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Community Baseline Data on Energy Access and Landscape: Microgrid Viability

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ABSTRACT

The research investigated the feasibility of microgrid implementation in geographically isolated and disadvantaged areas (GIDA) island barangays of Talibon, Bohol, Philippines. The study comprehensively assessed existing energy infrastructure and identified communities suitable for microgrid installation. The research identified abundant solar resources and suitable terrain, making off-grid solar microgrids a viable option for these communities.
While significant upfront costs are associated with microgrid development, the projected revenue streams and potential for financial sustainability, coupled with the benefits of improved quality of life and economic growth, make these investments worthwhile. The study emphasizes the importance of community engagement, education, and the development of demand-side management strategies to optimize energy usage and ensure long-term success. The research concludes with recommendations for sustained investment, community engagement, government support, enhanced policy and regulatory frameworks, fostered partnerships and collaboration, and strengthened grid modernization and infrastructure development to accelerate the transition towards a sustainable energy future in these island communities.

INTRODUCTION

Solar energy, a clean and abundant renewable source, has emerged as a critical player in the global transition towards sustainable energy production. With growing concerns about climate change and the depletion of fossil fuels, research and development efforts in solar energy have seen a significant surge in recent years. Maka, A. *et al.* (2022) stated that solar energy stands out as a champion for the environment. It is a reliable and abundant renewable resource, making it a key player in the fight for a sustainable energy future. The enormous amount of daily solar energy makes it a desirable option for generating electricity. This clean and renewable energy source is crucial for achieving sustainable development goals. Recent studies also highlight that renewable energy and microgrid initiatives are essential in promoting sustainability and resilience, particularly in developing countries facing infrastructure challenges (Soh, Puah, & Arip, 2023). Solar energy is increasingly recognized as a pivotal contributor to achieving global net-zero targets, with policies and technological innovations driving its adoption at both national and community levels (Saad, 2025). This aligns with the Philippines' renewable energy goals and emphasizes the role of solar microgrids in sustainable development. A major challenge in renewable integration is grid stability; however, research shows that artificial intelligence techniques such as ANN-based static VAR compensators (SVC) can optimize renewable systems, ensuring a more reliable and constant power supply (Ifeanyi, Gregory, & Linus, 2025). Hybrid renewable systems have also been explored to address intermittency issues. For instance, studies demonstrate the viability of solar-wind hybrid systems in providing stable electricity in off-grid regions, which parallels the energy challenges faced by Philippine Island communities (Haque, Uddin, & Khatun, 2025). Recent advancements in next-generation solar cell technologies—including improved materials, designs, and system integration—have enhanced the efficiency and scalability of renewable systems, further strengthening the case for solar-based microgrids in rural areas (Saad, 2025).

The Climate Change Conference, COP26, held in Glasgow, UK, in 2021, and the Paris Climate Accords in 2015 forged an agreement to prioritize a global shift concerning renewable and sustainable energy sources. These international efforts aim to curb climate change by drastically reducing greenhouse gas emissions, particularly those produced by fossil fuels. Achieving this transition hinges on rapidly developing and employing renewable energy resources such as solar, wind, and geothermal. By focusing on clean energy, these agreements aim to control global warming to well below 2 degrees Celsius, ideally 1.5 degrees, compared to pre-industrial levels. The global shift towards renewable energy is also closely tied to digital transformation and innovation, as new technologies optimize grid efficiency and energy management systems. Emerging analyses underscore that renewable energy development must integrate digital transformation strategies to ensure sustainability and community participation (Passas, Garefalakis, & Thanasas, 2024). Moreover, social sustainability studies reveal that the equitable adoption of renewable energy

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and digital solutions contributes significantly to addressing energy poverty and achieving inclusive development (Nosratabadi, Atobishi, & HegedHus, 2023).

