FINANCING AND INTEGRATING RENEWABLE ENERGY IN THE CITY OF BUTUAN

PILOT 10MW GROUND-MOUNTED SOLAR PROJECT FOR BUTUAN CITY

PRE-FEASIBILITY STUDY

JUNE 2025

SUPPORTED BY:

Federal Ministry for Economic Affairs and Climate Action

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IKI INTERNATIONAL CLIMATE INITIATIVE

PREPARED FOR:

WWF

CITY OF BUTUAN OFFICIAL SEAL

PREPARED BY:

PREFERRED ENERGY, INC.

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ABBREVIATIONS

ANECO	Agusan del Norte Electric Cooperative, Inc.
BCEDP	Butuan City Energy Development Plan (2023-2050)
BCWD	Butuan City Water District
BXU	Butuan City
CGB	City Government of Butuan
CLUP	Butuan City Comprehensive Land Use Plan 2019-2028
CPDD	City Planning and Development Department
CSP	Competitive Selection Process
DOE	Department of Energy
DPP	Distribution Development Plan
DU	Distribution Utility
EIA	Environmental Impact Assessment
EIRR	Economic Internal Rate of Return
EPIRA	Electric Power Industry Reform Act of 2001
ERC	Energy Regulatory Commission
EZ	Economic Zone
FinRE-BXU	Financing Integration of the Renewable Energy Projects in Butuan City
FIT	Feed-in-Tariff
GEAP	Green Energy Auction Program
GEOP	Green Energy Option Program
GHI	Global Horizontal Irradiation
GWh	Gigawatt-hour
HUC	Highly Urbanized City
IEICES	International Exchange and Innovation Conference on Engineering and Sciences
IRR	Implementing Rules and Regulation
IRR	Internal Rate of Return
kWh	Kilowatt-hour
LCOE	Levelized cost of electricity
LGC	Local Government Code of 1991
LGUs	Local Government Units
MPSUID	Master Plan for the Sustainable Urban Infrastructure Development in Butuan City December 2020
MW	Megawatt
NEA	National Electrification Administration
NEECP	National Energy Efficiency and Conservation Plan
NPC-PSALM	National Power Corporation-Power Sector Assets and Liabilities Management Corporation
NPV	Net Present Value
NREL	United States National Renewable Energy Laboratory
PEI	Preferred Energy, Inc.
PEP	Philippine Energy Plan 2020-2040
PMU	Project Management Unit
PSA	Power Supply Agreement
PSPP	Power Supply Procurement Plan 2024-2033
PR	Performance Ratio
Pre-FS	Pre-Feasibility Study

PV	Photovoltaic
PUV	Public Utility Vehicle
RE	Renewable Energy
REM	Renewable Energy Market
ROI	Return of Investment
RPS	Renewable Portfolio Standards
SEDZ	Special Economic Development Zone
SPP	Solar Pilot Project
TWG	Technical Working Group
US NREL	National Renewable Energy Laboratory of the United States of America
UPEEI-RDFI	University of the Philippines Electrical and Electronics Engineering Institute-Research and Development Foundation, Inc.
WACC	Weighted Average Cost of Capital
WB	World Bank
WWF Philippines	Kabang Kalikasan ng Pilipinas Foundation, Inc.

1. INTRODUCTION

The Philippines is blest with abundant supply of renewable energy (RE) resources. To take advantage of these indigenous resources, the Philippine government enacted Republic Act (R.A.) No. 9513 or the Renewable Energy Act of 2008 to promote the exploration, development, utilization, integration of RE power generating facilities in the country. The Philippine government, through its Philippine Energy Plan 2020-2040 (PEP), also implemented energy roadmaps[1] with the goals of increasing the RE share in the country's energy generation mix and releducing the dependence on imported fossil fuels. Under the PEP (2020-2040), the country's goal is to increase its RE share by 35% by 2030 and 50% by 2040[2].

The City Government of Butuan (CGB) has successfully conducted its RE resource assessment within its political boundaries. The results of these assessments are cited in its Butuan City Energy Development Plan 2023-2050 (BCEDP). The findings indicate the city can potentially develop solar and biomass power projects as well as the operation of electric vehicles within the city. Following these findings, the CGB opted for the partnership offered by Kabang Kalikasan ng Pilipinas Foundation, Inc. (WWF Philippines) for the implementation of the Financing Integration of the Renewable Energy Projects in Butuan City (FinRE-BXU). CGB will lead the approval and execution of development of several RE pilot projects within their jurisdiction to support the city's growing energy demand. The CGB will spearhead innovative economic development solutions for the Province of Agusan del Norte and the entire Region XIII or the Caraga Administrative Region. It aims to be the leading LGU in energy efficiency aligning with the Local Government Code of 1991, Renewable Energy Act of 2008, the Energy Efficiency and Conservation Act of 2019, and other relevant laws and regulations in the country.

WWF-Philippines sought the expertise of Preferred Energy, Inc. (PEI) as its renewable energy consulting firm for the identification, preparation and provision of applicable financial solutions for the FinRE-BXU Project. PEI is a non-stock, non-profit organization registered with the Securities and Exchange Commission on 19 April 1996 that promotes the development of renewable energy, other clean development mechanisms as well as energy efficiency and demand-side management in the Philippines. PEI is one of the pioneer firms engaged in RE market analysis, financial and technical feasibility studies in the country. It pioneered several outstanding initiatives and projects which led to commercial implementation of RE projects in the Philippines. Among these are the Philippine Wind Energy Atlas (2001) by the National Renewable Energy Laboratory of the United States (US NREL), the first 1 MW solar farm, the largest in the developing world in 2007 which operated in conjunctive use with hydropower in Cagayan de Oro City, the first 1 MW rice husk-fired biomass power plant (2005) in Isabela, Cagayan, and the first biogas power project to qualify for carbon credits under the Clean Development Mechanism, among others.

The proposed 10MW ground-mounted solar project will be the first PV solar project to be developed in Butuan City. This project will be implemented in accordance with the country's national and regional plans and policies for accessible, reliable and sustainable energy sources.

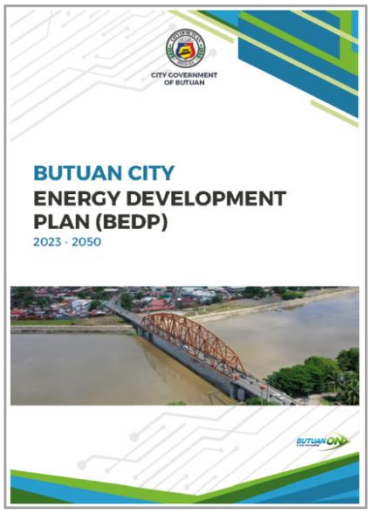
[1] p. 3, Energy Roadmaps and Sustainable Development Goals, Philippine Energy Plan 2020-2040

[2] p. 2, Clean Energy Scenario, Philippine Energy Plan 2020-2040

2. OBJECTIVES OF THE STUDY

In the BCEDP, the CGB identified the development of a 10MW ground-mounted solar photovoltaic project (SPP) as a viable power supply solution. Solar power is the fastest way to increase capacity of the local grid, while allowing Agusan del Norte Electric Cooperative, Inc. (ANECO) to meet its Renewable Portfolio Standards (RPS) obligations. The SPP shall be embedded into the distribution grid, enabling ANECO to avoid transmission charges and enhance energy security by providing a stable, locally sourced, power supply. Moreover, the SPP will create economic and social benefits by generating jobs during construction and operation while also serving as a demonstration model for future renewable energy initiatives, promoting knowledge transfer and capacity building within the community.

