BEYOND THE GRID: ASSESSMENT OF RESOURCE LIMITATIONS IN GIBITNGIL ISLAND AS BASIS FOR COMMUNITY EXTENSION PROPOSALS

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ABSTRACT. *This paper presents data aimed at identifying the key resource limitations in the remote, off-grid island barangay of Gibitngil, Medellin, Cebu. It analyzes how these limitations impact the daily lives and socio-economic activities of the residents. The findings reveal that the majority of the population is primarily engaged in agriculture or fisheries. The data shows that, while all beneficiaries are employed, their earnings are generally low to moderate. Additionally, all respondents' report that energy availability is very low, indicating that although energy is somewhat accessible, it is woefully inadequate to meet their needs. The study also highlights a strong dependence on generators and solar energy, with solar power being the only renewable energy option available to the community. The two primary barriers to adopting renewable energy systems are economic constraints (62%) and a lack of technical knowledge (38%). These findings suggest that financial limitations and insufficient expertise are the most significant obstacles preventing the wider adoption of renewable energy technologies in the area. Furthermore, a large portion of the community (90%) has limited knowledge of renewable energy systems, emphasizing the urgent need for educational programs that raise awareness and build capacity regarding renewable energy technologies. Despite these challenges, there is a notable* ***100% willingness*** *among the community members to undergo training on the installation, operation, and maintenance of photovoltaic systems. This shows a strong desire to acquire the necessary skills to manage renewable energy technologies. The community's openness to training offers a promising opportunity for development. With appropriate educational and skill-building initiatives, they could successfully transition to sustainable energy solutions. To effectively address the persistent energy challenges faced by marginalized communities in Barangay Gibitngil, Medellin, Cebu, the researcher proposes a series of capacity-building extension projects aimed at empowering local farmers and fishers to adopt and leverage renewable energy solutions. These* initiatives are designed to enhance energy access, promote sustainability, and build long-term self-reliance within the community.

Keywords*: solar home, charging stations, renewable energy, skills training*

INTRODUCTION

Electricity is the backbone for the economic and social development of a country. [1] As the cornerstone of modern society, access to energy has been linked to improvements in health, education, and social welfare [2]. It is also acknowledged by the Sustainable Development Goals set by the United Nations that the provision of affordable and clean energy (Goal 7) is interconnected with other milestones in poverty elimination, environmental protection, and peace [3]. However, there are still over a billion people worldwide, 87% of whom are in rural areas, without access to electricity [4]. Many are still dependent on traditional biomass and imported fossil fuels (e.g. kerosene, diesel) for their energy needs. While there have been great efforts to address this gap, the energy problem remains a challenge due to the interplay between technology, economics, the environment, and society [5].

In many remote barangays, and particularly in Gibitngil Island, Medellin Cebu, access to essential resources such as electricity, clean water, and healthcare remains a significant challenge. Gibitngil Island, a small yet vibrant community, remains beyond the reach of many basic utilities and resources commonly found in mainland settings. Remote off-grid barangays in the Philippines face significant challenges due to their isolation from centralized infrastructure and services. These communities often rely on decentralized systems, which can be unreliable and insufficient to meet their needs. The lack of reliable energy sources, in particular, hampers economic development and quality of life, perpetuating cycles of poverty and underdevelopment.

This research aimed to assess the resource limitations faced by these off-grid barangays, with a focus on understanding the underlying limitations and potential solutions. The findings of this research will be crucial in formulating targeted and appropriate extension programs tailored to the community's requirements. Such programs could encompass sustainable energy solutions, improved water supply systems, enhanced educational opportunities, and better healthcare services. Addressing these gaps will not only improve the quality of life for Gibitngil Island's inhabitants but also promote sustainable development and self-reliance within the community.

Research Objectives:

1. To identify the key resource limitations in this remote off-grid barangay Island.
2. To analyze the impact of these limitations on the daily lives and socio-economic activities of the residents.
3. To provide proposals for community extension programs tailored to the needs of the community.
4. To explore potential sustainable energy solutions, such as decentralized renewable energy systems, and assess their feasibility and impact on improving resource access and overall community resilience.

This research is timely and relevant, given the global push towards achieving the United Nations Sustainable Development Goals (SDGs), particularly SDG 7, which aims to ensure access to affordable, reliable, sustainable, and modern energy for all. By focusing on the unique challenges faced by remote off-grid barangays, this study seeks to provide actionable insights that can inform policy and drive meaningful change in these underserved communities.

METHODOLOGY

To achieve the objectives of this study, a mixed-methods research design will be employed, integrating both qualitative and quantitative approaches to ensure a comprehensive analysis. The methodology will begin with an extensive literature review focused on energy access, resource limitations, and sustainable development in remote communities. This review will also explore decision-making methods and tools for sustainable solutions. Quantitative data will be gathered through structured field surveys administered to selected households. These surveys will collect essential data on energy usage, resource availability, and socio-economic conditions. A stratified random sampling technique will be used to ensure that the sample accurately represents the broader population of the area. To gain deeper insights into the community's lived experiences, qualitative data will be collected through semi-structured interviews with key informants, including local leaders and representatives from relevant government and non-governmental organizations. Focus group discussions will also be organized to gather community perspectives on existing challenges and possible solutions.