The United Nations launched in 2015 the 17 Sustainable Development Goals (SDGs) to address global challenges by 2030. One of these goals, SDG 7, focuses on ensuring access to affordable, reliable, sustainable, and modern energy for all. This specific goal recognizes the dual need for energy security and environmental protection. Fossil fuel dependence threatens both through price fluctuations and climate change. SDG 7 aims to promote renewable energy sources like solar, wind, and geothermal to meet energy demands while reducing pollution. Since their inception, the SDGs have spurred significant developments in renewable energy. Costs have decreased dramatically, making them more competitive with fossil fuels. Investment in renewables has surged, with new solar and wind power capacity outpacing traditional sources in recent years. However, challenges remain. Millions still lack access to electricity, and a shift in energy infrastructure and storage solutions is needed to integrate renewables into the global energy grid fully. Despite these hurdles, the SDGs have undeniably placed renewable energy at the forefront of the global development agenda.

In the Philippines, the Renewable Energy Act of 2008, also referred to as RA 9513, is designed to expedite the exploration and advancement of renewable energy sources to attain energy self-sufficiency by implementing sustainable energy development approaches. The legislation aims to shift stakeholders away from their reliance on fossil fuels towards increased adoption of renewable energy by enhancing national and local capacities, establishing systems, and encouraging efficient and cost-effective commercial applications through incentives. These initiatives create opportunities for innovation, utilization, and commercialization in the renewable energy sector. Additionally, the act includes policies and initiatives such as Renewable Portfolio Standards (RPS), Feed-In Tariffs, and the National Renewable Energy Program to not only attract investments and stimulate competition within the industry but also to facilitate a comprehensive transformation of the sector to reduce the country's dependence on imported energy sources (Pojadas, D. J., & Abundo, M. L. S. 2021).

The electrification profile of the Philippines showcases significant advancements in the country's electrical infrastructure and renewable energy industry. There has been notable growth in renewable energy sources in the Philippines. Projections indicate that by 2035, the capacity for renewable generation will reach 33GW, with a Compound Annual Growth Rate (CAGR) of 12%. Wind power is expected to exhibit the highest growth rate at 20.34% by 2035, followed by solar PV at 18%. The Philippines aspires to achieve a 35% renewable energy allocation in the power generation mix by 2040, according to its Energy Plan 2020 – 2040. Additionally, under the more ambitious Clean Energy Scenario, the country targets a 35% clean energy share by 2030 and 50% by 2040. Renewable energy sources are forecast to account for 52% of the total electricity generation capacity in the Philippines by 2035, compared with 34% in 2023, according to Global Data's power capacity and generation database.

Bohol is one of the island provinces of Visayas, covering an approximate area of 4000 km2. It is part of the Philippines' 81 provinces and comprises 1109 barangays, 47 component municipalities, and the singular city of Tagbilaran, organized into three legislative districts. Known for its tropical climate, Bohol boasts abundant solar energy resources, with yearly global horizontal irradiance levels ranging from 1500 to 1900 kilowatt-hours per square meter. The province also possesses a rich wind energy potential, with certain regions exhibiting wind classes surpassing 7 m/s. Since it is functioning as an agro-industrial hub, Bohol's main agricultural produce includes rice, corn, coconut, cassava, and oil palm, presenting opportunities for biopower energy generation. Furthermore, Bohol features 11 watersheds, such as Abatan, Alijawan, Caroud, Wahig-Inabanga, Ipil, Loboc, Lumbay, Manaba, Mualong, Panampan, and Soom, which offer possibilities for hydropower projects. The province operates a 16 MW grid-connected dieselfueled power plant based in Dampas District, Tagbilaran City, participating in the country's spot market, along with three embedded mini-hydro projects situated in the Loboc watershed. Bohol is linked to the national grid through a 100 MVA, 138 kV Leyte-Bohol Interconnection, which supplies more than two-thirds of the province's electricity requirements. In 2018, a 32 MW diesel/bunker-fired power barge stationed at Tapal Wharf, Ubay, was contracted as a dispatchable reserve to support the heavily utilized Leyte-Bohol Interconnection. The province's energy demand is divided into three franchise areas managed by three Distribution Utilities (DUs): Bohol Light Company, Inc. (BLCI), Bohol Electric Cooperative 1 (BOHECO 1), and Bohol Electric Cooperative 2 (BOHECO 2) (BIPDP, 2017).

The residents of Bohol face a blend of natural beauty and challenges. While the province is celebrated for its stunning landscapes and diverse ecosystems, its location on the Pacific Ring of Fire exposes it to earthquakes and formidable typhoons. Events like the 7.2 magnitude earthquake, Typhoon Yolanda (Haiyan) in 2013, and Typhoon Odette (Rai) in 2021 underscore these vulnerabilities. The susceptibility to such natural disasters raises concerns as disruptions to the power grid not only impact daily life but also impede economic activities and vital services.