Figure 1. The Butuan City Energy Development Plan 2023-2050



Specifically, the consulting firm, PEI, have conducted this pre-feasibility study (Pre-FS) for a solar power plant to be developed in Butuan City. The objectives of the Pre-FS are:

- Verify the optimal capacity that can be viably developed and integrated into the ANECO grid with a maximum of 10 MW to be within current rules and regulations,
- Determine the plant location, technology and necessary technical and system requirements for grid integration,
- Evaluate the technical, financial and economic feasibility of the proposed project,
- Determine the social and environmental impact of the proposed project, and
- Prepare and develop materials for presentation to would-be investors and financing institutions.

During the development of this Pre-FS, PEI is working closely with the Project Management Unit (PMU) of WWF Philippines and the CGB's Technical Working Group (TWG). PEI is also coordinating with the planning consultants of the University of the Philippines Electrical and Electronics Engineering Institute-Research and Development Foundation, Inc. (UPEEI-RDFI) to verify the information in the Butuan City Energy Development Plan 2023-2050 (BCEDP) and Butuan City Comprehensive Land Use Plan, which the planning consultants prepared. Major references of this study include the Master Plan for the Sustainable Urban Infrastructure Development in Butuan City December 2020 (MPSUID), the Executive Summary 2019-2028 of the CGB's Comprehensive Land Use Plan (CLUP), the Power Supply Procurement Plan 2024 (PSPP) of Agusan del Norte Electric Cooperative, Inc. (ANECO) as the

local power utility serving Butuan City, as well as local stakeholders, potential RE developers, financing institutions and others.

Figure 2. Introductory Meeting among WWF Philippines, CGB and PEI Feb 2024

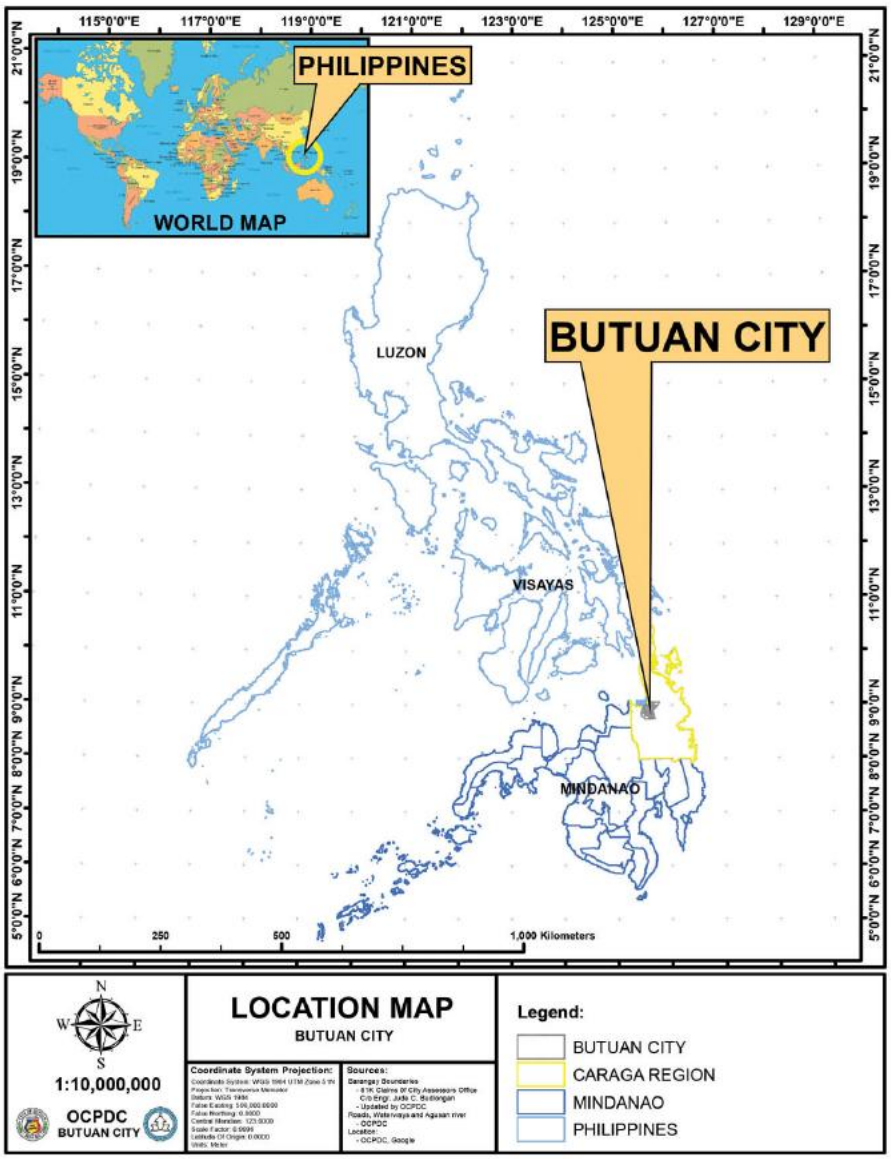
3. PROJECT BACKGROUND

3.1 Profile of Agusan del Norte

Geographic Profile of Agusan del Norte

The province of Agusan del Norte is one of the five provinces in the Caraga Administrative Region or Caraga Region, designated as Region XIII. Caraga Region is located at the northeastern part of Mindanao Island, Philippines. The province is situated at the northwestern part of the Caraga Region. The City of Cabadbaran is its capital, and the province is bordered by the province of Surigao del Norte and Lake Mainit in the northeast, Butuan Bay at the northwest, the province of Surigao del Sur in the middle east, the province of Agusan del Sur in the southeast and the province of Misamis Oriental in the southwest. Agusan River, the country's third longest river, traverses the province. The land surrounding the river is relatively flat to rolling lands while mountainous terrain is mostly located in the northeastern and western areas. Figure 3 shows the location of Butuan City and Caraga Region in the Philippines while Figure 4 presents the Map of Agusan del Norte with its geopolitical components.

Figure 3. Butuan City in the Philippines and Caraga Administrative Region[3]



Demographic Profile of Agusan del Norte

Agusan del Norte is a third-class province covering ten municipalities and one component city[4], Cabadbaran City, with a total population of 387,503 per the 2020 census and a land area of 2,611.63 square kilometers[5]. It is the second smallest province in the Caraga Administrative Region or Region XIII[6]. The independent highly urbanized city, Butuan City, is geographically located at center of the province and is administratively independent from the province.

