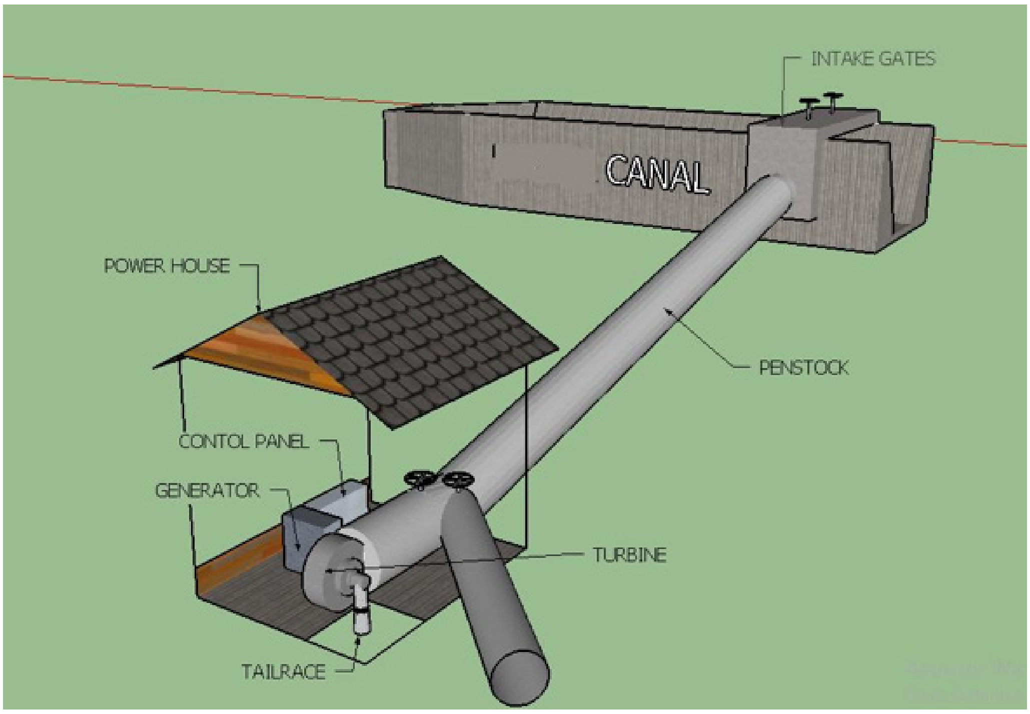

Figure 1. Microhydro Power Plant Design

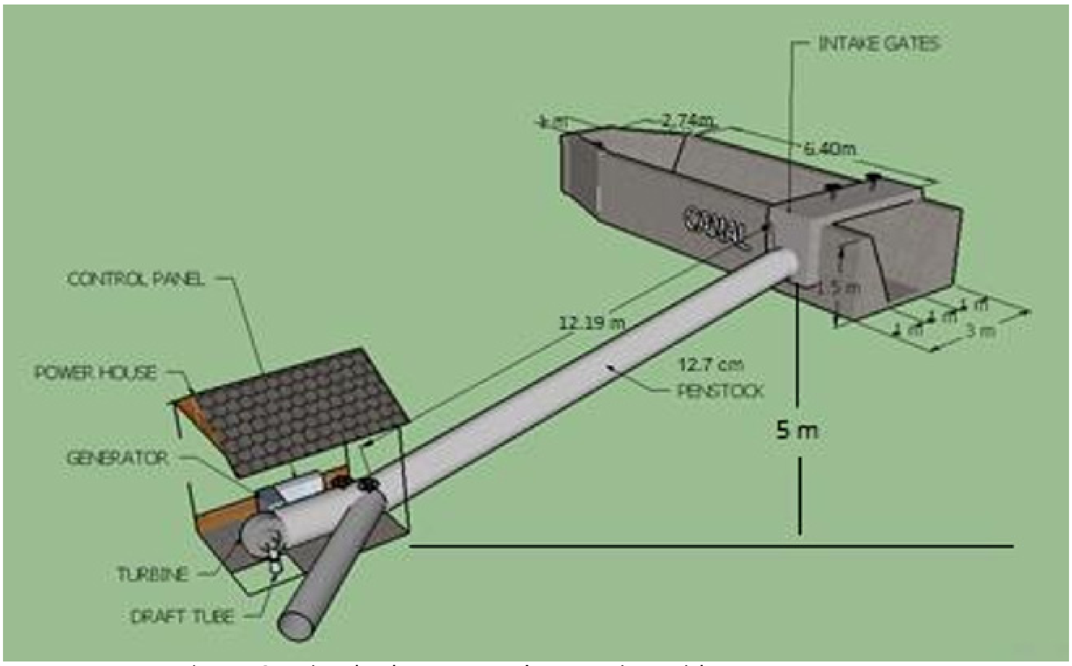

Figure 2. Microhydro Power Plant Design with Measurements

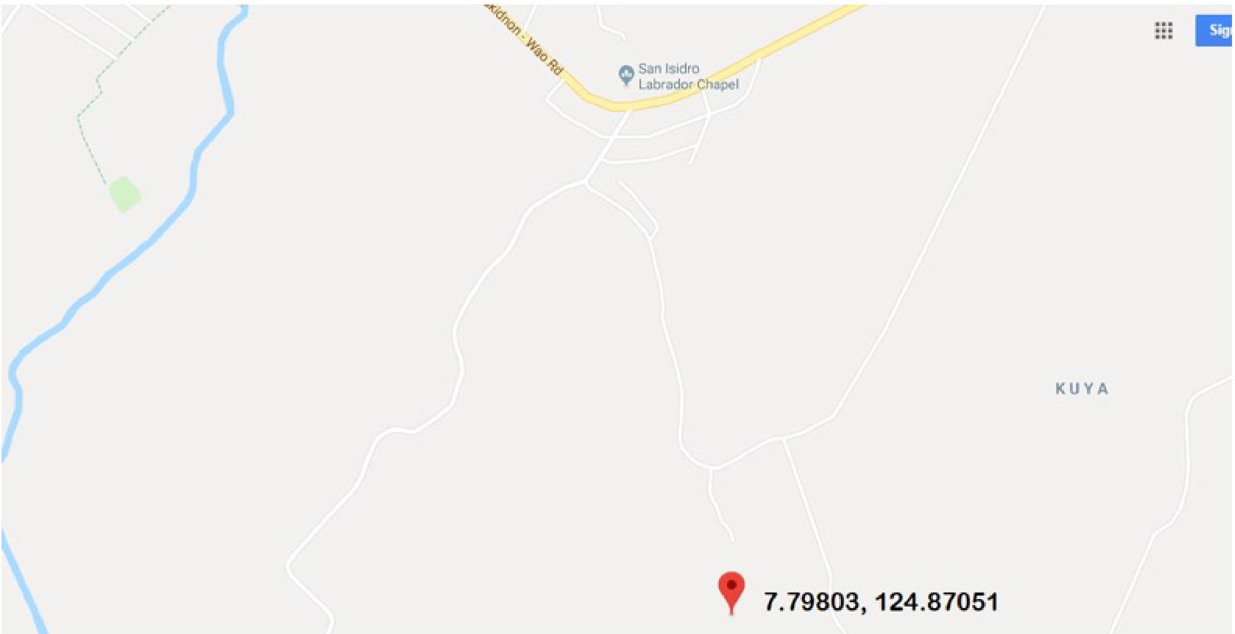

Figure 3. Road Map

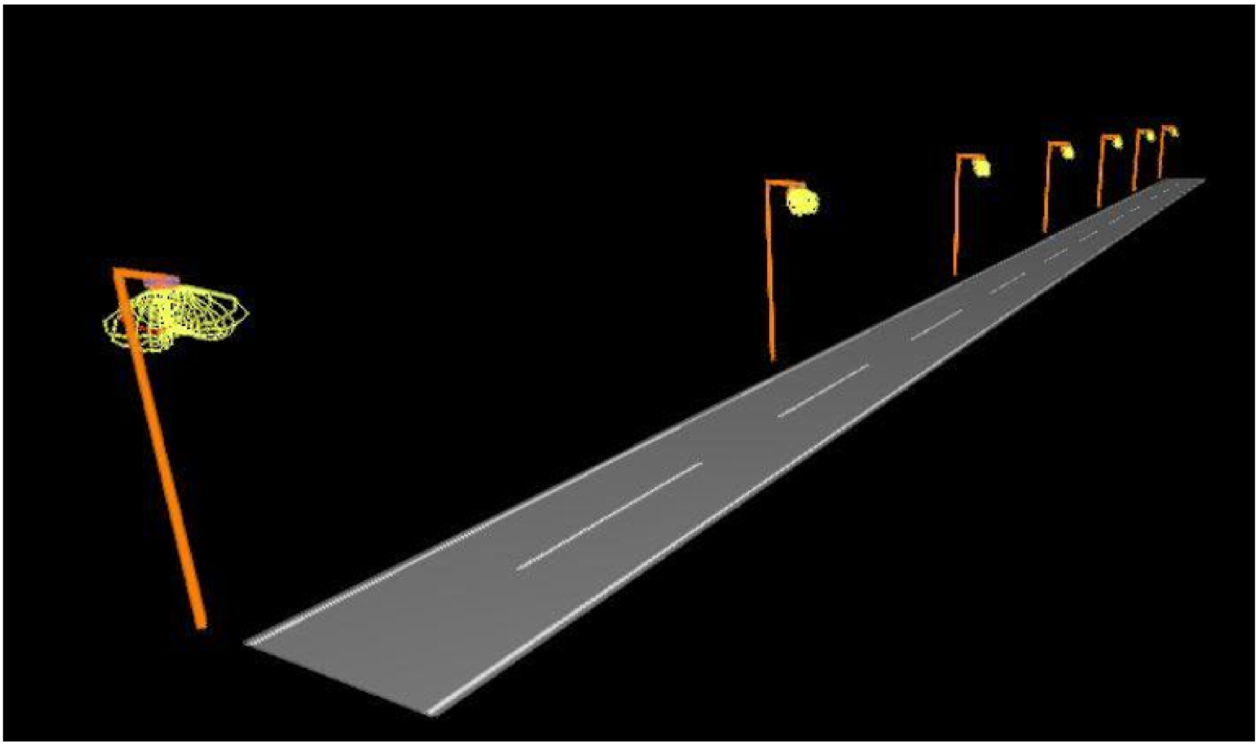

Figure 4. Road Lighting Design

The power house was designed to be 12.19m from the irrigation canal, housing the turbine, generator and control panel.

Street Lighting

The street lighting design was based on the standards set by Department of Energy (DOE). Based on the guidelines of DOE, the road concerned is classified as minor road since it is a local road that is used primarily as an access to the different part of the area. The street lighting will start at the location and coordinates shown in Figure 3. The pinned area with coordinates is the location of the micro hydro and the road around the area is the road considered for street lighting.