In response to these challenges, the Bohol Association of Non-Government Organizations, Inc. (BANGON) implemented the Advancing Sustainable Provincial Investments for Renewable Energy (ASPIRE) project. BANGON, in turn, commissioned the University of Bohol Community Development Foundation, Inc. (UBCDFI), one of its member organizations, to research on Community Baseline Data on Energy Access and

Landscape. The initiative focuses on reducing external dependencies, reinforcing infrastructure against natural disasters, and lowering electricity expenses to establish a self-reliant and dependable energy supply. By advocating for robust policies and investments, the project strives to create a favorable regulatory framework for sustainable development and economic prosperity. Through technical interventions, the project aims to optimize Bohol's energy landscape for improved efficiency and reduced vulnerabilities. Additionally, the project's core objectives include driving the province towards a sustainable and decentralized energy future, promoting responsible energy consumption practices, and supporting Provincial Ordinance No. 005-2023 to align with the sustainable goals and principles of Just Energy Transition (JET).

The study aims to assess the current energy access and usage patterns in the selected geographically isolated and disadvantaged areas (GIDA) island barangays of Talibon, Bohol, identify areas that lack adequate energy access and assess the existing infrastructure for vulnerabilities, identify communities where a viable community-led microgrid installation is feasible, develop targeted interventions and strategies to improve energy access, reduce electricity costs, and enhance resilience against natural disasters.

MATERIALS AND METHODS

Design

The study adopted a mixed-methods approach, integrating quantitative and qualitative research methods. The quantitative aspect focused on the collection of numerical data related to electricity supply, consumption, costs, duration, and quality. In contrast, the qualitative aspect involved gathering insights, opinions, and perceptions through interviews, focus group discussions, and document analysis.

Environment

The research was conducted in Talibon, Bohol, and 3 selected GIDA island barangays, namely Barangay Calituban, Barangay Nocnocan, and Barangay Guindacpan. In the 2020 census, the population was 71,272 and was located in the northern part of Bohol, 115 kilometers from Tagbilaran City. It is flanked on the east by Bien Unido, south by Trinidad, north by the Camotes Sea, and west by Getafe. It has a land area of 140.46 square kilometers (54.23 sq mi), of which about 7.97 square kilometers (3.08 sq mi) or 5.7% is classified as urban. In contrast, the remaining 132.49 square kilometers (51.15 sq mi) are rural. It is politically subdivided into 25 barangays. Each barangay consists of puroks, and some have sitios. There are 17 barangays located on the mainland and 8 island barangays.

The 3 island barangays were chosen based on the average level of deprivation and barangays relying on generators or lacking an electricity supply. The deprivation levels were based on the following indices per household: Child malnourished, Child Mortality, Crime Incidence, Food Threshold, Makeshift Housing, Income Threshold, Meals Threshold, Unsanitary Toilet, School Dropouts, Not Owning the Lot, Person/Persons are Unemployed, and Non-Potable/Doubtful Drinking Water.

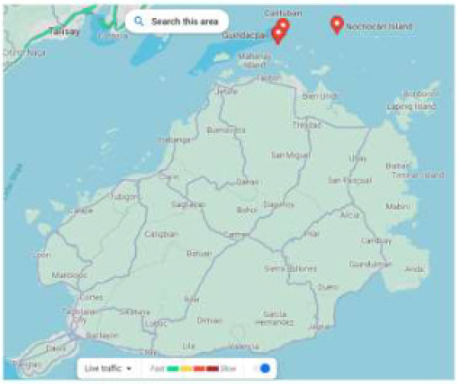

Figure 1: Map of Bhole

Research Questions

1. What is the profile of the respondent as to:
1.1. age;
1.2. sex;
1.3. marital status;
1.4. occupation; and
1.5. highest educational attainment?
2. What is the microgrid viability of the community as to:
2.1. resource assessment;
2.2. technical feasibility;
2.3. economic analysis;
2.4. energy demand assessment, and
2.5. grid stability and resilience?
3. What is the electrification data of the municipality as to:
3.1. economic activities;
3.2. local government initiatives;
3.3. social services;
3.4. community engagement;
3.5. environmental initiatives;
3.6. electrification data;
3.7. electrification challenges; and

3.8. existing policies on renewable energy?