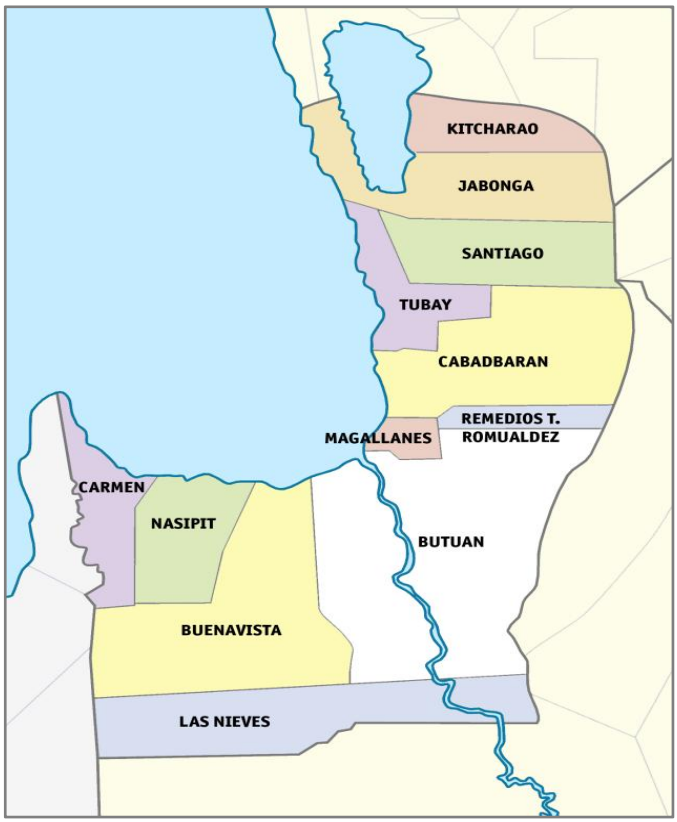
[3] Location Map, 2016-2020 Ecological Statistics Yearbook, City Government of Butuan

[4] p. 5, Philippine Standard Geographic Code, 4Q 2024 National and Provincial Summary, https://psa.gov.ph/system/files/scd/PSGC-4Q-2024-National-and-Provincial-Summary.xlsx

[5] p. 4, TABLE 1.1 Population, Land Area and Density by Region and by Province: CENSUS YEARS 1995 to 2020, 2023 Philippine Statistical Yearbook, https://psa.gov.ph/system/files/psy/2023-Philippine-Statistical-Yearbook.pdf

[6] Agusan del Norte website, Provincial Profile webpage, https://agusandelnorte.gov.ph/government/geophysical-resources-and-environment

Figure 4. Agusan del Norte with its 10 municipalities, 1 component city and 1 highly urbanized city[7]



Socio-Economic Profile of Agusan del Norte

Agusan del Norte is marked by its rich natural resources, predominantly agricultural economy, and growing industrial and service sectors. Agriculture remains the backbone of Agusan del Norte's economy, with rice, corn, coconut, and bananas as the primary crops. In addition, forestry and mining, notably gold and nickel, are critical industries. Manufacturing, while small, is growing, particularly in food processing and wood products, supported by the commercial growth of Butuan City. Despite economic progress, poverty remains a challenge in the province, particularly in its rural areas. The poverty incidence was recorded at 28.1% in 2021, with a marked income disparity between urban centers like Butuan City and rural municipalities.

Electricity Supply in the Province is delivered by ANECO, the distribution utility (DU) that has the franchise area to distribute electricity to the province of Agusan del Norte. ANECO's power supply is primarily relying on hydroelectric power as supplemented by coal. Power outages remain common due to increasing demand and aging infrastructure, especially in rural areas.

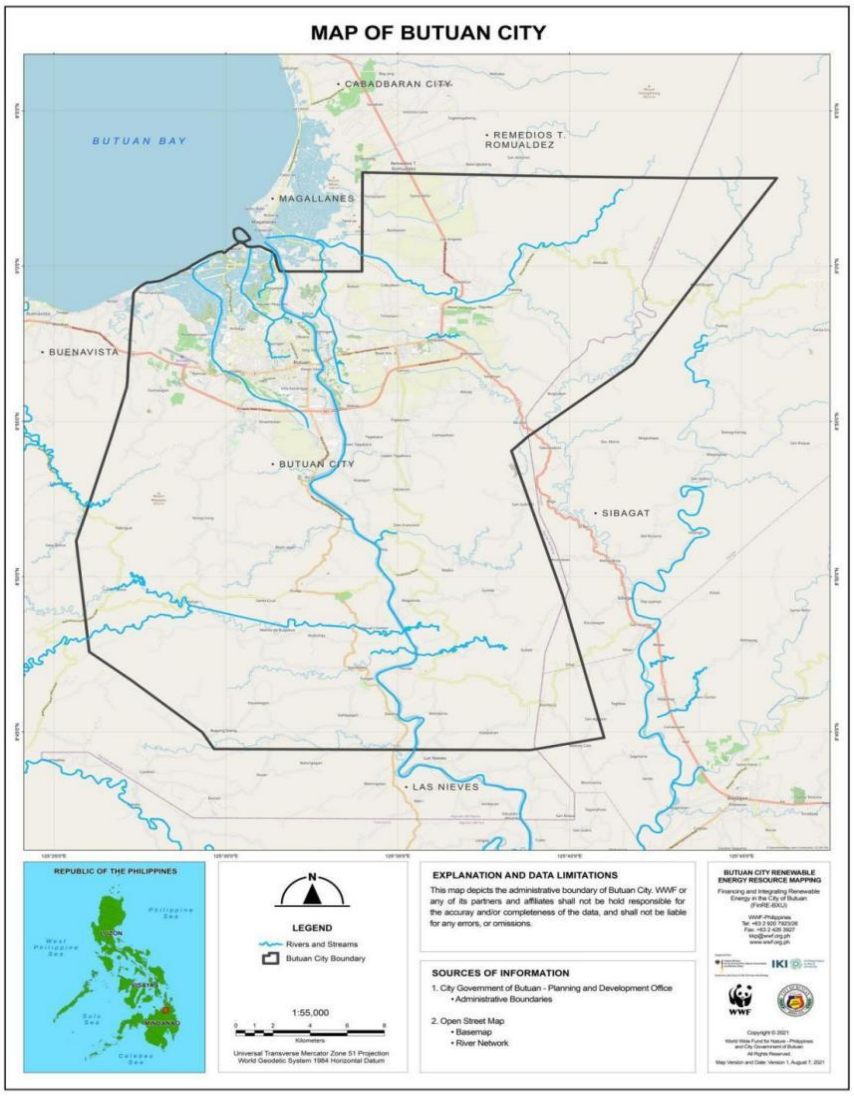
[7] Map of Agusan del Norte with the Municipalities and Cities, https://upload.wikimedia.org/wikipedia/commons/3/3f/Ph_fil_agusan_del_norte.png

3.2 Profile of City of Butuan[8]

Geographic profile of Butuan City[9]

The City of Butuan is a coastal urban center located along Butuan Bay. The city is geographically located at the center of Agusan del Norte and serves as the regional hub of the Caraga Administrative Region. The city is classified as a Highly Urbanized City (HUC) located within the geographical coordinates from 125°27'23"E to 125°43'13"E and from 8°44'27"N to 9°2'53"N. The Agusan River Basin traverses in the city flowing off to Butuan Bay. Butuan City is bordered by Butuan Bay, the Municipalities of Magallanes and Remedios T. Romualdez in the north, the Municipality of Sibagat, Agusan del Sur in the east, the Municipality of Las Nieves in the south, and the Municipality of Buenavista in the west. Figure 5 presents the map of Butuan City with its geopolitical boundaries.