The DOE standards/ guideline for placement or streetlight arrangement and the lighting parameter was consider for this road is a minor road. The street lighting design is shown in Figure 4 and the specifications of the street lighting design are summarized in Table 3. The streetlight used for the design is 80 Watts Philips Aurora SPP202.

Assuming 66.67% efficiency of the microhydro power output at 4 kW, 50 streetlights of 80 W can be placed that can cover a road distance of 1250 m with

Table 3

Street Lighting Design Specifications

Road	Road Width (m)	Arrangement	Lamp Wattage (W)	Luminaire Spacing (m)	Mounting Height (m)	Mast Arm Length (m)
Minor Road	6*	Single Side	80	25	8	1.5

**Assumed Value*

Table 4

Street Lighting Design Comparison to Standard

Parameters	Design Values	Recommended Values
Luminance (cd/m2)	0.66	≥0.60
Overall Uniformity (Uo)	0.57	≥0.35
Uniformity of Illuminance (Ul)	0.85	≥0.40
Glare Threshold Increment (TI)	10	≤15
Edge Illuminance Ratio (EIR)	0.51	≥0.50

Table 5

Microhydro Power Plant Cost

No.	Item(s)	Quantity	Unit	Unit Cost	Total Cost
1	6 kW Cross Flow Turbine	1	pc.	*P 72,000.00	P 72,000.00
2	6 kW Generator	1	pc.	**P 9,129.00	P 9,129.00
	Total				P 81,129.00

**Fabrication cost at P 12,000.00 per kW*
***Generator price as of September 14, 2018*

Table 6

Street Lighting Bill of Materials

No.	Item(s)	Quantity	Unit	Unit Cost	Total Cost
1	Philips Aurora SPP202	50	pcs.	*P 5,402.00	P 270,100.00
2	8 m Galvanize Pole	50	pcs,	*P 541.40	P27,070.00
3	10/2 AWG MC Cable	1250	m	*P 8.12	P 10,150.00
4	Automatic Photocell Control Sensor	3**	pcs.	*P 508.00	P 1,524.00
	Total				P 308,844.00

**Prices as of September 14, 2018*
***3 pieces of Photocell Sensor of 10 A rating (1 Photocell Sensor for 17 Streetlights)*

luminaire spacing of 25 m.

