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Cost benefit Analysis Between Solar-Powered and Diesel Fuel-Fed Pumps of the National Irrigation Administration Upper Pampanga River Integrated Irrigation Systems

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Abstract— *This study described the profitability of the National Irrigation Administration- Upper Pampanga River Integrated Irrigation Systems NIA-UPRIIS' newly inaugurated solar-powered pumps in the Philippines. The researchers utilized the descriptive research design using the questionnaire technique to gather the necessary information. Engineers from NIA-UPRIIS Division IV were the respondents of the study. The researchers discovered that the project was profitable with cumulative estimated savings of Php 277,028,649.18. Moreover, the project resulted in reduced noise pollution which would have been generated by diesel fuel-fed generators. This has also reduced the gas emission from using the conventional method. The researchers suggest that more solar-powered projects be installed by the said agency in all its irrigation projects as this would result in big savings, while sparing some funds which can be used for other purposes.*

Keywords— ***National Irrigation Administration, solar-powered pumps efficiency, savings, profitability.***

I. INTRODUCTION

The National Irrigation Administration (NIA) is a government-owned and controlled corporation primarily responsible for irrigation development and management. "It was created under Republic Act (RA) 3601 on 22 June 1963. Its charter was amended by Presidential Decree (PD) 552 on 11 September 1974 and PD 1702 on 17 July 1980. Both increased the capitalization and broadened the authority of the Agency".

Upper Pampanga River Integrated Irrigation Systems (UPRIIS) is one of the government agencies under the National Irrigation Administration with the main base of operations located at Maharlika Highway, Cabanatuan City, Nueva Ecija, Philippines. It all started in May 1969 when Republic Act 5499 or the Upper Pampanga River Project Act was approved by the Philippine Congress. The act authorized the construction of the Pantabangan Dam and its related structures and facilities and the approval of local counterpart funds. The Upper Pampanga River Project became officially known as the Upper Pampanga River Integrated Irrigation Systems. The provinces covered by UPRIIS consist mostly of the whole Nueva Ecija Province and parts of Pampanga, Bulacan, and Tarlac. As of Calendar Year 2015, UPRIIS serves 119,216.49 hectares which comprise of 4 Provinces, 23 Municipalities, 5 Cities, and 452 Barangay. The main source of water supply for UPRIIS is the Pantabangan Dam with a reservoir area of 8,420 hectares. A total of about 3 billion cubic meters of water can be stored in the reservoir. Aside from providing irrigation and flood

control, the Pantabangan Dam also generates electricity that supplies power to the different provinces of the region through the Pantabangan and Masiway hydroelectric power plants.

However, with the prediction of fossil fuel depletion, many alternative sources of energy have been in development for the past few years were considered by NIA-UPRIIS. One such alternative energy source is solar energy. With it being harnessed from the sun it is renewable, free from the worry of future depletion and since it does not result in the release of harmful gases into the atmosphere, it is also environmentally friendly. Hence, NIA-UPRIIS has inaugurated solar-powered pumps into their irrigation system in July of 2021.

They have built two new solar powered pump projects in San Isidro and Penaranda, Nueva Ecija. "The Peñaranda Solar Powered Pump Irrigation Project, whose main water source comes from the Penaranda Dam through PENRIS Main Canal, is a P20.461-M project that is expected to provide reliable and proficient irrigation water supply in its 228.878-hectare service area located in Barangays Poblacion I, Poblacion Il, Santo Tomas in Penaranda, and Pambuan, Gapan City, benefitting a total of 114 farmer members of Penaranda IA. The San Isidro Solar Powered Pump Project, on the other hand, is situated in Brgy. Pulo, San Isidro, Nueva Ecija. With a total project cost of PI 7,780.519.47, this project will benefit 159 farmer-beneficiaries and their families in 323.2762-hectare agricultural lands, covering the Barangays Pulo and Mangga in San Isidro, Nueva Ecija. Its main water source is Malimba Creek" (Nocum, 2021). With this transition to solar energy, the researchers as Nueva Ecija University of Science and Technology Master of Business Administration students explore the profitability and feasibility of the two NIA-UPRIIS' newly-inaugurated solar-powered pumps. The findings of this study aims to compare the use of solar-powered pump as against the conventional diesel fuel-fed pump in terms of installation and maintenance costs.