Figure 5. Map of Butuan City



Source: WWF Philippines and City Government of Butuan

[8] p. ES-1, Executive Summary, Master Plan for Sustainable Urban Infrastructure Development in Butuan City December 2020; p. 2, Butuan City Energy Development Plan (2023-2050)

[9] p. 13, Geographical Location, Chapter 1, Geo-Physical Environment, Butuan City Ecological Profile (EP) 2023

Demographic Profile of Butuan City

The city's official name, City of Butuan, is known as the Timber City of the South and considered the regional center of Region XIII or the Caraga Administrative Region in the northeastern section of Mindanao Island. The city was reclassified from a chartered city of Agusan del Norte to a HUC on 7 February 1985[10]. Butuan City has a population of 372,910 per the 2020 census and a land area of 816.62 square kilometers[11].

Socio-Economic Profile of Butuan City

Butuan City plays a crucial role as the gateway to the mineral-rich and agricultural heartland of the region. The city's strategic location has long made it a center for trade and economic activity of the province. The city is rapidly undergoing transformation as it strives to balance its historical roots in agriculture and timber with emerging opportunities in industrial and service sectors. Butuan City's economy is diversified and driven by agriculture, forestry, fishing, trade and services complemented by commercial activities and industrial enterprises, particularly in wood processing and mining. The city's fertile land supports the cultivation of rice, coconuts, bananas and other high-value crops. Local business development and investments in infrastructure have contributed to economic diversification in recent years. To stimulate further growth, the city has identified several Special Economic Development Zones (SEDZs) focusing on agro-industrial, wood-processing sectors and potential international trading hubs[12]. These SEDZs comprises 1,746.85 has. for the city's industrial and commercial investments and activities in the city[13]. Figure 6 shows the location of the identified SEDZs.

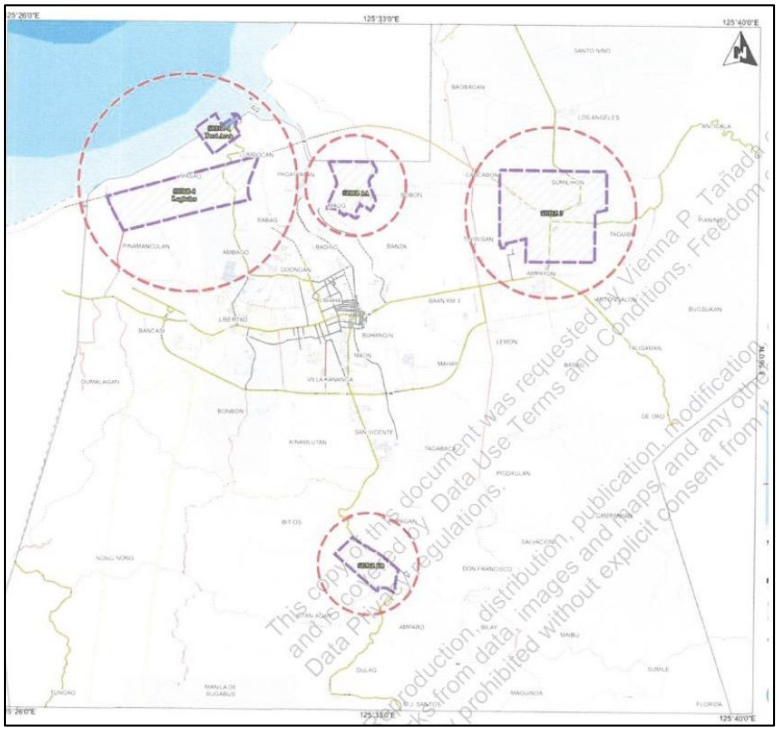
[10] Butuan City Government website, ABOUT BUTUAN webpage, https://www.butuan.gov.ph/about/

[11] p. 4, TABLE 1.1 Population, Land Area and Density by Region and by Province: CENSUS YEARS 1995 to 2020, https://psa.gov.ph/system/files/psy/2023-Philippine-Statistical-Yearbook.pdf

[12] p. 103, Special Economic Development Zones, Butuan City Energy Development Plan (2023-2050)

[13] p. 15, Geographical Location, Chapter 1, Geo-Physical Environment, Butuan City Ecological Profile (EP) 2023

Figure 6. Map of Butuan City with the SEDZs



Source: Butuan City Comprehensive Land Use Plan, The Executive Summary 2019-2028

Approximately 20-25% of the population lives below the poverty line, higher than the national average, particularly in rural sections of the city[14]. Livelihood programs and social services aim to reduce poverty by improving agricultural productivity and providing skills training for non-farm work.

Electricity in Butuan City is supplied by the Agusan Norte Electric Cooperative (ANECO), the city being covered by its distribution franchise.

3.3 Profile of Agusan del Norte Electric Cooperative, Inc. (ANECO)

Organization and Franchise Coverage

ANECO is a local distribution utility registered under the National Electrification Administration (NEA) in accordance with the Presidential Decree No. 269. ANECO was incorporated on February 12, 1977[15] and has the franchise to distribute electricity in the entire province of Agusan del Norte and in the City of Butuan. It is one of the seven local power utilities in Caraga Region.

