

# PERCEPTIONS ON THE STATUS AND SUSTAINABILITY OF MINI-HYDRO POWER PLANT IN CANTILAN, SURIGAO DEL SUR

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**ABSTRACT:** *This study was conducted to propose some guidelines in the use of the proposed Mini-hydro Electric Power at Sipangpang Falls, Cabangahan, Cantilan, Surigao del Sur during the calendar year 2010. The study sought to assess the status of the project as to its community power resources, capacity to generate energy, community needs, and sustainability; the extent of influence of the project along social services; and the perceived problems in the implementation of the mini-hydropower plant. The study was descriptive research employing purposive quota sampling. The respondents were the 30 officials of the local government unit and 300 community folks in Cantilan. The purpose of the study is to determine the status of the mini-hydro power plant. It was evaluated in terms of community power resources, capacity to generate energy, community needs, and sustainability. The finding showed that the respondents believed that the project was sufficient in terms of community power resources, capacity to generate energy, community needs and sustainability. The project generated a favorable impact to the lives of Cantilangnons. The project was responsive to the needs of the community, sustainable and had the capacity to generate energy enough to serve the municipality and some neighboring municipalities.*

**Keywords:** ZnO NPs, LP-LPA, surface morphology, AFM, laser parameter, FTIR

## 1. INTRODUCTION

Electric power is essential to modern society. Economic prosperity, national security, and public health and safety cannot be achieved without it. Communities that lack electric power, even for short periods, have trouble meeting basic needs for food, shelter, water, law, and order. The economic significance of electricity is staggering. It is one of the largest and most capital-intensive sectors of the economy.

Harnessing and utilization of Renewable Energy (RE) comprises a critical component of the Philippines government's strategy to provide energy supply for the country, the Philippine power sector has increased generation from geothermal and hydro resources and therefore lessened the country's independence on imported and polluting fuels. In the government's rural electrification efforts, on the other hand, renewable energy sources such as solar, micro-hydro, wind and biomass resources are seeing wide-scale use.

Now that the Republic Act No. 9513 (Renewable Energy Act of 2009) and its Implementing Rules Regulations (IRR) are in full effect, the Philippine government is enthusiastic about how this will impact the energy mix of the country in the future and how this will reduce greenhouse gas emissions.[1] Renewable energy application seemed to have really kicked in 2009 as 93 service contracts were signed, a total of 57 for hydropower projects. The Department of Energy (DOE), even with the realization that it contributes to global greenhouse gas emissions minutely, has endeavored to deal with the issue of climate change by putting into place effective and implementable renewable energy projects.

In-stream hydro and mini hydropower based on a run of river, design is most efficient and ecologically balanced renewable energy systems available today. They are 5 times better cost to energy output and a corresponding reduction in total emissions including manufacturing and installation than other renewable technologies [2].

The economic development of the rural areas, the availability of adequate energy supply is one of the key factors of this study. Besides domestic uses such as lighting and household appliances, energy is essential for small scale industrial purposes. The use of energy for industrial purposes supports

economic development contributing for the improved overall welfare of rural areas. Appreciating its fundamental importance to the economic development of rural areas, the government has long been committed to a program of rural electrification.

The Sipangpang Falls Mini-Hydro Power Project is a one-megawatt mini hydroelectric power project of Cantilan LGU financed by LANDBANK thru the World Bank-fund Support for Strategic Local Development and Investment Project or S2LDIP that would give benefits to the towns of Carrascal, Cantilan and Madrid, Surigao del Sur. The power generation project will complement the existing electricity requirement of about 12,500 households in the area at reduced rates. The project is also expected to generate additional income for Cantilan which LGU can use to provide other basic services to its constituents and the protection and preservation of the watershed covering the Sipangpang Water Falls. The primary purposes of the Sipangpang Falls Mini-Hydro Power Project are the following: to be energy self-sufficient and be independent of the distant NPC operated Agus Hydroelectric Power Complex in Iligan City, the main source of power for Mindanao Grid; to have an assurance against power outages except during the periods of annual plant maintenance, or during typhoon and other natural disturbances; to improve or maintain a good quality supply of power with negligible voltage fluctuation since the Plant will serve as stabilizer having a separate Sub-station adjacent to the Powerhouse; to generate significant income for the Municipality as the Mini Hydropower Plant will last for more than 50 years and insure more priority infrastructure projects especially hospital/farm to market roads/bridges encourage investors to the Municipality, especially small and medium-scale enterprises (SME's) since power supply will be reliable and eventually cheaper which in turn should trigger economic uplift; to provide jobs and training for semi-skilled and skilled workers during and after construction; to provide assistance and livelihood to the host Barangay and Indigenous People's (IP's) to preserve its watershed thru continuous tree planting with funds coming from a percentage of the Power Plant's annual gross revenues; to