4. What recommendations can be gleaned from the results of the study?

RESULTS AND DISCUSSIONS

Profile of the Respondent

Age

The majority of respondents in all three barangays fall within the 25-44 years age group, with Barangay Calituban having the highest percentage at 53.33%, followed by Barangay Guindacpan (43.33%) and Barangay Nocnocan (20.00%). The 45-64 years age group is also well-represented across all barangays, with Barangay Nocnocan having the highest percentage at 53.33%. The 65-year-old and above category shows varying percentages across barangays, with Barangay Guindacpan having the highest representation at 10.00%.

Sex

Females constitute the majority of respondents in all three barangays, with Barangay Nocnocan having the highest percentage at 56.67%. Males make up the minority, with the highest representation in Barangay Nocnocan at 53.33%.

Marital Status

The majority of respondents across all barangays are married, with Barangay Nocnocan having the highest percentage at 86.67%. Single respondents are the minority, with percentages ranging from 6.67% to 10.00%. The other marital status categories (widowed, separated/annulled, domestic partnership) show varying percentages across barangays.

Occupation/Primary Source of Income

Homemakers constitute a significant proportion of respondents, with the highest percentage in Barangay Calituban at 63.33%. The occupation distribution varies across barangays, with fishing, barangay officials, and unemployed individuals also represented. Each barangay shows a unique distribution of occupations, reflecting the diversity of economic activities and livelihoods in the communities.

Highest Educational Attainment

Respondents with an elementary-level education form a substantial portion, with percentages ranging from 26.67% to 46.67% across barangays. The educational distribution includes a mix of educational levels, from elementary graduates to college graduates, reflecting varied levels of educational attainment among respondents.

Number of Household Members

The distribution of household members varies across barangays, with 4-5 member households being the most common in Barangay Guindacpan and Barangay Nocnocan. Barangay Calituban shows a more evenly distributed number of household members across different categories.

Table 1: Profile of the Respondents

Items	Barangay Calituban (n1=30)		Barangay Guindacpan (n2=30)		Barangay Nocnocan (n3=30)	
	f	%	f	%	f	%
Age						
18 - 24 y/o	3	10	3	10	3	10
25 - 44 y/o	16	53.33	13	43.33	6	20
45- 64 y/o	9	30	11	36.67	16	53.33
65 years old and above	2	6.67	3	10	5	16.67
Sex						
male	9	30	13	43.33	16	53.33
female	21	70	17	56.67	14	46.67
Marital Status						
single	3	10	3	10	2	6.67
married	24	80	24	80	26	86.67
widowed	1	3.33	2	6.67	1	3.33
separated/annulled	0	0	1	3.33	0	0
domestic partnership	2	6.67	0	0	1	3.33
Occupation/Primary source of income						
housewife	19	63.33	4	13.33	4	13.33
fishing	4	13.33	6	20	5	16.67

Microgrid Viability

Resource Assessment

a. Solar resource availability through historical solar irradiance data (sun hours). Sun hour is a unit of measurement of the intensity of sunlight on the Earth at a given time that can be used for the generation of solar power, recognizing factors such as climate and weather. A full sun hour is measured as the intensity of sunlight at noon, whereas less than a full sun hour will result during the hours before and after noon. A peak sun hour is when the sun's intensity is an average of 1,000 watts of photovoltaic power per square meter. Based on the Phil Sun hour chart, Bohol has at least 5 sun hours, but the efficiency for solar panels is at least 4 hours.

b. Suitability of the Place for Solar Panel Installation. The three island barangays present an ideal condition for solar installation, lacking any significant topographical or vegetative obstructions like hills or dense tree cover.