Data analysis will involve the use of statistical tools to compute frequency counts, percentages, and means. Statistical software will be used to process the quantitative survey data, while thematic analysis will be applied to qualitative responses to identify significant themes and insights. The research findings will be compiled into a comprehensive report that identifies the key barriers to resource access and proposes viable, community-specific interventions. These results will be disseminated to relevant stakeholders—such as policymakers, development organizations, and community leaders—to guide future efforts and interventions. Based on the findings, the study will also design sustainable solutions aimed at addressing the identified community needs. These include the development of community extension proposals, livelihood training programs, strategic partnerships with local government units and NGOs, and innovative product development for long-term sustainability. Patent initiatives will be considered for unique, locally developed tools, and policy recommendations will be formulated to strengthen public-private partnerships. Additionally, the study aims to publish its findings in reputable, Scopus-accredited journals to contribute to academic discourse. By Gender and Development (GAD) guidelines, the study will uphold ethical standards, ensuring voluntary participation and the confidentiality of all responses. No respondent will be coerced, and the rights and dignity of all participants will be respected throughout the research process.

However, the project also recognizes certain limitations. These include the geographical scope, which is limited to Gibitngil Island in Medellin, Cebu, and may not be generalizable to other rural communities. Time constraints could affect the depth of data collection and analysis, and reliance on surveys and interviews may introduce response bias. Despite efforts to ensure representativeness, the sample size may not capture the full diversity of community experiences. Furthermore, while policy recommendations will be developed, the practical implementation of these suggestions may face obstacles such as political limitations, resource constraints, or institutional challenges.

REVIEW OF RELATED LITERATURE

The effects of energy limitations in off-grid communities are profound, impacting socio-economic development and sustainability. Research highlights various strategies and technologies aimed at addressing these challenges, particularly in rural areas of developing countries.

The assessment of resource limitations in off-grid communities is critical for developing sustainable energy solutions. Various studies highlight the limitations, challenges, and opportunities associated with the remote off-grid community areas.

Impacts of RE energy access in communities:

The lack of access to electricity in Pacific Small Island Developing States (SIDS) produces adverse economic and social impacts. It is widely acknowledged that access to electricity is welfare-enhancing, although evaluation can be difficult due to attribution problems. Electricity facilitates economic activity and the provision of a range of basic services. It enables cold storage of food and vaccinations and is essential for the use of appliances such as computers, televisions, radios, and mobile phones. Electronic appliances are often important sources of information for rural households, and in many SIDS are leading to greater access to formal financial services in rural areas. The use of electricity for lighting extends working hours, makes public spaces safer, and permits children to do homework at night. It has also been demonstrated around the world that the provision of electricity helps attract teachers and health-care workers to rural areas.

Access to electricity has financial advantages. Electricity replaces expensive traditional fuels such as kerosene for lighting and use of batteries to power radios and other small appliances. Households with access to electricity therefore spend less money on energy than comparable households without access to power, although upfront costs associated with electricity connections are often unaffordable for rural households. The financial benefits of access to electricity are true for both households connected to the grid and those connected to off-grid systems [6].

The most commonly cited benefits of PV hybrid mini-grid systems (PVHMS) in the literature are improved electricity service and lower operating costs. The first usually stems from the capabilities of PVHMS to serve larger loads relative to individual PV systems, and their ability to provide a more reliable supply in the challenging context of rural electrification [7].

In Sub-Saharan Africa, only 28% of the rural population has electricity access, leading to increased poverty and limited economic opportunities. The deployment of hybrid solar mini-grids has shown a 45% improvement in electrification [8]. Access to electricity is known to support the improvement of the well-being of humankind. Access to electric power supply has always had a significant role in promoting improvements in all the society sectors. [9].

The importance of rural electrification (RE) in bringing about both direct and indirect social and economic benefits for communities, ranging from incremental livelihood leading to reduced poverty to better facilities for health and education has been well documented [10].

Kerosene lighting is up to 6 times as expensive as electric lighting. If electricity replaces kerosene for lighting, large subsidy savings can be realized [11].

The Challenges in Implementing Renewable Energy Systems:

While these advancements present promising solutions, the complexity of energy needs and local contexts necessitates tailored approaches to ensure effective implementation and sustainability in off-grid communities. Community-based off-grid systems utilizing renewable energy sources like photovoltaic (PV) and wind energy are promising solutions for rural electrification. These systems, however, come with their own set of limitations and challenges:

1. Energy Management and Quota Sharing: Effective energy management is crucial to prevent the uncontrolled depletion of resources. Implementing a democratized quota-sharing system can help ensure fair distribution of energy among community members. Additionally, unused energy can be sold through local energy marketplaces, enhancing the system's economic viability [12].

2. Micro-Scale Wind Resource Assessment: Proper identification and assessment of local renewable energy resources are essential for the success of off-grid projects. In Peru, micro-scale wind resource assessment models have been optimized to account for the unique characteristics of rural electrification projects, such as limited data and steep terrains. These models have proven effective in creating accurate resource maps for community projects [13].

3. Hybrid Renewable Energy Systems: In Canada, hybrid renewable energy systems combining solar, wind, and diesel generators have been evaluated for their effectiveness in off-grid communities. Various scenarios have been tested to determine the optimal mix of renewable and non-renewable resources to meet energy demands while minimizing costs and greenhouse gas emissions [14].