improve access especially to Barangays Lobo and Cabangahan; to provide full development and potential tourist attractions in the project area; to incorporate other productive water use projects such as water supply, irrigation and tourism and recreation; to provide an alternative to diesel-fed power plants thus helping reduce CO<sub>2</sub>, gas emissions associated with fossil fuels which is harmful to the environment and the ozone layer, as well as contribution to government dollar savings; And most importantly, for every Cantilangnon to eventually avail of inexpensive power, especially after full payment of loan amortization.

The harnessing and utilization of renewable energy (RE) comprise a critical component of the government's strategy to provide energy supply for the country. This is evident in the power sector where increased generation from geothermal and hydro resources has lessened the country's dependency on imported and polluting fuels. In the government's rural electrification efforts, on the other hand, these renewable sources of energy are seeing wide-scale use:

**Wind Energy** – energy received from the movement of the wind across the earth. This energy is a result of the heating of our ocean, earth, and atmosphere by the sun. The wind will blow as long as the sun shines down on earth. As more efficient wind harnessing technologies become available, we will be able to take advantage of this clean, renewable energy source.

**Solar Energy**- energy received by the earth from the sun. This energy is in form of solar radiation, which makes the production of solar electricity possible. Solar electricity relies upon man-made devices such as solar panels or solar cells in order to provide a source of clean, and low-cost renewable energy.

**Biomass energy**- any organic materials that can be burned and used as a source of fuel. It is a renewable energy source that makes use of such biofuels as methane (biogas) generated by sewage, farm, industrial, or household organic waste materials. It relies on combustion and therefore produces carbon dioxide; its use would not, therefore, alleviate the greenhouse effect.

Most developed nations are dependent on non-renewable energy sources such as fossil fuels (coal and oil) and nuclear power. These sources are called non-renewable because they cannot be renewed or regenerated quickly enough to keep pace with their use. Some sources of energy are renewable or potentially renewable.

**Fossil Fuels**- sources of electricity include fossil fuels are found within the rocks of the earth's surface. They are called fossil fuels because they are thought to have been formed many millions of years ago by geological processes acting on dead animals and plants just like fossils.

Coals, oil and natural gas are fossil fuels. Because they took millions of years to form, once they are used up they cannot be replaced.

**Oil and Natural Gas**- sources of electricity include oil and gas are chemicals made from molecules containing just carbon and hydrogen. All living things are made of complex molecules of long strings of carbon atoms. Connected to these carbon atoms are others such as hydrogen and oxygen. A simple molecule, called methane (CH<sub>4</sub>), is the

Coal- sources of electricity can include coal, which mainly consists of carbon atoms that come from plant material from ancient swamp forests. It is a black soil that is reasonably soft. You can scratch it with the fingernail, it is not as soft as charcoal, however, and is quite strong. It can be carved into shapes. There are different types of coal. Some contain impurities such as sulphur that pollute the atmosphere further when they burn, contributing to acid rain.

**Economy and reliability**- the industry has achieved significant improvement in the economy of operations and in the reliability of power systems either through direct operational pool functions or with contractual economical agreements.

**Energy management** is important for many reasons; economic, environmental and social. It makes economic sense because energy is a commodity which all cannot afford to waste. Shortage of electrical energy supply in the Philippines is a major consideration of why electrical energy should be used wisely. Because of the oil crisis, the government could save cost-effectively by investing in energy conservation. The money would boost the economy when spent on other goods and services [3].

Energy management can only be realized if companies or institutions look into their existing energy management policies, practices of the personnel of energy utilization and existing maintenance practices.