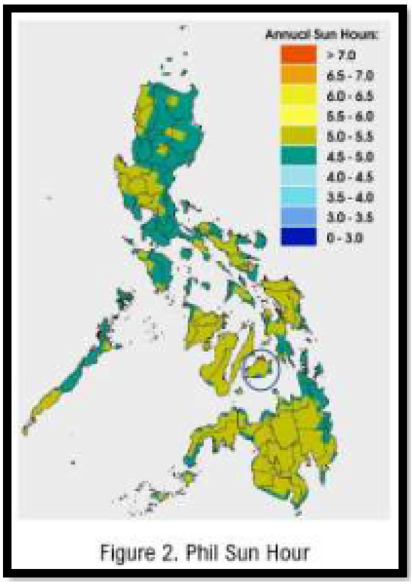

Figure 1: Phil Sun hour

Technical Feasibility

a. Existing Infrastructure for Renewable Energy. For Barangay Calituban, solar panels can be installed on the covered basketball court and in high school and elementary school buildings. For Barangay Guindacpan, solar panels can be installed on the covered court, barangay hall, elementary building, and church. Ground-mounted solar panels are also a viable option. For Barangay Nocnocan, solar panels can be installed on the ground and fabricated in sheds.

b. Grid Interconnection Requirements. Grid interconnection is currently not feasible due to the necessity for a submarine cable, and the island barangays do not have any energy connections from the mainland provided by BOHECO.

c. Availability/Suitability of the Sites for Installing Solar Panels within the Island Barangay. The flat terrain of all three island barangays presents a significant advantage for solar energy development, allowing for both rooftop and ground-mounted installations. This unobstructed landscape facilitates efficient solar panel placement, maximizing energy generation and minimizing potential challenges associated with uneven terrain.

Table 2: Available Sites for BARANGAY NOCNOCAN

Public Facilities	L (m)	W (m)	Area	Facing South Area
GYM	22	10	220 sq.m	110 sq.m
Elementary School				
Building 1	10	9	90 sq.m	45 sq.m
Building 2	14	10	140 sq.m	70 sq.m
Building 3	18	8	144 sq.m	72 sq.m
Building 4	13	8	104 sq.m	52 sq.m

Table 3: Available Sites for BARANGAY GUINDACPAN

Public Facilities	L (m)	W (m)	Area (sq. m)	Facing South Area
Covered Court	25	16	400 sq. m	200 sq. m
Barangay Hall	9.5	6.5	61.75 sq.m	30.875 sq. m
Church	21	11	231 sq. m	115.5 sq. m
Elementary Building	13	9	117 sq. m	58.5 sq. m
Purok 3 Chapel	8.5	7	59.5 sq. m	29.75 sq. m

Table 4: Available Sites BARANGAY CALITUBAN

Public Facilities	L (m)	W (m)	Area (sq. m)	Facing South
Elementary Covered Court	30	19	570	285 sq. m
Elementary School (B1)	33	10	330	165 sq. m
Elementary School (B2)	15	9	135	67.5 sq. m
Elementary School (B3)	23	10	230	115 sq. m
Elementary School (B4)	14	12	168	84 sq. m
Elementary School (B5)	28	9.5	266	133 sq. m
Chapel (1)	10	9.5	95	47.5 sq. m
Barangay Health Center	13	11	143	71.5
Covered Court	23	13	299	149.5
Barangay Hall	10	9	90	45
Chapel (2)	25	14	350	175

d. The type of Solar Panel System that is Most Suitable. Given the challenges of grid interconnection, an off-grid solar system appears to be the most suitable option for the proposed renewable energy project. Off-grid systems are particularly well-suited for remote locations with limited grid access, providing a reliable and sustainable source of power. While off-grid systems require battery storage for energy management, they offer greater control over energy usage and reduce reliance on the existing grid infrastructure. To ensure optimal performance and longevity, the off-grid solar system should incorporate lithium iron phosphate (LiFePO4) batteries. These batteries are known for their extended lifespan, high storage capacity (up to 95%), and enhanced safety compared to traditional lead-acid batteries.

e. The most effective way to Distribute Solar Energy. To accurately track energy usage and facilitate fair billing, each household connected to the off-grid solar system will have its own electric meter. It allows for precise measurement of electricity consumption for each household, enabling transparent billing and promoting responsible energy use.

Energy Demand Assessment

a. Energy demand profile of the microgrid, including peak and off-peak periods. While individual households may upgrade their electrical appliances, a minimum consumption of 1500 watts per household should be established to ensure a balanced distribution of electricity across the community. It will help to optimize the microgrid's performance and prevent imbalances that could impact the reliability of the system.