In British Columbia, remote and First Nations communities are increasingly pursuing energy self-sufficiency as a means of achieving both material and political autonomy. These communities view energy projects as a step towards decolonization and self-determination. However, there is often a disconnection between community goals and the approaches taken by government and industry, which tend to view these communities as easy targets for sustainability projects [15].

Managing limited energy resources in isolated micro-grids requires dynamic allocation strategies. In developing countries, increasing load demands without a corresponding expansion of PV capacity can lead to operational challenges. A power supply scheduling mechanism that allocates maximum power capacity to each user based on historical load profiles and current battery capacity can help maintain network stability and ensure equitable access to electricity [16].

In Indian communities, people live in different parts of the ecosystem, where all people are not beneficiaries of electricity. Due to uneven geographical location, it is difficult to provide electrical energy through a traditional power grid. Sustainable development of the community should be ensured at the grassroots level regarding energy distribution and consumption grassroots innovations and public participation are crucial for the success of off-grid solar projects, emphasizing the need for community engagement in energy initiatives [17].

Access to electricity is limited in Sub-Saharan African countries, with only 43% of the population having access, and the number is even lower, at 28% in rural areas. Connecting small remote villages to the national utility grid is not feasible due to long distances and high investment costs [18].

Pandyaswargo et al., 2022 in their study emphasize the community engagement. Assessments in Indonesia emphasize the importance of aligning energy systems with local needs and socio-economic conditions to ensure sustainability.

Even though several studies argue that PV systems are becoming mature enough to compete with other conventional energy sources, a study reveals that the diffusion and adoption of PV systems still face several barriers. Although the barriers should be evaluated in a particular context, e.g., in regard to a country or a type of grid connection, the barriers commonly constitute four interrelated dimensions: sociotechnical, management, economic, and policy. From an economic point of view, the cost of PV systems is still generally perceived as high. In regard to the sociotechnical dimension, several studies imply that the complexity of interaction between people and PV systems can hinder the adoption. In addition, there are still several barriers related to the policy dimension and technology management. Ineffective policy measures and inappropriate management can hamper the diffusion process in a variety of contexts.

For the wide adoption of PV systems, the literature discussed in this review paper suggests that the involvement of all stakeholders—adopters, local communities, firms, international organizations, financial institutions, and government—is still crucial [19].

In a study conducted in Eastern Africa to assess the opportunities and challenges facing the development of off-grid solar systems, the main problem discussed here was the financial constraint, whereby the energy users are unwilling or unable to pay. The investment is not feasible for the private developer or access to the financial means is limited. In order to bring about a solution, both investors and buyers need to be taken into consideration. The government needs to equip citizens in rural areas with education and generate developmental activities that bring them earnings. To encourage private developers to venture into the business, the government needs to offer subsidies to ensure fair play, so that private developers are able to provide power at the same rate as government institutions [20].

In the Philippines, policies and regulations and implementing guidelines that make it easier for cooperatives to venture into RE generation is identified as the most serious implementation risk. The discontinuity between the present administration's policy pronouncement and its policy implementation practice. This is a challenge to local engineers and higher education institutions in general [21].

In another recent study conducted in a rural island community in the Philippines, findings suggest that insufficient policies and regulatory frameworks, research and development, education, and training were among the most crucial barriers that impact other barriers to the adoption of Photo Voltaic (PV) systems in such areas [22].

Off-grid communities face numerous challenges in managing limited energy resources. Effective energy management systems, accurate resource assessments, hybrid renewable energy solutions, and dynamic allocation strategies are essential for optimizing resource use and achieving sustainable electrification. Additionally, understanding and aligning with community goals, particularly in the context of self-sufficiency and decolonization, is crucial for the success of these projects.

Technological Solutions:

Access to clean energy for communities living in remote areas where grid extension is considered unfeasible can be provided by off-grid electrification systems using renewable energy (RE). Especially in developing countries, ensuring the appropriateness of such systems is crucial because it will determine the system's sustainability despite its limited resources [23].

Community-centred off-grid systems utilizing photovoltaic technologies and blockchain-based peer-to-peer energy markets can optimize energy distribution and usage. Connecting small remote villages to the national utility grid is not feasible due to long distances and high investment costs. Community-based off-grid systems using photo-voltaic and energy-storage technologies offer a solution for rural electrification. Due to the limited energy capacity in the system and variations in energy needs and consumption within the community members connected and supplied by the off-grid system, there needs to be democratized quota sharing between the connected households in place. In off-grid systems, there could be cases where there is a certain amount of unused energy every day, which with quota sharing and local energy marketplace can potentially be sold to users with higher energy needs. When the available energy is used effectively, it impacts directly the system's business model and payback time [24].

Off-grid small-scale electricity generation represents one of the most appropriate options to face this issue, both as a first step in the electrification process or as a building block for future grid development [25].

The forecasts drawn by the International Energy Agency (IEA) reported that about 60% of the additional electricity generation requested to provide universal access to energy, is expected to be generated through off-grid systems. Furthermore, the analyses also report that off-grid systems are almost totally required for rural electrification and about 90% of them are supposed to rely on renewable-based systems and mini-grid [26].

The high costs of delivered electricity can be attributed to strong dependence on centralized energy systems which operate mostly on fossil fuels and require huge investments for establishing transmission and distribution grids that can penetrate remote regions [27]. Stand-alone electric generation hybrid systems are generally more suitable than systems that only have one energy source for the supply of electricity to off-grid applications, especially in remote areas with difficult access [28].