The social benefits of investing in electric power includes (a) provide additional generating capacity to displace the country's dependence on very expensive imported fuel, (b) provide income to the people or consumers since the owner is a Local Government Unit (LGU) and Electric Cooperative, with all benefits or income going back to the people thru various projects, (c) provide reliable and eventually cheap power thereby enticing investors to invest in the community, (d) provide environmentally friendly source of power, (e) protect the watershed thru extensive tree planting program with funds coming from the power plant revenues, and (f) provides jobs and livelihood to the host community.

A systematic energy management process effectively promotes energy conservation. Depending on the level of energy cost in the final product, the technology, the policies and the type of organization, three stage of action are possible; a "housekeeping stage", an information collection stage and an investment stage [4].

Energy conservation requires the cooperation of all workers. To make the program success it is important to create a climate which is favourable to generating suggestions at all levels, encouraging ideas and promoting awareness: all the workers should understand why the program cannot function without them, to involve workers in energy conservation program, it is important to explain how escalating energy prices will affect the survival of the enterprise and their own employment; to stress their crucial role in the conservation; to show inconsistency between excessive energy, consumption and the values held by workers [5].

The success of any energy conservation program depends largely on the commitment of everyone within an organization, in the households, and on the habits and lifestyle of each worker. People, therefore, are the key to an effective conservation program. Since workers take their cue

from management, management must initiate energy conservation efforts

Energy Conservation (ENERCON) committees are primarily responsible for formulating and implementing energy conservation programs. An energy coordinator or full-time energy manager may be appointed to report to top management. Some ENERCON committees are even headed by a company president or vice president. Typical ENERCON committee functions include planning and participating in energy-saving surveys, developing uniform record-keeping, report an energy accounting, including conservation goals and communicating ideas on how to achieve them, developing ideas and plans for enlisting staff support and participation; planning and conducting a continuing program of activities to stimulate interest in energy conservation efforts [7] (International Energy Agency :2004)

The National Power Corporation is the biggest government-owned corporation in the Philippines. It was established more than seventy years ago by virtue of Commonwealth Act No. 120, which was signed into law by then President Manuel L. Quezon.

NPC, being the largest government-owned corporation in the Philippines, was originally established to construct power plants and supply electricity to the country. Its mission is to achieve and maintain the highest standards of generation and transmission practices of the power industry. It aims to make optimum use of indigenous resources of energy and work for the continuous improvement of processes and technologies.

NPC also envisioned itself to be a world class, globally competitive Filipino power corporation. It commits itself to the highest standards of customer satisfaction by providing quality and reliable electricity.

The National Transmission Corporation is a government-owned and controlled corporation created in 2001 by the Electric Power Industry Reform Act. It started operating independently from NPC in March 1, 2003. The company handles the planning, construction and centralized operation and maintenance of high-voltage transmission facilities, grid interconnections and ancillary services.

TRANSCO has a unique and crucial role of transmitting bulk electric power from power plants owned by the National Power Corporation and Independent Power Products (IPP) to the distribution utilities, industries and other customers. Overhead transmission of electric power remains one of the most important elements of today's electric power system. Transmission systems deliver power from generating plants to industrial sites and to substations from which distribution system supply residential and commercial service. It also interconnects electric utilities, permitting power exchange when it is of economic advantage and to assist one another when generating plants are out of service because of damage or routine repairs.

**2. METHODS**

A letter of request asking permission to conduct the study was prepared addressed to the municipal Mayor of Cantilan, Surigao del Sur. With the approved letter request, the researcher distributed the researcher-made questionnaire. The

townspeople of Cantilan and its local officials were briefed with reference to the inclusion and exclusion criteria in the choice of the respondents and number of respondents to be given with the questionnaire and check all entries in the questionnaire before retrieving them from the respondents. Data obtained were collated, tabulated, statistically analyzed and interpreted.

The data gathered were analyzed and interpreted using the following statistical treatment:

The Weighted Mean was used to describe the status of the project in terms of community power resources, the capacity to generate energy, community needs, and sustainability and in the extent of influence of the project along social services, economic development services, and environmental protection services.

For the analysis and interpretation of data that were gathered, weights were assigned to each category on the different variables with a corresponding verbal description.