Table 5: Energy Usage Pattern of Barangay Calituban

BARANGAY CALITUBAN						
Appliances & lights	**f**	**watts**	**total watts**	**hrs of use**	**total watt-hr**	**days of use**
ref	6	350	2100	5	**1750**	**7**
TV	10	20	200	5	100	1
electric fan	13	100	1300	5	500	7
aircon	1	500	500	1	500	1
speaker/amplifier	3	250	750	5	1250	4
coconut grinder	1	1100	1100	2	**2200**	**7**
cellphone	30	0.05	1.5	4	0.2	7
laptop/computer	4	20	80	4	80	7

bulbs	120	15	1800	4	**60**	**7**
			7,831.50 watts		6,440.20 watt-hr	
TOTAL WATTS	7,831.50	for 30 household				
TOTAL WATT-HOUR	6,440.20	for 30 household				
WATTS per household	261.05	watts				
no. of household	956					
Total watts for the island	**249,563.80**	**watts**				
Total watt-hour	249,563.80	watt-hour				

The provided data outlines the energy consumption profile for Barangay Calituban, detailing the wattage and usage duration of various appliances and lights within the community. The total energy consumption for the barangay is calculated based on the wattage, hours of use, and number of households. The data shows a total of 7,831.50 watts consumed and 6,440.20 watt-hours used by 30 households, averaging approximately 261.05 watts per household. The energy consumption is distributed across different appliances, with significant contributions from appliances like the coconut grinder, refrigerator, and bulbs. The data provides insights into the energy-intensive appliances within the community. Extrapolating the data for 956 households yields a total energy consumption of 249,563.80 watts, highlighting the substantial energy demand of the entire island. This total wattage indicates the scale of energy required to meet the community's needs. The data underscores the importance of energy efficiency measures and the potential for optimizing household energy usage.

Table 6: Energy Usage Pattern of Barangay Guindacpan

BARANGAY GUINDACPAN						
Appliances & lights	**f**	**watts**	**total watts**	**hrs of use**	**total watt-hr**	**days of use**
refrigerator	7	350	2450	5	**1750**	**7**
rice cooker	1	400	400	2	800	3
flat iron	4	1000	4000	0.5	500	1
electric cooker	2	1500	3000	1	1500	4
TV	27	20	540	5	100	7
electric fan	29	100	2900	5	**500**	**7**
electric stove	4	1000	4000	1	1000	6
speaker/amplifier	9	250	2250	5	1250	7
cellphone	30	0.05	1.5	4	0.2	7
bulbs	120	15	1800	4	60	7
			21341.50 watts		7460.20 watt-hr	
TOTAL WATTS=	21341.5	for 30 household				
TOTAL WATT HOUR=	7460.2	for 30 household				
WATTS per household=	711.38	watts				
no of household	538					
Total watts for the island	382724.23	watts				
Total watt-hour	133786.25	watt-hour				

The data provided presents the energy consumption profile for Barangay Guindacpan, detailing the wattage and usage duration of various appliances and lights within the community. The total energy consumption for the barangay is calculated based on the wattage, hours of use, and number of households. The data shows a total of 21,341.50 watts consumed and 7,460.20 watt-hours used by 30 households, averaging approximately 711.38 watts per household. The energy consumption is distributed across a range of appliances, with notable contributions from appliances like electric stoves, refrigerators, and electric fans. This breakdown provides insights into the energy-intensive devices commonly used in households within the community. Extrapolating the data for

538 households yields a total energy consumption of 382,724.23 watts, highlighting the substantial energy demand of the entire island. This total wattage indicates the scale of energy required to meet the collective needs of the community.