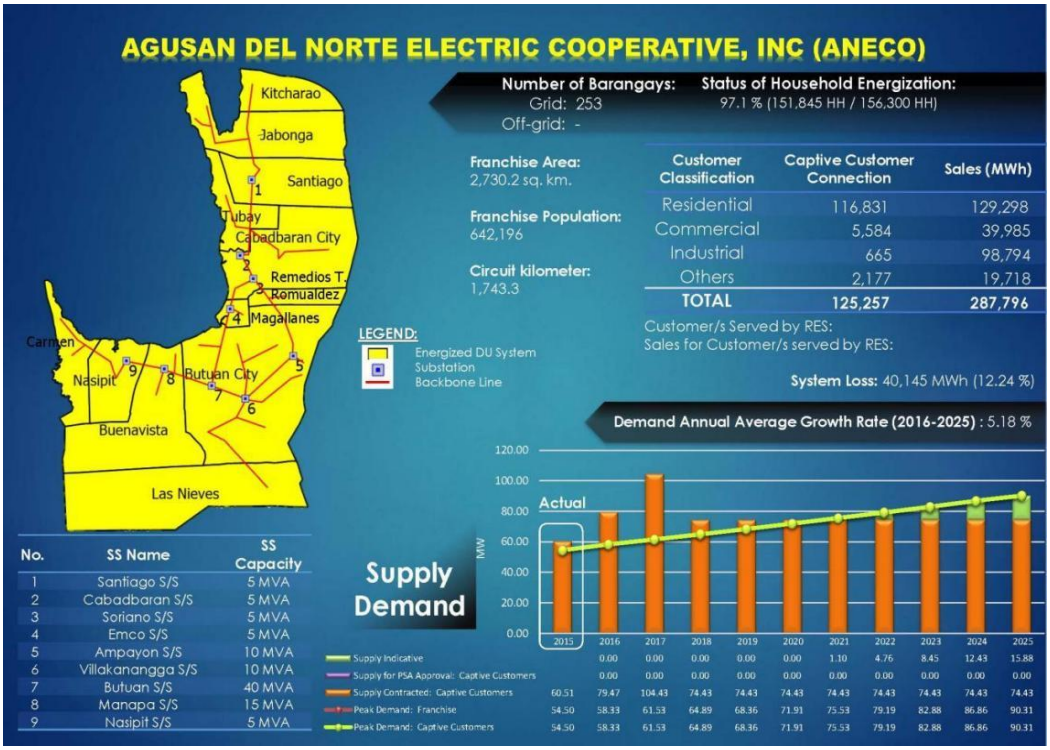
ANECO distributes power to the two (2) cities of Butuan and Cabadbaran and ten municipalities that comprise the rest of Agusan del Norte namely, Las Nieves, Remedios T. Romualdez, Santiago, Tubay, Magallanes, Jabonga, Kitcharao, Nasipit, Buenavista and Carmen. It is serving almost 137,000 member-consumers in the entire Butuan City and the Province of Agusan del Norte.

[14] p. III-17, Master Plan for Sustainable Urban Infrastructure Development in Butuan City December 2020

[15] ANECO Corporate Profile, https://www.aneco.ph/corpprofile#corp_profile

ANECO has a well-established energy supply infrastructure with several substations serving its distribution network namely Santiago, Cabadbaran, Soriano, Emco, Ampayon, Villa Kananga, Butuan, Manapa, and Nasipit, have capacities ranging from 5 MVA to 40 MVA. These substations play a crucial role in ensuring a reliable supply of electricity to the consumers.

Figure 7. ANECO Profile[16]



Source: ANECO Distribution Utility Profile, DOE Website

Current Power Supply Situation

ANECO sources its power from multiple generation companies, with 68% of contracted power supply sourced from renewable energy, particularly hydropower. The remaining 32% comes mainly from coal power plants. However, while ANECO's supply is predominantly renewables, this is expected to change soon once their power supply contract with National Power Corporation-Power Sector Assets and Liabilities Corporation (NPC-PSALM) ends in December 2025. Table 1 shows ANECO's power energy supply mix.

[16] ANECO Distribution Utility Profile, https://doe.gov.ph/ducsp/profile/aneco

Table 1. ANECO: Energy Supply Mix[17]

GENERATION COMPANIES	ERC CASE NUMBER	LOCATION	FUEL TYPE	STATUS OF ERC APP'N	CONTRACT		MINIMUM	
					CAP. (MW)	PERIOD (YRS)	MWh/yr	MW
1. National Power Corp. Power Sector Assets and Liabilities Management Corporation (NPC – PSALM)	2016-186RC	Mindanao	Mix of Hydro, Geothermal & Coal	Approved	36	4 (until Dec 2025)	170,030	19.75
2. Sarangani Energy Corporation (SEC)	2013-010RC	Maasim, Sarangani Province	Coal	Approved	10	25 (until 2041)	35,040	4.00
3. Therma South, Inc. (TSI)	2014-164RC	Davao City	Coal	Approved	1	25 (until 2040)	4,380	0.50
4. FDCUI - MISAMIS POWER COR.	2015-069RC	Villanueva, Mis. Oriental	Coal	Approved	12	25 (until 2041)	42,048	4.80
5. GN Power Kauswagan Ltd. Co. (GNPK)	2014-011RC	Kauswagan, Lanao Del Norte	Coal	Provisional Authority	24.96	25 (until 2042)	109,325	12.48
6. Asiga Green Energy Corporation (AGEC)	2014-063 RC	Santiago, Agusan Del Norte	Hydro	Approved	8	25 (until 2044)	35,040	4.00
7. Agusan Power Corporation	2012-112RC	Jabonga, Agusan Del Norte	Hydro	Provisional Authority	24.9	25 (Dec 2048)	87,250	9.96
8. ANECO Modular Generator Sets	2019-072RC	Aneco Warehouse, Brgy. Bit-Os, Butuan City	Diesel	For Approval	10	N/A	0.00	0.00
TOTAL					**126.86**		**483,113.00**	**55.49**

Source: ANECO Power Supply Procurement Plan, 2024

Currently, ANECO has been facing increasing energy demand across all sectors, with a notable increase in peak demand from 68.41MW in 2020 to 84.72MW in 2023, marking a 24% growth due to new loads in the region. Population grown, rapid urbanization and planned infrastructure particularly in Butuan City is expected to further increase the energy demand in the next 10 years. A reduction in supply of low-cost power supply from NPC SPUG and increase in non-renewable energy sources in the supply mix will result in increased generation rate and dependence on coal and diesel. This will subject ANECO to price instability as imported fuel prices are vulnerable to fluctuations in the international markets and disruptions caused by geopolitical events. Hence there is an urgent need to develop more renewable energy projects like solar power to meet both short-term and long-term energy demands. The SPP will be a critical addition to ANECO's energy mix, reducing dependence on coal and mitigating the potential increase in generation costs from the expected decrease in capacity coming from its NPC-PSALM contract.

4. MARKET ASSESSMENT

The proposed 10 MW Solar Power Plant will be embedded to ANECO. As such, the ANECO being the expected off-taker of the plant's output will be the direct market of the power plant. This section presents the prevailing market of ANECO and an analysis of its project growth and demand gap that the solar plant will be filling up.

[17] p. 6, List of Power Suppliers as of December 2023, Agusan del Norte Electric Cooperative, Inc. Power Supply and Procurement Plan 2024

4.1 ANECO's Current Market

ANECO's operation for 2023 registered over 438,435 MWhs of electricity, delivering 99.6% of these to its various consumers. Of total power supply delivered, 69% were consumed by Butuan City and 8.8% by Cabadbaran City. The rest were delivered to the other 10 municipalities within its franchise area. Table 2 presents the utility's sales per city or municipality in its franchise area while Table 3 and Figure 8 show the energy consumption per customer type.