**3. RESULTS AND DISCUSSION**

The status of the mini-hydro power plant was evaluated in terms of community power resources, capacity to generate energy, community needs, and sustainability. These areas were rated by the local officials of the municipality and local folks as to whether very sufficient, sufficient and insufficient. Community Power Resources. This section portrayed the power situation of the municipality and the justification on the need to establish the mini-hydro plant. The responses of the respondents are shown in Table 1.

Table 1  
The Perceptions of Respondents on the Community Power Resources

Community Power Resources	Weighted Mean of Perceptions		Ave.	Desc.
	Brgy. Officials	Community Folks		
There is adequacy of power supply in the municipality	1.80	2.20	2.00	S
There is the presence of local energy sources.	1.13	1.57	1.35	IS
The sufficiency of the energy supply from NPC generated Agus Hydroelectric Power Complex in Iligan City	1.93	2.00	1.97	S
There is assurance against power outages except during periods of annual plant maintenance or during a typhoon and natural disturbances.	1.20	1.02	1.11	IS
The municipality has a potential site or waterfall capable of generating mini-hydroelectric power	2.93	2.32	2.63	VS
The LGU has the necessary infrastructures that will support the project.	2.67	2.33	2.50	VS
The LGU has flood control program and waste disposal system in	1.93	2.22	2.08	S

support to the project				
The proposed mini hydro project has no effect on the existing irrigation systems for agriculture	3.00	2.24	2.72	VS
The power plant has a flood control program and waste disposal facilities	2.07	2.32	2.19	S
The power plant wins approval and support by the populace	3.00	.36	2.68	VS
Average. . . .	2.17	2.06	2.12	S

It can be deduced from the Table that the community power resources were sufficient as perceived by the local officials with an average weighted mean of 2.12 or sufficient. They perceived that the municipality had potential site or waterfall capable of generating mini hydroelectric power, the LGU had the necessary infrastructures that supported the project, “ the proposed mini hydro project had no effect on existing irrigation systems for agriculture and the project had the approval and support by the populace” with weighted mean of 2.63, 2.50,2.72 and 2.68, respectively. These conditions were rates by local officials as very sufficient. They believed on the "adequacy of power supply in the area" with a weighted mean of 2.00 or sufficient. They believed on the "sufficiency of the energy supply from NPC generated Agus Hydroelectric Power Complex in Iligan City” with a weighted mean of 1.97 or sufficient.

The LGU had flood control program and waste disposal system in support to the project with a weighted mean of 2.08 or sufficient. The respondents were favorable in "setting up a mini-hydro plant in their municipality” because they believed that the presence local energy sources were insufficient with a weighted mean of 1.35 and the “assurance against power outages except during typhoon and natural disturbances” was also insufficient with a weighted mean of 1.11 or insufficient.

The respondents, both the local officials and town folks, believed that the power supply from Agus Hydroelectric Power Complex in Iligan City was not adequate especially during periods of annual plant maintenance or during a typhoon and natural disturbances. This constraint justified their perceptions that there was a need to put up a mini-hydro plant in the municipality. Anyway, the municipality had the resources needed to establish a mini-hydro plant.

This implies that putting up a mini hydro was advantageous to the municipality. It lowers the cost of electricity and makes the power available at all times to the benefit of everybody in the community. Further, it opens the door of opportunities for the people in the municipality to sink into their consciousness and broaden their knowledge about power plants on its benefits for the community folks. However, the respondents perceived the presence of local energy sources and the assurance against power outages except during periods of annual plant maintenance or during the typhoon and natural disturbances to be Insufficient with a mean of 1.35 and 1.11 respectively. This tells that the power plant is not working or not helpful during the times when there are calamities because of its lack of local energy sources.

Cantilan is endowed with resources capable of generating power. The respondents perceived that the supply of power resources was sufficient. Proper utilization of these resources and appropriate resource conservation could make this sufficiency level sustainable. All stakeholders must jointly put their hands together in preserving this bounty for sustainable development.

Capacity to Generate Power. The status of the project as to its capacity to generate power as perceived by local officials and community folks are pooled in Table 1.