Several hybrid energy system configurations can be used for power generation like PV–wind-diesel systems, hydro–wind–PV-based systems, biomass–wind–PV installations, wind–PV-based installations, PV–wind–hydrogen/fuel cell hybrid energy systems etc. The hybrid energy system has the following main advantages in comparison to single source-based system: 1. Higher reliability 2. Reduced energy storage capacity especially where different sources have complementary behavior.3. Better efficiency. 4. Minimum levelized life-cycle electricity generation cost, when optimum design technique is used [29].

RESULTS AND DISCUSSION

This section presents, analyzes, and interprets the data gathered from the 29 beneficiaries in Barangay Gibitngil, Medellin, Cebu. The findings are structured to reflect key dimensions relevant to the study, including demographic profile, socio-economic status, energy availability and resources, technical and economic constraints, and community engagement. The analysis provides insight into the current conditions and challenges faced by the community and supports the development of a proposed extension capability training program focused on renewable energy solutions.

A. Profile of the Respondents.

Table 1 provides an overview of the demographic characteristics of a sample group of 29 beneficiaries, including their age, sex, civil status, and educational attainment. The analysis below highlights the distribution across these categories.

Age Distribution

The majority of beneficiaries are concentrated in the **22 to 45-year-old** age range, comprising **62%** of the total. This suggests that the program or service is most utilized by adults in their prime working years. The representation of older individuals (**46-64 years old**) and the very young (**21 and below**) is minimal, indicating that the intervention may be targeted more toward middle-aged individuals.

Sex Distribution

The sample group is slightly skewed toward males, with **55%** of the beneficiaries being male compared to **45%** being female. The difference is relatively small, suggesting a balanced representation between the sexes in this group.

Civil Status Distribution

A larger proportion of the beneficiaries are **married** (52%), followed by those who are **single** (38%). The smaller groups include **widowed** and **separated** individuals, making up just **7%** and **3%**, respectively. This indicates that the majority of the beneficiaries are in stable, marital relationships.

Education Attainment Distribution

The educational attainment of the beneficiaries is predominantly low, with **52%** having only an elementary level of education. The group with **high school education** is also substantial, accounting for **34%**. Only a small proportion of the beneficiaries have **college-level education** (**14%**), and no beneficiaries have completed vocational training. This indicates that the program or service is reaching a population with relatively low levels of formal education.

Table 1. Demographic profile of beneficiaries

Demographic Profile of Beneficiaries	F	%
1. Age		
21 years old and below	1	3.5
22yrs old – 45yrs old	18	62
46yrs old – 64yrs old	9	31
65 years old and above	1	3.5
Total	29	100
2. Sex		
Male	16	55
Female	13	45
Total	29	100
3. Civil Status		
Single	11	38
Married	15	52
Widowed	2	7
Separated	1	3
Total	29	100
4. Education Attainment		
Elementary Level	15	52
High School Level	10	34
College Level	4	14
Vocational		
Total	29	100

B. Socio-Economic Status

Based on the results of the survey questionnaire provided to the respondents of Barangay Gibitngil Island Medillin, the Twenty-nine beneficiaries in terms of socio-economic status are shown in Table 2.

Table 2. Socio-economic status of beneficiaries

Socio-Economic Status	F	%
1. Employed?		
No	-	-
Yes	29	100
Total	29	100
2. Occupation		
No response		
Fishers	17	59
Farmer	5	17
Others	7	24
	29	100
Total		
3. Monthly Income		
4,000 Paubos	13	45
4,001- 6,000	5	17
6,000 - 8,000	9	31
10,000 Pataas	2	7
Total	29	100

Employment Status

All 29 beneficiaries (100%) are employed, with no individuals reporting as unemployed. This suggests that the beneficiaries are engaged in some form of work, highlighting an active labour force within this group.

Type of Occupation

A significant portion of the beneficiaries, **59%**, did not respond to the question regarding their occupation. This could imply that the occupation is either not well defined or not disclosed by the beneficiaries. Among those who provided an occupation, **farmers** make up the largest group, accounting for **24%**, followed by **fishers**, representing **17%**. No beneficiaries reported other types of occupations. This distribution suggests that the group is largely involved in agriculture or fisheries, which could reflect the local economy or the specific focus of the program.

Monthly Income

The majority of beneficiaries (45%) report a monthly income of **4,000 or below** (declining or low income). This is followed by beneficiaries earning between **6,001 and 8,000** (31%), and those earning between **4,001 and 6,000** (17%). A small portion, **7%**, reports earning **10,000 or more**, indicating that a few beneficiaries belong to a higher income bracket. Overall, the income levels suggest that most beneficiaries are in the lower income range, with a few exceptions reaching moderate to higher incomes.

C. Energy Availability and Resource

Table 3 provides information on the **primary source of energy**, **types of renewable energy available**, and the **rate of availability** of energy resources among 29 beneficiaries. Below is a detailed analysis based on the data.

The majority of beneficiaries (83%) rely on **generators** as their primary source of energy. A much smaller group (17%) depends on **solar energy**. This suggests that while renewable energy sources like solar are used by a small portion of the group, traditional or more conventional energy sources like generators are still predominantly utilized. There are no reports of beneficiaries using **biomass** or other energy sources, indicating limited diversity in the primary energy sources within the group.