Table 2. ANECO: Energy Sales, 2023[18]

Cities and Municipalities	Energy Sales (MWh)	Service Percentage (%)
Butuan City	301,698.93	69.08%
Cabadbaran City	38,436.91	8.80%
Buenavista	23,455.40	5.37%
Carmen	6,090.01	1.39%
Jabonga	4,520.34	1.04%
Kitcharao	6,243.81	1.43%
Las Nieves	4,722.22	1.08%
Magallanes	16,788.55	3.84%
Nasipit	18,481.08	4.23%
Remedios T. Romualdez	5,031.47	1.15%
Santiago	4,523.52	1.04%
Tubay	6,716.81	1.54%
TOTAL	**436,709.05**	**100.00%**

Source: ANECO

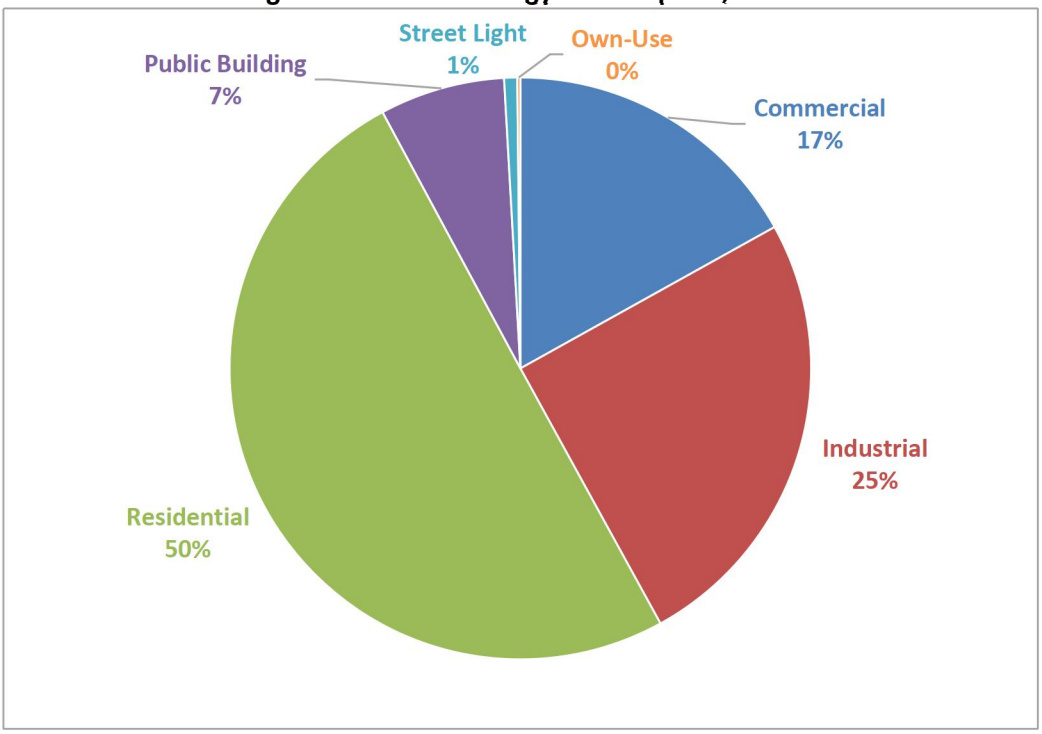
[18] Year 2023 kWh Sales, Agusan del Norte Electric Cooperative, Inc.

Table 3. ANECO: Energy Consumption Per Customer Type in 2023

Customer Type	MWh	Percentage
Commercial	74,044.33	16.93
Industrial	109,704.54	25.08
Residential	219,334.25	50.14
Public Building	30,453.13	6.96
Street Lighting	3,172.81	0.73
Own-Use	753	0.17
TOTAL	**437,462.05**	**100.00**

Source: ANECO

Figure 8. ANECO's Energy Consumption, 2023



Source: ANECO Year 2023 kWh Sales and Power Supply Procurement Plan 2024

As shown in Table 3, residential customers account for the bulk of energy sales at 50.14% on the average due to being the highest in number of connections. While Industrial Customers accounted for the lowest in terms of number of customers, it is second highest in terms of consumption because this sector is highly energy intensive in their utilization of electricity. The Commercial Sector consumed 16.93% and Others, composed of low and higher voltage public buildings and streetlight customers accounted for only 7.69% of energy sales due to its relatively low energy consumption.

4.2 ANECO Current Energy Mix and Consumption[19]

ANECO has experienced significant growth in energy demand over the past decade. Peak demand increased from 34.66MW in 2000 to 84.72MW in 2023, reflecting a growing population, increasing industrial activity, and expanded commercial development within the region. The MWh output in 2023 reached 438,435 MWh, a figure that is expected to rise as urban areas such as Butuan City continue its urbanization and infrastructure development initiatives. Table 4 and Figure 9 show ANECO's historical consumption data from 2000 to 2023. Comparing the past 2 years of operation, ANECO's coincident peak load increased from 76.71 MW in 2022 to 84.72 MW in 2023 a jump of 10.44%. ANECO attributes this to the increased consumption of the public buildings, large load, and commercial consumers. The MWh offtake also increased by 5.48% from 461,794 MWh in 2022 to 487,080 MWh in 2023.

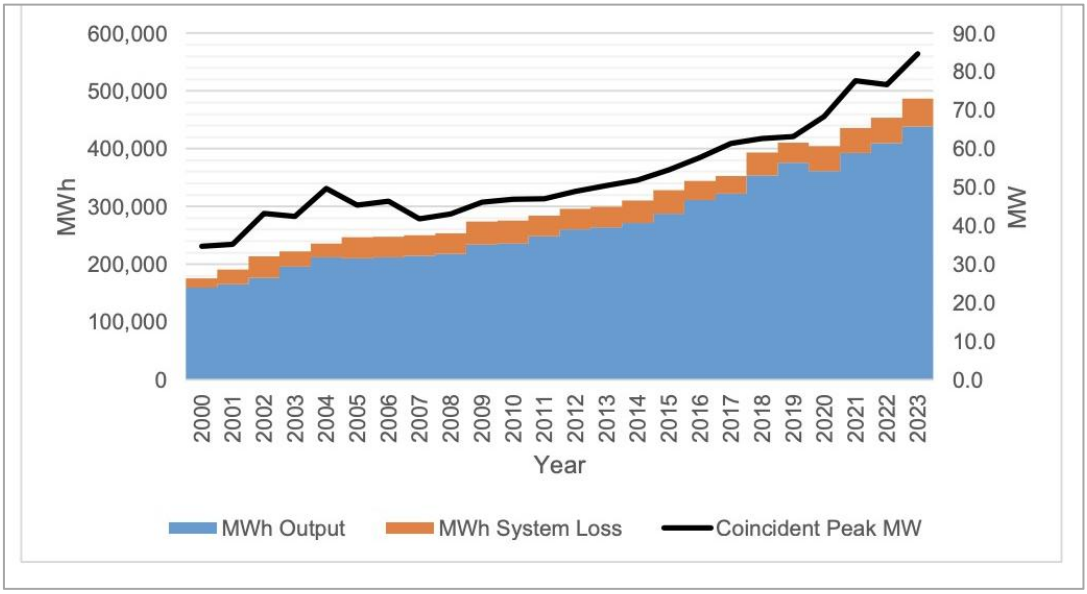
Table 4. ANECO: Historical Coincident Peak and Offtake, 2000-2023