The comparison of street lighting design to the standard is shown in Table 4 which concludes that the design passed the recommended values set by DOE. This shows that the design is a sufficient road lighting system for the area concerned.

Assuming 66.67% efficiency of the microhydro power output at 4 kW, 50 streetlights of 80 W can be placed that can cover a road distance of 1250 m with luminaire spacing of 25 m.

The comparison of street lighting design to the standard is shown in Table 4 which concludes that the design passed the recommended values set by DOE. This shows that the design is a sufficient road lighting system for the area concerned.

Basic cost of the Turbine and Generator of the microhydro plant and the street lighting design in the study area.

The cost of the turbine and generator of the microhydro plant and street lighting system were calculated. The cost of the turbine and generator is estimated at Php 81,129.00 considering the breakdown of prices of materials shown in Table 5. The lower cost of turbine is attributed to the established cross turbine design software that can generate the mechanical drawing which is the basis for fabrication.

For the street lighting system, an estimated cost of Php 308,844.00 is calculated as the installation cost considering the breakdown of materials' prices shown in Table 6.

There is no direct monetary benefit that can be generated from the system since the power generated is not for sale and used solely for the street lighting purpose. However, benefits such as free power consumption for streetlights and illumination of the access roads around the area concerned can be expected from the system.

CONCLUSION(S)

The microhydro designed in this research utilizes a cross flow turbine with power output of 6 kW and a single-phase generator with power rating of 6 kW. Therefore, the microhydro can generate a maximum power output of 6 kW which is considered enough when applied to street lighting. Utilizing only 66.67% of the maximum power output of the microhydro it can illuminate a distance of up to 1.25 km through street lighting. This can greatly help the residents in the area since the area is rural and away from the main highway which lacks proper street lighting. Installation cost of the turbine and generator of the microhydro is estimated at Php 81,129.00 and the street lighting at Php 308,844.00 totaling to an amount of Php 389,973.00. The development of the microhydro and the street lighting system can significantly provide assistance to the residents in the area with proper street illumination without worrying about the power consumption cost as long as the microhydro can provide the required power output. Thus, the microhydro has high potential for providing power to the street lighting system and even households around the area of study that are not yet energized by the distribution utility, about more or less 100 households could potentially benefit to the power that would be generated by the microhydro powerplant.

RECOMMENDATION

For further studies, it is recommended to consider the cost of building the power house and other structures; and to calculate the Return On Investment if the powerplant is to operate 24 hours a day 7 days a week and sell the generated energy to consumers.

REFERENCES

Al-Ammar, E.A., Malik, N.H., Usman, M. (2011). Application of Using Hybrid Renewable Energy in Saudi Arabia. ETASR - Engineering, Technology & Applied Science Research Vol. 1, _o. 4, 2011, 84-89

Butera, I., Balestra, R. (2015). Estimation of the hydropower potential of irrigation networks. *Renewable and Sustainable Energy Reviews 48* , 140–151

Diega, A. S. (2014). Microhydro plant from irrigation to supply electricity to a municipality in Isabela. Business Mirror. Retrieved from http://www.businessmirror.com.ph/index.php/en/business/agri- commodities/28697-microhydro-plant-from-irrigation-to-supply-electricity-to-a- municipality-in-isabela

Hanmandl, M., Himani, G., Kothari DP, (2006) . An advanced control scheme for micro hydro power plant. International conference on power Electronics, drives and Energy System, PEDES06, New Delhi, pp.1–7 IEEE 0-7803-9772-X/06/$20.00 &2006 IEEE

Paish O. (2002) Small hydro power: technology and current status. *Renew Sustain Energy Rev 6*, 537–56.

Suwa, A. (2009). How Things Work: Micro Hydroelectricity in Japan. Retrieved from Our world United Nations University: https://ourworld.unu.edu/en/rice-water-power-micro-hydroelectricity-in-japan

Zema, D. A., Nicotra, A. Tamburino, V. N., Zimbone, S. M.(2016). A simple method to evaluate the technical and economic feasibility of. *Renewable Energy 85*, 498 -506.