Table 3. Energy availability and resource

Energy Resource	F	%
1. Present Primary Source of Energy		
Generator	24	83
Solar	5	17
Biomass		
other	29	
Total		100
2. Types of Renewable Energy available		
Wind	29	100
Solar		
Hydro		
Biomass		
others	29	100
Total		
3. Rate of Availability		
Very Low	29	100
Low		
Just enough		
More than enough		
Plenty		
Total	29	100

Types of Renewable Energy Available

Every beneficiary (100%) has **solar energy** available as a renewable energy source, but there is no availability of other renewable energy types like **wind**, **hydro**, or **biomass**. This suggests that solar energy is the only renewable option accessible to all beneficiaries, highlighting a reliance on solar power as the main **renewable** energy resource, while other alternatives are absent.

Rate of Availability of Energy

All beneficiaries (100%) report that the availability of energy is **very low** to meet their needs. This suggests an inadequate supply of energy for the entire group.

D. Technical, Environmental and Economic Factors

Table 4 provides insights into the **constraints to implementing renewable energy**, the frequency of **power breakdowns or interruptions**, and the **monthly spending on energy** among a group of 29 beneficiaries.

Constraints to Implementing Renewable Energy

Economic constraints (Funds) are the most significant barrier to implementing renewable energy solutions, with **62%** of beneficiaries citing financial limitations as a primary challenge. This indicates that the lack of available funding is seen as the key obstacle to adopting or expanding renewable energy systems, such as solar panels or wind turbines.

Technical knowledge (38%) is the second most common barrier. This could imply that even if funds were available, there might be a lack of expertise in implementing or maintaining renewable energy technologies.

Interestingly, there are no reports of barriers related to **terrain**, **distance**, **accessibility**, or **weather**, suggesting that these factors are not seen as significant limitations, or the group does not face environmental or logistical challenges in installing renewable energy systems.

Table 4. Technical, environmental and economic factors

Technical, Environmental and Economic Factors	f	%
1. Constraints to implementing Renewable energy		
Terrain		
Distance		
Accessibility		
Wheather	18	62
Funds (economic)	11	38
Technical Knowledge		
others		100
Total		
2. How often do you experience breakdowns/power interruptions?	29	100
Daily		
Monthly		
Yearly	29	100
Total		
3. How much do you spend on energy/electricity monthly?	0	
3,000 and above	4	14
2,000 - 2,999	15	52
1,000 - 1,999	10	34
below 1,000	29	100
Total		

Frequency of Power Breakdowns/Interruptions

All beneficiaries (100%) report experiencing **daily power breakdowns or interruptions**. This is because generator sets are operational only between 6:00-10:00 PM. This is a significant issue, as it indicates that the energy supply is unreliable, with daily disruptions occurring. The absence of **monthly** or **yearly** interruptions implies that the disruptions are frequent and consistent, which could point to an unstable energy grid that affects all beneficiaries regularly.

Monthly Spending on Energy/Electricity

The majority of beneficiaries (52%) report spending between **1,000 and 1,999** on energy each month. Considering that the majority of the monthly income of the beneficiaries is below 4,000 a month, this indicates that most are facing high energy costs, and the overall spending on energy within the group is very high.

E. Community Engagement and Willingness

Despite limited income and low educational exposure to renewable energy, the community exhibits a remarkable openness and readiness for change. The overwhelming willingness to adapt and be trained in photovoltaic systems reflects a deep-rooted desire for sustainable solutions to alleviate high energy costs and frequent power interruptions. This spirit of engagement reveals not just a community burdened by economic and technical constraints—but one empowered by hope, adaptability, and the collective pursuit of a better energy future.

Table 5. Community engagement and willingness

Community Engagement and Willingness	f	%
1. How willing are you to switch to renewable energy systems?		
Not willing	1	
Not Sure		
Willing	28	
Very Willing	29	100
Total		
2. What is your level of education do you have regarding Renewable Energy System	26	
Low	2	
Basic	1	
Intermediate		
Advance	29	100
Total		
3. Are you willing to be trained on the installation, operations and maintenance of the Photo Voltaic	29	100
System?	0	0
Yes	29	100
No		
Total		

The table focuses on the community's **willingness** to switch to renewable energy systems, their **level of education** about renewable energy, and their **interest in receiving training** for the installation, operation, and maintenance of **Photovoltaic (PV) Systems**.

Willingness to Switch to Renewable Energy Systems

A vast majority (**97%**) of the beneficiaries are **very willing** to switch to renewable energy systems. This reflects a strong interest and openness within the community to adopt renewable energy technologies. Only **3%** of the beneficiaries are **unsure** about making the switch, while **none** are unwilling or moderately willing. This indicates an overwhelmingly positive attitude towards renewable energy adoption, suggesting that there is a high level of support for such transitions within the community.

Level of Education on Renewable Energy Systems

The majority of beneficiaries (**90%**) have a **low** level of education regarding renewable energy systems, suggesting that there is limited understanding or exposure to renewable energy technologies among the community. A small portion of the group (**7%**) has a **basic** understanding, while only **3%** have an **intermediate** level of knowledge. Notably, no beneficiaries report having an **advanced** level of knowledge about renewable energy systems, indicating a significant gap in expertise and education within the community.