Table 7: Energy Usage Pattern of Barangay Nocnocan

BARANGAY NOCNOCAN						
Appliances & lights	**f**	**watts**	**total watts**	**hrs of use**	**total watt-hr**	**days of use**
ref	1	350	350	5	**1750**	**7**
TV	9	20	180	4	80	3
electric fan	9	100	900	4	400	7
speaker/amplifier	7	250	1750	2	500	3
cellphone	30	0.05	1.5	3	0.15	7
bulbs	120	15	1800	4	**60**	**7**
4981.50 watts		2790.15				
watt-hr						
TOTAL WATTS=	4981.5	for 30 household				
TOTAL WATT HOUR=	2790.15	for 30 household				
WATTS per household=	166.05	watts				
no. of household	398					
Total watts for the island	66087.9	watts				
Total watt-hour	37015.99	watt-hour				

The data provided showcases the energy consumption profile for Barangay Nocnocan, detailing the wattage and usage duration of various appliances and lights within the community. The total energy consumption for the barangay is calculated based on the wattage, hours of use, and number of households. The data indicates a total of 4,981.50 watts consumed and 2,790.15 watt-hours used by 30 households, averaging approximately 166.05 watts per household. Energy consumption is distributed across essential appliances, with notable contributions from devices like refrigerators, electric fans, and bulbs. This breakdown offers insights into the prevalent energy-consuming devices in households within the community. Extrapolating the data for 398 households yields a total energy consumption of 66,087.90 watts, underscoring the significant energy demand of the entire island. This total wattage signifies the collective energy requirement to fulfill the needs of the community.

b. Regulatory Requirements and Permitting Processes for Installing Solar Panels in the Island Barangay. The barangay council has not yet established any permitting processes or guidelines specifically for solar panel installations within the community.

c. Local Incentives, Rebates, or Financing Options Available to Support Solar Energy Projects in the Barangay. Currently, there are no local incentives, rebates, or financing options specifically designed to support solar energy projects within the barangay.

d. Ways the Barangay can Ensure the Proper Operation and Performance Monitoring of the Solar Panel System over its lifetime. The barangay welcomes the idea of the electrification project through solar energy and is willing to manage the system. All barangays have organized people's organizations, but lack the appropriate knowledge and skills to run such a business venture. However, in order to ensure the long-term operational efficiency and performance of the solar panel system, the barangay should establish a dedicated solar monitoring team. This team would be responsible for regular inspections, maintenance, and data analysis to identify any potential issues and optimize system performance. By proactively addressing maintenance needs and monitoring system output, the barangay can maximize the lifespan and efficiency of the solar panels, ensuring a reliable and sustainable energy source for the community.

e. Potential for demand-side management strategies to optimize energy usage. Demand-side management (DSM) strategies hold significant potential to optimize energy usage in conjunction with solar energy. Peak Shaving can be done to encourage households to shift energy-intensive activities to off-peak hours (when solar generation is lower), and the demand on the microgrid can be smoothed out. It reduces the strain on the battery storage system during peak periods, extending its lifespan and improving overall efficiency. Load shifting can be done, which involves shifting energy usage to periods when solar energy is abundant. For example, encouraging the use of freezers when solar generation is high can reduce reliance on battery storage for evening use. Energy conservation can be advocated by promoting energy efficiency measures, such as using LED lighting for energy-efficient appliances and reducing unnecessary consumption, which can significantly reduce the overall energy demand on the microgrid. It allows the solar system to generate enough energy to meet the needs of the community, minimizing reliance on battery storage.

Expected watts generated from the microgrid per island barangay. The projected energy output from the microgrid is estimated to range from 400,000 to 600,000 watts per island barangay.

Grid Stability and Resilience. The solar energy system cannot be integrated into the existing electrical grid of the island barangay, indicating a potential limitation in grid connectivity for renewable energy sources. The solar energy system and the grid infrastructure in the barangay are not compatible and interoperable, highlighting a need for infrastructure upgrades or modifications to support renewable energy integration.

While there are backup power sources or alternative methods available to supplement solar energy generation during periods of low sunlight or grid disturbances, such as some households having personal diesel generators, this indicates a partial reliance on non-renewable energy sources for backup power. The barangay cannot monitor and control solar energy systems for timely response to grid events and performance optimization, suggesting a potential lack of real-time monitoring and control systems for effective energy management.

There are no measures in place to monitor weather forecasts and preemptively activate emergency response protocols in anticipation of severe weather events, indicating a potential gap in emergency preparedness for weather-related disruptions to the solar energy system.