Year	Coincident Peak, MW	MWh Offtake
2000	34.66	175,214
2001	35.14	190,802
2002	43.13	213,875
2003	42.38	222,018
2004	49.71	235,598
2005	45.33	246,512
2006	46.41	247,636
2007	41.79	250,492
2008	43.12	253,768
2009	46.11	273,824
2010	46.93	275,420
2011	47.06	284,353
2012	48.89	295,621
2013	50.48	299,286
2014	51.83	311,420
2015	54.50	332,398
2016	57.75	350,201
2017	61.44	359,490
2018	62.61	398,387
2019	63.15	418,284
2020	68.41	412,327
2021	77.67	442,636
2022	76.71	461,794
2023	84.72	487,080

Source: ANECO Power Supply Procurement Plan, 2024

[19] p. 2, Agusan del Norte Electric Cooperative, Inc. Power Supply and Procurement Plan 2024

Figure 9. ANECO: Graph of Historical Consumption, 2000-2023

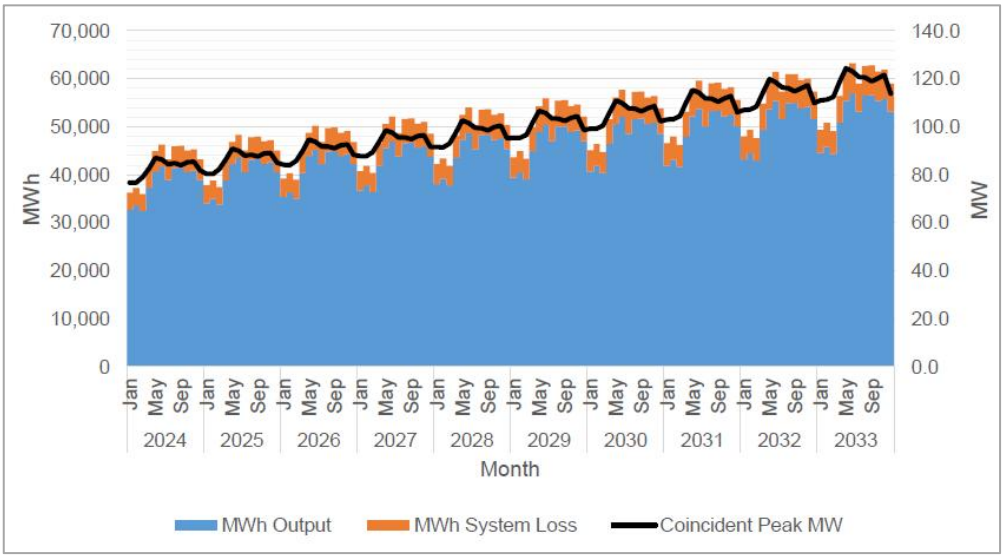


Source: ANECO Power Supply Procurement Plan, 2024

4.3 Future Energy Demand and Growth

ANECO forecasts a continued increase in energy consumption driven by population growth, expanding urban areas, and the ongoing industrialization of Butuan City. According to ANECO's 2024-2033 Procurement Plan, growth in consumption is projected to be 4.7% annually over the next 10-year horizon. This growth trajectory presents an urgent need for additional generation capacity to avoid potential energy shortages and mitigate the risk of higher electricity prices. Figure 10 shows ANECO's load forecast from 2024-2033, as presented in its Power Supply Procurement Plan.

Figure 10. ANECO: Power Consumption Forecast (2024-2033)

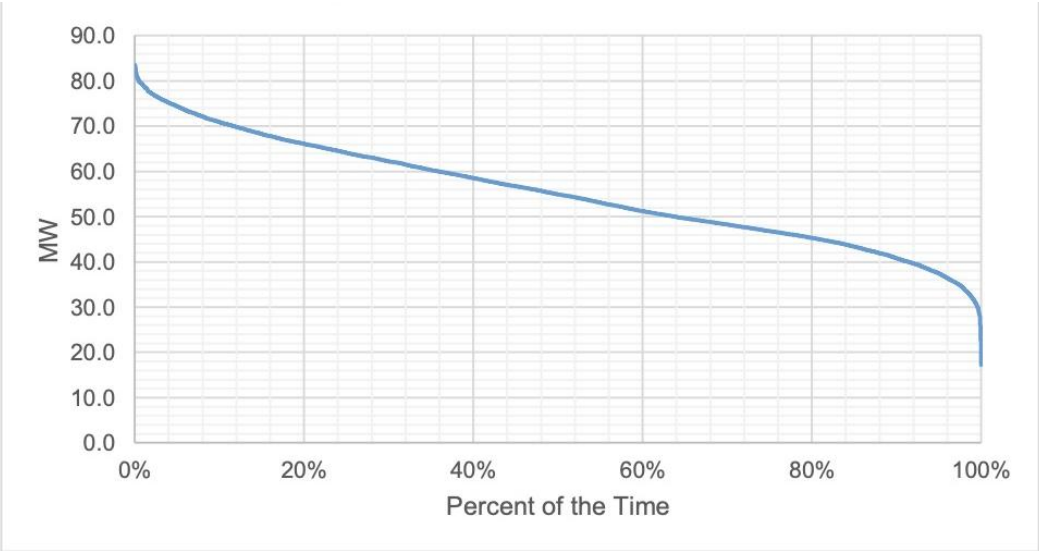


Source: ANECO Power Supply Procurement Plan, 2024-2033

Load Duration Curve

ANECO's load duration curve is presented in Figure 10. This graph indicates that its base load, which occurs 100% of the time is approximately 30 MW. Peaking Load occurs at only around 12% of the time while Intermediate Load occurs at around 88% of the time. Nevertheless, ANECO procures power above its peak load because utilities are to ensure the reliability and security of the supply and should have enough and readily available power supply to allow them to cope whenever any unscheduled emergency shutdown of any power plants occur. This over-contracting results in oversupply of power at certain periods which forces ANECO to sell power at the spot market at a loss.

Figure 11. ANECO Load Duration Curve, 2023



Source: ANECO Power Supply Procurement Plan, 2024-2033

4.4 Energy Demand Forecast for Butuan City

The whole franchise of ANECO required 485.50GWh for the year 2024. BXU power demand and growth accounts 70% of demand[20]. This energy demand of BXU is expected to grow 7% per annum. Table 5 below shows the energy demand forecast followed by Figure 12 presenting the projected energy forecast for the city.