Table 2  
The Perception of the Respondents on the Status of the Power Plant as to its Capacity to Generate Power

Capacity to Generate Power	Weighted Mean of Perceptions		Ave.	Desc.
	Brgy Officials	Community Folks		
The LGU has available technical manpower to man the mini hydro plant during and after the establishment	2.27	2.10	2.19	S
The run-of-the-river type of dam could be established in the proposed site.	2.07	2.27	2.17	S
The location of the mini hydro plant has all the required resources to generate electric power.	2.80	1.05	1.93	S
The inhabitants are capable of supplying the manpower requirement of the project in terms of skills.	2.07	2.46	1.23	IS
The local populace has sufficient support for the establishment of the mini hydro plant	3.00	2.38	2.69	VS
The project has sufficient support from politicians	3.00	2.35	2.68	VS
The power plant has the capacity to generate the power requirement of the municipality	2.93	2.34	2.64	VS
The power plant has passed all the technical requirements of the Department Energy	3.00	2.30	2.68	VS
The power plant passed of ECC requirements of the Department of Environment and Natural Resources	3.00	2.30	2.65	VS
The LGU is ready and capable of managing the operation of the project.	3.00	2.32	2.66	VS
Average.....	2.71	2.19	2.45	S

The local officials perceived the project to generate very sufficient to power while the town folks perceived that the project can generate adequate amount of power. The combined perceptions of respondents showed that the project can generate sufficient power to the community with an average weighted mean of 2.45 or sufficient.

It was observed that the local populace had sufficient support for the establishment of the mini hydro plant with a weighted mean of 2.69 or very sufficient. The project had sufficient support from politicians as well with a weighted mean of 2.64 or very sufficient. The project has the capacity to generate the power requirement of the municipality with the weighted mean of 2.68 or very sufficient. The project had passed all the technical requirements of the Department of Energy with the weighted mean of 2.65 or very sufficient. The LGU is ready and capable of managing the operation of the project with the weighted mean of 2.66 or very sufficient.

The LGU had available technical manpower to man the mini-hydro plant during and after the establishment with the weighted mean of 2.19 or sufficient. The run-of-the-river type of dam could be established in the proposed site with the weighted mean of 2.17 or sufficient. The location of the mini hydro plant has all the required resources to generate electric power with the weighted mean of 1.93 or sufficient.

The respondents believed that the inhabitants are capable of supplying the manpower requirement of the project in terms of skills with a weighted mean of 1.23 or insufficient.

The responses of respondents suggest that the mini hydro has the capacity to generate power. The power generates from the mini hydro is a cheaper substitute of power coming from the Agus Hydroelectric Power Complex of Iligan City.

The data revealed that the mini hydro project has the technical capability to generate power in the locality. The capacity of the project to generate energy wins the support by local leaders and community folks. It is believed that with stable energy source could result to a stable economy of the municipality since this will sustain and even enhance the direct and indirect economic activities of the people.

Sipangpang Falls Mini Hydro Project has installed capacity of 1.0 MW. And can be a multi-use project (water supply, irrigation, and tourism). The scheme of development was a run-of-river rubble masonry dam to divert water to a pressurized steel penstock then to a power plant and the water will be brought back to Eyamjo River. This means that water from the river will be diverted to and utilized by the mini hydropower plant at the same rate it would normally flow through the river. It is important to point out that water will not be consumed by the power plant and its quality of water will never be affected because no oil, pollutants or chemical will be mixed. Full capacity operation is

Expected during the rainy season and even during a normal period. Project costs are P86M.

The proposed Sipangpang Falls Mini Hydroelectric Power Project (SFMHPP) has a potential generating capacity of 2,000 kW per hydrology study but LGU Cantilan has decided to develop only 1,000 kW capacity with no more expansion due to its plan to develop the site as tourist attraction, thus the need to have water continuously flowing of the main falls. Present power demand for the whole Cantilan municipality is less than 400 kW thus ensuring ample power supply while two (2) neighboring towns will be supplied.

The final scheme of development was to build a run-off the river type of a dam located approximately three hundred meters top of the Sipangpang Falls. This offers additional head to generate more power while taking advantage of the minimal costs of aggregates that can be sourced from the

nearby Carac-an and Eyamjo River bed. The shed would also preserve the beauty of the falls by allowing a fraction of the flow through.