CONCLUSIONS

The feasibility analysis for microgrid implementation in Bohol's island barangays shows strong potential for off-grid solar systems. With abundant sunlight and suitable terrain, solar energy is viable and ideal for remote areas lacking grid access. Though initial costs range from ₱14 million (Nocnocan) to ₱56 million (Guindacpan), projected revenues indicate long-term sustainability, with ROIs of 19–58 years. Effective demand-side management—through peak shaving, load shifting, and conservation—can enhance efficiency. Despite challenges in stability and resilience, the promise of reliable, sustainable energy and community commitment positions these microgrids as key steps toward energy security and sustainable rural development.

Recommendations

The study highlights that investing in microgrid solutions—especially off-grid solar systems—is a practical and promising step toward sustainable energy in Bohol's island barangays. With abundant sunlight, favorable terrain, and strong community commitment, solar energy offers both environmental and economic benefits. Although the upfront costs are high, long-term financial gains, improved quality of life, and local economic growth make the investment worthwhile. Success depends on a holistic approach: continuous funding to sustain projects, active community participation through training and energy awareness, and solid government support through clear policies and financial incentives. Strengthening partnerships among local governments, private sectors, NGOs, and international groups will help leverage expertise and resources. Likewise, modernizing grid infrastructure and extending connections to remote areas will improve energy reliability and resilience, especially during extreme weather. By combining financial investment, policy reform, and community empowerment, Bohol's island barangays can transition toward a cleaner, more resilient, and inclusive energy future—one that supports local livelihoods, reduces dependence on fossil fuels, and serves as a model for other rural communities seeking energy independence and sustainability. This integrated approach ensures that the shift to renewable energy is both people-centered and economically viable for years to come.

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REFERENCES

Bohol Island Power Development Plan (BIPDP). (2017). *Bohol Island Power Development Plan 2016-2045*. Province of Bohol. https://ppdo.bohol.gov.ph/ppdofiles/BEDAG/BIPDP_2016-2045.pdf.

Issa, N., Adamu, A., Lamba, H. D., Riagbayire, F. V., Abdulganiyu, M., & Auwal, S. (2025). Design and Installation of a Solar and Wind Hybrid System in Kano State, Nigeria. *American Journal of Energy and Natural Resources, 4*(1), 20–28. https://doi.org/10.54536/ajenr.v4i1.4157.

Ifeanyi, C. M., Gregory, O., & Linus, C. (2025). Improving Constant Power Supply in Renewable Energy Integration and Optimization Using ANN Based SVC. *American Journal of Multidisciplinary Research and Innovation, 4*(3), 205–215. https://doi.org/10.54536/ajmri.v4i3.4821.

Maka, A. O., & Alabid, J. M. (2022). Solar energy technology and its roles in sustainable development. *Clean Energy, 6*(3), 476-483. https://doi.org/10.1093/ce/zkac023.

Nosratabadi, S., Atobishi, T., & Hegedűs, S. (2023). Social sustainability of digital transformation: Empirical evidence from EU-27 countries. *Administrative Sciences, 13*(5), 126. https://arxiv.org/abs/2305.16088.

Petropoulou, K., Angelaki, E., Rompogiannakis, I., Passas, I., & Garefalakis, A. (2024). *Digital Transformation in SMEs: Pre and Post-Covid-19 Era: A Comparative Bibliometric Analysis.* https://doi.org/10.3390/

su162310536

Pojadas, D. J., & Abundo, M. L. S. (2021). Spatio-temporal assessment and economic analysis of a grid-connected island province toward a 35% or greater domestic renewable energy portfolio: a case in Bohol, Philippines. *International Journal of Energy and Environmental Engineering, 12*(2), 251-280. https://doi.org/10.1007/s40095-020-00369-7.

Saad, A. M. H. (2025). Next-Generation Solar Cells: Advancements in Materials, Architectures, and System Integration for A Sustainable Energy Future. *American Journal of Innovation in Science and Engineering, 4*(2), 23-30. https://doi.org/10.54536/ajise.v4i2.3832.

Saad, A. M. H., & Myat, A. Role of Solar Energy in Achieving Global Net-Zero Targets: Policy and Technological Perspective. https://doi.org/10.54536/ajenr.v4i1.3828.

Soh, A. N., Puah, C. H., & Arip, M. A. (2023). A bibliometric analysis on tourism sustainable competitiveness research. *Sustainability, 15*(2), 1035. https://doi.org/10.3390/su15021035.