Willingness to Be Trained on PV System Installation, Operation, and Maintenance

Every beneficiary (**100%**) is willing to receive training on the **installation, operation, and maintenance** of **Photovoltaic (PV) systems**. This shows that there is a strong willingness within the community to acquire the necessary skills to implement and maintain renewable energy systems, particularly solar energy. The community's readiness to be trained highlights the potential for capacity building and empowering individuals with the skills needed to contribute to renewable energy adoption.

Proposed Extension Capability Training among Fishers and Farmers

Barangay Gibitngil, located in Medellin, Cebu, is an agricultural and fishing community that heavily depends on electrical appliances for farming and fishery operations. Unfortunately, the area suffers from an inadequate and unreliable electricity supply, disrupting daily activities and negatively impacting the livelihoods of its residents. Moreover, in line with the Philippines' commitment to reducing greenhouse gas emissions, transitioning to renewable energy sources is essential for achieving environmental sustainability. To address the persistent energy challenges faced by the marginalized sectors in the barangay, the researcher proposes a comprehensive solution: a capability-building extension project designed to empower farmers and fishers to harness renewable energy. The project is named the **"Solar (Photovoltaic) Home System (SHS) Training and Installation of Solar Charging Stations (SCS) Skills Training."**

The proposed program aims to equip the community with the necessary knowledge and practical skills to harvest energy from renewable sources, specifically solar power, through the following key topics:

1. **Introduction to Renewable Energy**: This session will provide an overview of various types of renewable energy, including solar, wind, and hydropower. It will highlight the benefits of utilizing renewable energy, such as reducing air pollution, mitigating climate change, and promoting sustainable development. The session will also emphasize the economic, environmental, and social advantages of transitioning to clean energy sources.
2. **Designing and Building Renewable Energy Systems**: This hands-on training will teach farmers and fishers how to design, install, and maintain their renewable energy systems, focusing primarily on solar technology. Participants will learn how to build and install **solar home systems** (SHS) and **solar charging stations** (SCS), enabling them to generate and store clean energy for their daily needs. The skills gained will empower them to become self-reliant in managing their energy consumption.

This extension program offers a practical and sustainable solution to the power inadequacy issues faced by the community in Barangay Gibitngil, Medellin, Cebu. By introducing renewable energy technologies, the project will not only improve the resilience of the community against power shortages but also promote long-term environmental sustainability. The initiative is aligned with the United Nations Sustainable Development Goal (SDG) of "Affordable and Clean Energy," which seeks to provide access to reliable, sustainable, and modern energy for all. Through this training, the community will gain valuable skills to generate clean, renewable energy locally, enhancing their living conditions, reducing dependence on external power sources, and contributing to sustainable development in the region.

CONCLUSION AND RECOMMENDATION

The Demographic Profile of beneficiaries shows that: The largest proportion of beneficiaries is aged **22 to 45** years old, predominantly **male**, and **married**. The group has a low level of **education**, with more than half having only completed elementary school. The sample group appears to be a mix of individuals with some educational attainment but with a notable portion lacking higher-level education or vocational skills.

All beneficiaries are employed, showing full participation in the labour force. The majority of those who provided their occupation are engaged in **farming** or **fishing**, with a significant portion not responding to the question. Most beneficiaries earn low incomes, with **45%** earning **4,000 Paubos** or less, while a small percentage (7%) reports earning over **10,000**. This suggests that while all beneficiaries are working, they generally have low to moderate earnings.

The majority of beneficiaries use **generators** (83%) as their main source of energy, while a smaller percentage (17%) rely on **solar energy**. Every beneficiary has access to **solar energy**, but there is no availability of other renewable energy sources such as **wind**, **hydro**, or **biomass**.

All beneficiaries report that the energy availability is **very low**, indicating that while energy is accessible, it is very inadequate. This data reflects a strong reliance on **generators** and **solar energy**, with renewable energy options limited to **solar power** alone. The two main obstacles to adopting renewable energy are **economic funds (62%)** and **technical knowledge (38%)**, suggesting that a lack of financial resources and expertise are the most significant barriers. All beneficiaries report experiencing **daily** power interruptions, signaling an unstable or inadequate power supply that affects them constantly. The majority of beneficiaries (52%) spend **between 1,000 and 1,999** on energy, and a smaller portion (34%) spends **below 1,000**, indicating beneficiaries face high energy costs relative to their monthly income.

Economic constraints and **technical knowledge** are key barriers to renewable energy implementation, the group faces frequent **daily power interruptions**. While expenses on energy consumption are very high suggesting that the cost of energy is very high and the inadequacy of the supply is a major concern. The community shows an overwhelmingly positive response, with **97%** of beneficiaries being **very willing** to transition to renewable energy systems. Only **3%** are unsure, but there are no unwilling respondents, indicating broad support for renewable energy adoption.

A large portion of the community (**90%**) has **low** knowledge of renewable energy systems. This highlights the need for educational initiatives to raise awareness and build knowledge in the community about renewable energy options and technologies.

There is **a 100% willingness** to undergo training on the installation, operation, and maintenance of Photovoltaic systems, showing strong interest in learning the necessary skills to manage renewable energy technologies.