II. METHODOLOGY

The researchers utilized the descriptive research design using the survey questionnaire to gather the necessary information. According to Dr. Y.P. Aggarwal (2008) as cited by Balaria (2012) and Garcia & Subia (2019) "descriptive research is devoted to the gathering of information about prevailing conditions or situations for the purpose of description and interpretation". Hence, this study described the profitability of NIA-UPRIIS' newly inaugurated solar-powered pumps, the costs associated with this project included. Engineers from NIA-UPRIIS Division IV served as respondents of the study. The contents of the instrument consisted of the costs of operating and maintaining the solar-powered pumps as well as their benefits and drawbacks. These data were needed to validate the claims made by those interviewed. Documentary evidence such as financial statements were also requested from the concerned offices.

Project Specifications for the San Isidro and Peñaranda, Nueva Ecija, Philippines Solar-Powered Pumps

Table 1. Construction of Solar-Powered Pump San Isidro Project Profile

Project Title	Improvement of Irrigation Facilities
Location	Brgy. Pulo, San Isidro, Nueva Ecija
Contract Description	PENRIS/Construction of Solar Powered Pump @ San Isidro
Water Source	Malimba Creek
Barangay Covered	Barangays Pulo and Mangga, San Isidro, Nueva Ecija
Service Area	323.2762 ha
No. of Farmer Beneficiaries	159 farmers
Total Project Cost	₱17,780,519.47
Coordinates of Pump Site	Site 1 Latitude: 15.232653^0 Longitude: 120.936101^0 Site 2

	Latitude: 15.22797^0 Longitude: 120.92979^0
Nature of Project	Water Pumping using Renewable Energy
Irrigation Facilities	1-Sub Lateral
Irrigation Association	Malimba-Bantog-Manggahan IA
Length of Canal	
Lateral D-6a	3+964-6+000 (2.036 KM)
Technical Specifications	
Solar Panel	90,390 watts of system capacity
No. of Solar Panels	228 pieces of 1m x 2m solar panel frame (395 watts each)
Orientation of Solar Panels	11^0 inclination facing south
Solar Panel Specifications	**Type:** Monocrystalline Silicone **Power Rating**: 85w/18w **Features**: Dust or Sandstorm proof **Lifetime**: 25 years **Warranty**: 10years

Table 2. Construction of Solar-Powered Pump Peñaranda Project Profile

Project Title	Improvement of Irrigation Facilities
Location	Brgy. San Josef, Peñaranda, Nueva Ecija
Contract Description	PENRIS/Construction of Solar Powered Pump @ Peñaranda
Water Source	Peñaranda Dam through PENRIS Main Canal
Barangay Covered	Barangays Poblacion I, Poblacion II, Santo Tomas in Peñaranda and Pambuan in Gapan City, Nueva Ecija
Service Area	228.878 ha
No. of Farmer Beneficiaries	114 farmers
Total Project Cost	₱20,461,285.99
Coordinates of Pump Site	Latitude: 15.345400^0 Longitude: 121.000766^0
Nature of Project	Water Pumping using Renewable Energy (Solar)
Irrigation Facilities	1-Lateral Canal 1-Sub Lateral
Irrigation Association	Peñaranda IA
Length of Canal	
Lateral A	0+000-2+577 (2.577 KM)
Lateral A-1	0+000-1+866 (1.866 KM)
Technical Specifications	
Solar Panel	90,390 watts of system capacity

No. of Solar Panels	228 pieces of 1m x 2m solar panel frame (395 watts each)
Orientation of Solar Panels	11^0 inclination facing south
Solar Panel Specifications	**Type:** Monocrystalline Silicone **Power Rating**: 85w/18w **Features**: Dust or Sandstorm proof **Lifetime**: 25 years **Warranty**: 10years

III. RESULTS AND DISCUSSION

Based on the gathered data, the service area of the Peñaranda solar-powered pump covers 228.878 hectares which is equivalent to 926,236.40 square meters, whereas the San Isidro solar-powered pump's service area is 323.2762 hectares that can be translated to 1,308,252.37 square meters. The total service area for the two pumps is 2,234,488,77 square meters**.** Each of the solar power pump installations can provide 90,390 watts or a combined capacity of 180,780 watts or 180.78 kW that can be considered adequate for the irrigation service area.