Community Needs. The respondents believed that with the establishment of mini-hydro plant will certainly improve the power requirements of the municipality with a weighted mean of 2.68 or very sufficient. They further perceived that the local energy source will reduce the cost of energy consumption by the various establishment in the municipality with a weighted mean of 2.58 or very sufficient.

Both the local officials and the community folks perceived the following as sufficient: the establishment of mini-hydro plant will also meet the power needs of the neighboring municipalities with a weighted mean of 2.25 or sufficient, the project will provide jobs and training for semi-skilled and skilled workers during and after construction with a weighted mean of 2.03 or sufficient, the project will provide access to inaccessible barangays particularly in Brgy Lobo and Brgy Cabangahan with weighted mean of 2.07 or sufficient, the project will incorporate other productive water use such as water supply, irrigation, tourism and recreation with a weighted mean of 2.43 or sufficient, the people believe that the generation of local energy source will improve their agriculture and trade industries with a weighted mean of 2.07 or sufficient, the project will enhance the economic activities of the respondents with a weighted mean of 2.35 or sufficient, and the local power source will enhance the standard of living of all the people living in the municipality with a weighted mean of 2.07 or sufficient.

The overall weighted mean of the responses was 2.29 or sufficient. This shows that the project was based on the need of the community. The respondents believed that the community needs to develop local energy sources to stabilize the supply of energy. The insufficiency of power distributed by NPC in some parts of the year had triggered that people in the municipality to look for the alternative local source of energy. The cost of energy will certainly lower with the use of locally produces energy.

Rural electrification is the key to a better life for all Filipinos. Detailed studies have clearly emphasized that electric power, wherever introduced,

stimulates the growth of industry and the economy in general. Electricity has made possible countless improvements that serve to alleviate the plight of many of our rural folk's golden opportunities that they could only dream of until that proclamation of Presidential Decree No.269, which mandated the government to effect sweeping changes and reforms in the social, economic and political structures of the nation through rural electrification.

As perceived by the respondents, the power plant provided a long term supply of electric power in the municipality and the neighboring municipalities with a weighted mean of 2.73 or very sufficient. The cost of electricity in the municipality lowered for as long as the mini hydro plant is operational with a weighted mean of 2.84 or very sufficient. The support of the people to the project continued in the years to come with a weighted mean of 2.62 or very sufficient.

The support of the project by the local leaders continued even if there was a change in the administration with a weighted mean of 2.63 or very sufficient. The support of the project by

our local leaders continued even if there was a change in the administration with a weighted mean of 2.62 or very sufficient. The operation of the project sustained the increased revenue collection of the municipality with a weighted mean of 2.50 or very sufficient

The project sustainability apportioned part of the Realty and Special Privileges taxes and other benefits to the host barangay/municipality/province where this was established with a weighted mean of 2.30 or sufficient. The project provided full development of potential tourist attractions with a weighted mean of 2.26 or sufficient. The project enhanced and sustained the economic prosperity of the municipality with a weighted mean of 2.44 or sufficient. The project continuously supports the economic activities of the people in the municipality with a weighted mean of 2.39 or sufficient.

As to sustainability, the local leaders believed that the project's sustainability was very sufficient while the community folks considered the project as sufficient. The overall sufficiency level as sustainability was very sufficient with an average weighted mean of 2.54.

The study reveals that the mini hydro project will continuously provide sustainable benefit to the municipality on a long term basis. The project will provide a low cost and sustainable supply of energy in the municipality.

The success of any energy conservation program depends largely on the commitment of everyone within an organization, in the households, and on the habits and lifestyle of each worker. People, therefore, are the key to an effective conservation program. Since workers take their cue from management, management must initiate energy conservation efforts. [6] (Torillo:2009, 50).

#### 4. CONCLUSION

The project generated a favorable impact on the lives of Cantilangnons. The object was responsive to the needs of the

community, sustainable and had the capacity to generate energy enough to serve the municipality and some neighboring municipalities. The project, likewise, was influential in providing social and economic development services to the people and very influential in promoting environmental protection services. The problems identified were mostly social and none was technical or even physical in nature.

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