While there is strong **willingness** and a positive attitude toward adopting renewable energy systems, there is a significant gap in **education** on renewable energy. The community is highly receptive to training, indicating that with proper education and skill-building programs, the community could effectively transition to renewable energy solutions.

To effectively address the persistent energy challenges faced by marginalized communities in Barangay Gibitngil, Medellin, Cebu, the researcher proposes a series of capacity-building extension projects aimed at empowering local farmers and fishers to adopt and leverage renewable energy solutions. These initiatives are designed to enhance energy access, promote sustainability, and build long-term self-reliance within the community. The proposed projects are as follows:

1. **Portable Solar Lamp and Flasher Fabrication Skills Training**

This extension project is specifically tailored for both farmers and fishers, focusing on the design and construction of affordable, easy-to-assemble solar lamps and flashers. These devices are intended to provide reliable lighting for homes and small fishing boats, even in remote areas. The project will ensure that the lamps and flashers are made from locally available, safe, and durable materials. Participants will gain hands-on skills in the fabrication, assembly, and maintenance of these devices, empowering them with the knowledge to repair and sustain the solar lighting systems for long-term use.

2. **Installation of Solar Charging Stations (SCS) Skills Training**

This community-wide extension project is designed to benefit all residents of Barangay Gibitngil by establishing Solar Charging Stations (SCS) to serve as accessible, renewable energy hubs for charging mobile phones, rechargeable lamps, batteries, and other small electronic devices. The training will equip participants with the necessary skills to install and maintain these solar charging stations, ensuring that the community has sustainable and reliable access to essential charging services. Additionally, the project will foster a sense of ownership and responsibility in the community regarding the proper usage and upkeep of these systems.

3. **Solar Photovoltaic (PV) Home System (SHS) Skills Training**

Aimed at providing a long-term energy solution for households, this extension project focuses on Solar Photovoltaic (PV) systems for home use. Through this training, participants will gain comprehensive knowledge of solar technology, including the proper selection of materials, system design, installation techniques, and ongoing maintenance requirements. The goal is to empower households with the skills to install and maintain Solar Home Systems (SHS), enabling them to reduce their dependency on non-renewable energy sources and enjoy a more stable and sustainable energy supply.

These initiatives not only address the immediate energy needs of the community but also foster a culture of sustainability and renewable energy adoption that can empower the residents of Barangay Gibitngil to take control of their energy future. By providing the necessary skills and knowledge, these projects will improve the quality of life for marginalized groups, create new economic opportunities, and contribute to the broader goals of environmental sustainability.

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REFERENCES:

1) Warner, K.J.; Jones, G.A. A Population-Induced Renewable Energy Timeline in Nine World Regions. Energy Policy 2017, 101, 65–76. https://doi.org/10.1016/j.enpol.2016.11.031.
2) World Bank. The welfare impact of rural electrification: a reassessment of the costs and benefit - an IEG impact evaluation (English). Washington, DC: 2008.
3) Aberilla, J. M., Gallego-Schmid, A., Stamford, L., & Azapagic, A. (2020). Synergistic generation of energy and water in remote communities: Economic and environmental assessment of current situation and future scenarios. Energy Conversion and Management, 207, 112543. https://doi.org/10.1016/j.enconman.2020.112543.
4) He, J., Yang, Y., Liao, Z., Xu, A., & Fang, K. (2022). Linking SDG 7 to assess the renewable energy footprint of nations by 2030. Applied Energy, 317, 119167. https://doi.org/10.1016/j.apenergy.2022.119167.
5) Aberilla, J. M., Gallego-Schmid, A., Stamford, L., & Azapagic, A. (2020). Design and environmental sustainability assessment of small-scale off-grid energy systems for remote rural communities. Applied Energy,