The two solar-powered pump projects have a total cost of Php 38,241,805.46 broken down as Php 20,461,285.99 for the Peñaranda project and Php 17,780,519.47 for the San Isidro project. A quick search on Google for a 225kva (equal to 180kw) diesel-fueled generator shows a result from Alibaba.com for one has a price of Php 661,720.10. Two generators will be required as there are two service areas to be inaugurated, thus bringing the amount to Php 1,323,440.20 (Twice the mentioned amount of 661,720.10)

"Diesel generators can last for at least **15,000 hours to a maximum of 50,000 hours** before needing a maintenance. Ultimately, the life expectancy of a generator will depend on factors such as generator sizing and preventive maintenance practices" (The life Expectancy of Your Diesel Generator, 2020). The above data point that the general average life of a diesel generator is **32,500 hours** (average of 15,000 hours and 50,000 hours). In comparison, the total number of hours in 25 years, the useful life of the solar power generators is approximately **219,000 hours** (24 hours a day, 365 days a year, for 25 years, excluding additional one day during leap year). This means that the diesel- powered generators would require major servicing 6 times, rounded from 5.74 times ((219,000/32,500)-1), within the span of 25 years.

"The average operations and maintenance cost for diesel reciprocating engine-driven generators is **$0.005-$0.010 per kWh**, according to the GTI. For natural gas generators, the average cost is $0.007-$0.015 per kWh" (Onsite Options, 2002). Using a conversion ratio of Php 50 to a dollar at the current rate, this can be translated to Php 0.375 per kilowatt-hour. With a generator of 180 kW capacity, the average maintenance cost is Php **12,187** each time (average of 0.25-0.50* 32,500 hours of useful life) before needing servicing. Since the major servicing is expected to occur 6 times within 25 years, the cumulative cost amounts to Php **73,125.**

With the assumption that the diesel-fed generator would run all day, as the solar power pumps would do, the total fuel volume for 25 years would amount to **1,823,175 gallons** (219,000 hours with 16.7 gallons used per hour). "Diesel prices: We show prices for the Philippines from 09-Aug-2021 to 15-Nov-2021. The average value for the Philippines during that period was Php **45.52** with a minimum of 41.35 Philippine Peso on 27-Sep-2021 and a maximum of 52.27 Philippine Peso on 15Nov-2021. For comparison, the average price of diesel in the world for this period is 75.51 Philippine Peso" (Philippine Diesel Prices, 2021). Global Petrol Prices.com presents Diesel prices in the Philippines to be 45.52 pesos per liter. A gallon is approximately equal to 3.79 liters. Thus, 1,823, 175 gallons is equivalent to 6,909,833.25 liters. The total fuel cost for the next 25 years will be Php **314,535,609.54**

Table 3. Cost-Benefit Analysis Between Solar-Powered and Diesel-Powered Pumps

	Initial Cost (Php)	Subsequent Fuel Cost (Php)	Overhaul Cost (Php)	Cumulative maintenance cost for 25 years (Php)
Solar Power Pump	38,241,805.46	-	-	-
Diesel Powered Pump	1,323,440.20	314,535,609.54	73,125.00	315,932,174.74
Difference				**277,028,649.18**

In comparison, solar-powered pump can be considered more efficient and cost-effective compared to diesel-powered pump. The figure does not include other costs for implementing a diesel-powered pump irrigation system, such as the irrigation lines and laterals, only making projections on the generator price, repair and fuel costs. Although the cost in installing solar-powered pump can be 29 times higher than diesel-powered pump, long term considerations in maintenance cost can save the Philippine government some Php 277,028,649.18.

IV. CONCLUSIONS AND RECOMMENDATIONS

Based on the findings of the study, the researchers concluded that the use of solar-powered pump is more efficient and cost-effective than the use of diesel-powered pump. It is also estimated a savings of approximately Php 277,028,649.18. Furthermore, solar-powered pump reduces noise pollution and eliminates the harmful effects of gas emission from diesel fuel-fed generators. The researchers recommend that more solar-powered pumps be installed by the agency for all its irrigation projects as this would result in big savings in the long term for the Philippine government.

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