258, 114004. https://doi.org/10.1016/j.apenergy.2019.114004.
6) Matthew Dornan, Access to electricity in Small Island Developing States of the Pacific: Issues and challenges, Renewable and Sustainable Energy Reviews, Volume 31, 2014, Pages 726-735, ISSN 1364-0321. https://doi.org/10.1016/j.rser.2013.12.037.
7) Hazelton J, et al., A review of the potential benefits and risks of photovoltaic hybrid mini-grid systems, Renewable Energy (2013). https://doi.org/10.1016/j.renene.2013.11.026.
8) Assessing the Viability and Impact of Off Grid Systems for Sustainable Electrification of Rural Communities in Sub-Saharan Africa, Utoh et al., SPE Nigeria Annual International Conference and Exhibition, Lagos, Nigeria, August 2024. https://doi.org/10.2118/221702-MS.
9) Stefano Mandelli, Jacopo Barbieri, Riccardo Mereu, Emanuela Colombo,Off-grid systems for rural electrification in developing countries: Definitions, classification and a comprehensive literature review,Renewable and Sustainable Energy Reviews,Volume 58, 2016, Pages 1621-1646) and is a crucial instrument to alleviate poverty (Kanagawa and Nakata, 2008. https://doi.org/10.1016/j.rser.2015.12.338.
10) Debajit Palit, Akanksha Chaurey, Off-grid rural electrification experiences from South Asia: Status and best practices,Energy for Sustainable Develop ment, Volume 15, Issue 3, 2011,Pages 266-276. https://doi.org/10.1016/j.esd.2011.07.004.
11) Kapil Narula, Yu Nagai, Shonali Pachauri,The role of Decentralized Distributed Generation in achieving universal rural electrification in South Asia by 2030, Energy Policy, Volume 47, 2012, Pages 345-357. https://doi.org/10.1016/j.enpol.2012.04.075.
12) . Demidov, I., Dibaba, H., Pinomaa, A., Honkapuro, S., & Nieminen, M. (2023). Energy Management System for Community-Centered Off-Grid System with a Blockchain-Based P2P Energy Market. 2023 19th International Conference on the European Energy Market (EEM), 1-6. https://doi.org/10.1109/EEM58374.2023.10161848.
13) Ranaboldo, M., Ferrer-Martí, L., & Velo, E. (2014). Micro-Scale Wind Resource Assessment for Off-Grid Electrification Projects in Rural Communities. A Case Study in Peru. International Journal of Green Energy, 11, 75 90. https://doi.org/10.1080/15435075.2013.769878.
14) Rahman, M., Khan, M., Ullah, M., Zhang, X., & Kumar, A. (2016). A hybrid renewable energy system for a North American off-grid community. Energy, 97, 151-160. https://doi.org/10.1016/j.energy.2015.12.105.
15) Rezaei, M., & Dowlatabadi, H. (2016). Off-grid: community energy and the pursuit of self-sufficiency in British Columbia's remote and First Nations communities. Local Environment, 21, 789 – 807. https://doi.org/10.1080/13549839.2015.1031730.
16) Anuebunwa, U., & Mokyrani, G. (2021). Optimal Energy Resource Allocation in Isolated Micro Grid with Limited Supply Capacity. 2021 International Conference on Smart Energy Systems and Technologies (SEST), 1. https://doi.org/10.1109/SEST50973.2021.9543449.
17) B. Maurya, A. Singh, R. K. Gatla, P. Munaswamy and S. Rao, "A Comprehensive Review on Off-Grid Solar Energy Project Initiatives in Rural Indian Communities, a Sustainable and Reliable Approach," 2023 International Conference on Power Energy, Environment & Intelligent Control (PEEIC), Greater Noida, India, 2023, pp. 371-375. https://doi.org/10.1109/PEEIC59336.2023.10451994.
18) Demidov, H. Dibaba, A. Pinomaa, S. Honkapuro and M. Nieminen, "Energy Management System for Community-Centered Off-Grid System with a Blockchain-Based P2P Energy Market," 2023 19th International Conference on the European Energy Market (EEM), Lappeenranta, Finland, 2023. https://doi.org/10.1109/EEM58374.2023.10161848.
19) Emrah Karakaya, Pranpreya Sriwannawit, Barriers to the adoption of photovoltaic systems: The state of the art, Renewable and Sustainable Energy Reviews, Volume 49, 2015, Pages 60-66. https://doi.org/10.1016/j.rser.2015.04.058.
20) Joshua Mugisha, Mike Arasa Ratemo, Bienvenu Christian Bunani Keza, Hayriye Kahveci, Assessing the opportunities and challenges facing the development of off-grid solar systems in Eastern Africa: The cases of Kenya, Ethiopia, and Rwanda, Energy Policy, Volume 150, 2021, 112131, ISSN 0301-4215, https://doi.org/10.1016/j.enpol.2020.112131.
21) Paul Bertheau, et al., Environmental Innovation and Societal Transitions, https://doi.org/10.1016/j.eist.2019.03.002.
22) Mario Rebucas, Jay Lester Radam, Narcis Molero, Ralph Rodzen Macayana, Chrisalyn Go, Dharyll Prince Abellana, Aristotle Ubando, Alvin Culaba, Lanndon Ocampo, An integrated fuzzy evaluation of photovoltaic systems adoption barriers in rural island communities of developing economies, Energy for Sustainable Development, Volume 80, 2024, 101424, ISSN 0973-0826, https://doi.org/10.1016/j.esd.2024.101424.
23) Andante Hadi Pandyaswargo, Alan Dwi Wibowo, Hiroshi Onoda, Socio-techno-economic assessment to design an appropriate renewable energy system for remote agricultural communities in developing countries, Sustainable Production and Consumption, Volume 31,2022,Pages 492-511
24) Demidov, H. Dibaba, A. Pinomaa, S. Honkapuro and M. Nieminen, "Energy Management System for Community-Centered Off-Grid System with a Blockchain-Based P2P Energy Market," 2023 19th International Conference on the European Energy Market (EEM), Lappeenranta, Finland, 2023
25) Tenenbaum B, Greacen C, Silyambalapitiya T, Knuckles J. From the bottom up. How small power producers and mini-grids can deliver electrification and renewable energy in Africa.

27) Stefano Mandelli, Jacopo Barbieri, Riccardo Mereu, Emanuela Colombo,Off-grid systems for rural electrification in developing countries: Definitions, classification and a comprehensive literature review,Renewable and Sustainable Energy Reviews,Volume 58,2016,Pages 1621-1646.
28) Oliver Paish, Small hydro power: technology and current status, Renewable and Sustainable Energy Reviews,Volume 6, Issue 6,2002,Pages 537-5560
29) [José L. Bernal-Agustín, Rodolfo Dufo-López,Simulation and optimization of stand-alone hybrid renewable energy systems, Renewable and Sustainable Energy Reviews,Volume 13, Issue 8,2009, Pages 2111-2118, ISSN 1364-0321