[20] p. 34, Historical Electricity Demand, Butuan City Energy Development Plan (BCEDP) 2023-2050

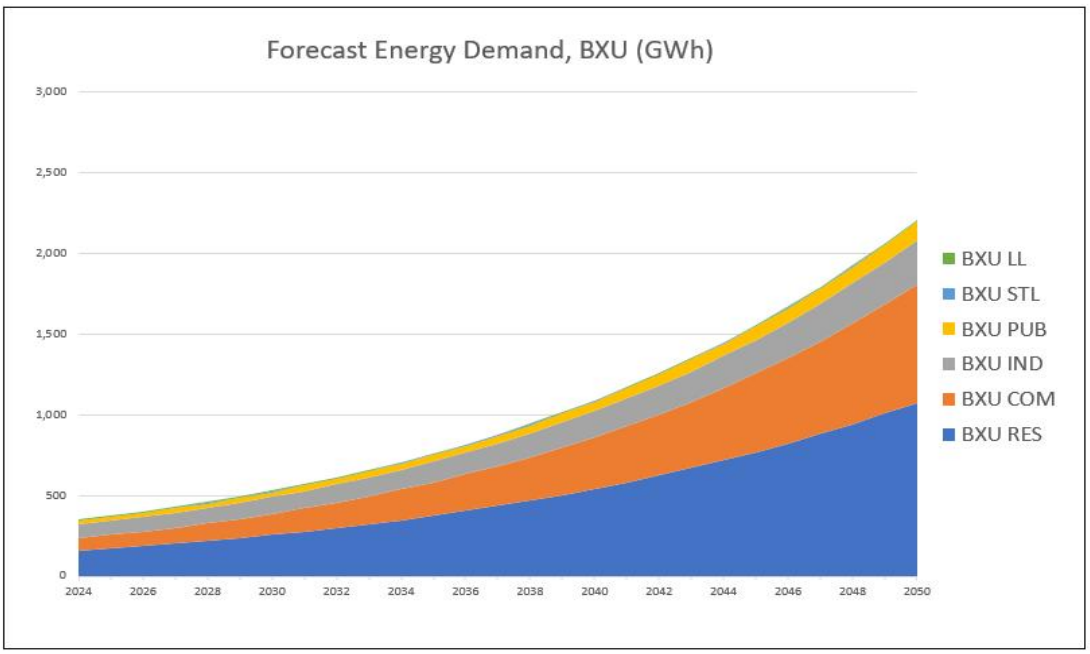
Table 5. Energy Demand Forecast for Butuan City

Year	Energy Demand (GWh)[21]	Annual Growth Rate (%)
2024	348.90	
2025	372.90	6.88
2026	399.00	7.00
2027	427.50	7.14
2028	458.50	7.25
2029	492.30	7.37
2030	528.90	7.43
2031	568.40	7.47
2032	611.10	7.51
2033	657.20	7.54
2034	706.60	7.52
2035	759.80	7.53
2036	817.00	7.53
2037	878.40	7.52
2038	944.30	7.50
2039	1,014.90	7.48
2040	1,090.70	7.47
2041	1,171.80	7.44
2042	1,258.70	7.42
2043	1,351.70	7.39
2044	1,451.00	7.35
2045	1,555.10	7.31
2046	1,670.60	7.29
2047	1,791.60	7.24
2048	1,920.70	7.21
2049	2,058.20	7.16
2050	2,204.90	7.13

Source: Butuan City Energy Development Plan (BCEDP) 2023-2050

[21] p. 38, Baseline Demand Forecasts for Butuan City, Butuan City Energy Development Plan (BCEDP) 2023-2050

Figure 12. Graph showing Butuan City's Power Demand Forecast[22]



Source: Butuan City Energy Development Plan (BCEDP) 2023-2050

4.5 Assessment of ANECO's Power Supply Mix and Projected Demand Situation

ANECO's current power supply mix that about 68% of its power supply already comes from renewable energy sources. Thus, currently, it is able to comply with the Renewable Energy Portfolio Standards (RPS) required under the Renewable Energy Act of 2008, which requires distribution utilities like ANECO to source a percentage of their energy supply from renewable sources.

As presented earlier in Table 1, ANECO's existing contract with the National Power Corporation - Power Sector Assets and Liabilities Management Corporation (NPC-PSALM) contract is expiring in December 2025. According to ANECO, a request has already been made to NPC-PSALM for the renewal of its power supply agreement. Contract renewal is in process however, the capacity under this new contract will be lower than its current contracted capacity because NPC-PSALM will equitably distribute its generated capacity to all Mindanao-grid connected electric utilities. The impact of this reduce capacity are, one, ANECO needs to fill-in the supply gap from this reduced supply from NPC-PSALM and two, ANECO needs to mitigate the possible increase of power generation cost to its customers due to the reduction of power supply from NPC-PSALM, which averaged at a much lower price of PhP2.94/kWh in 2023-2024 compared with the other supply sources.

Hence, the inclusion of the SPP in its supply mix is necessary to mitigate the power generation cost and reduce the dependency on the coal fired-power generation facilities. The SPP is strategically positioned to fill these gaps by providing clean, affordable energy and at the same time generate power at lower rate than imported

[22] LL: Large Load, STL: Streetlight, PUB: Public Building, IND: Industrial, COM: Commercial, RES: Residential
p. 38, Forecasted Energy Demand of Butuan City, Butuan City Energy Development Plan (BCEDP) 2023-2050

fossil fuel-based power, the price of which are fluctuating and highly vulnerable to global geopolitical events. Additionally, the SPP has priority dispatch and is exempt from Value Added Tax (VAT) giving it further comparative advantage.

The SPP will provide critical support during peak demand periods, particularly during the daytime when solar irradiance is highest. This is especially important given ANECO's projected increase in peak demand in the coming years, particularly from year 2025 onwards. Moreover, by being located within ANECO's franchise area, the solar project will help reduce transmission losses associated with long-distance power facilities, contributing to a more efficient and reliable power supply system. Having an embedded power generation facility within ANECO's distribution area will also reduce its system losses. A careful planning and assessment of ANECO's power demand and supply situation can lead to a more efficient power supply procurement and avoid over-contracting while ensuring reliability and sufficiency of power supply.

5. SOLAR RESOURCE ASSESSMENT

The Philippines is located 1,445.54 km north of the equatorial line[23]. Geographically, this makes the country suitable for harvesting solar energy resource during the entire calendar year. According to the National Renewable Energy Laboratory (NREL), the Philippines' average solar radiation ranges from 128-203 watts per square meter, or an average of 161.7 watts per square meter, based on sunlight duration. This translates to potential power generating capacity of 4.5-5.5 kWh per square meter per day.[24] The availability of solar resources in both the northern and southern parts of the country make solar power a viable solution to transitioning the country away from imported fossil-based power.

5.1 Solar Resource in Agusan del Norte

Table 6 presents the relevant solar resource and Photovoltaic Power output (PVOUT) and PV Power output distribution for the province of Agusan del Norte, respectively. **In terms of** distribution, specific PV power output data shows that 45.7% is at the 3.60-3.80 range (see Figure 12). Meanwhile, Global Horizontal Irradiation (GHI) level is highest at 32.4% at the 4.60-4.80 range as shown in Figure 14.

Table 6. Solar Resource and PVOUT data, Agusan del Norte

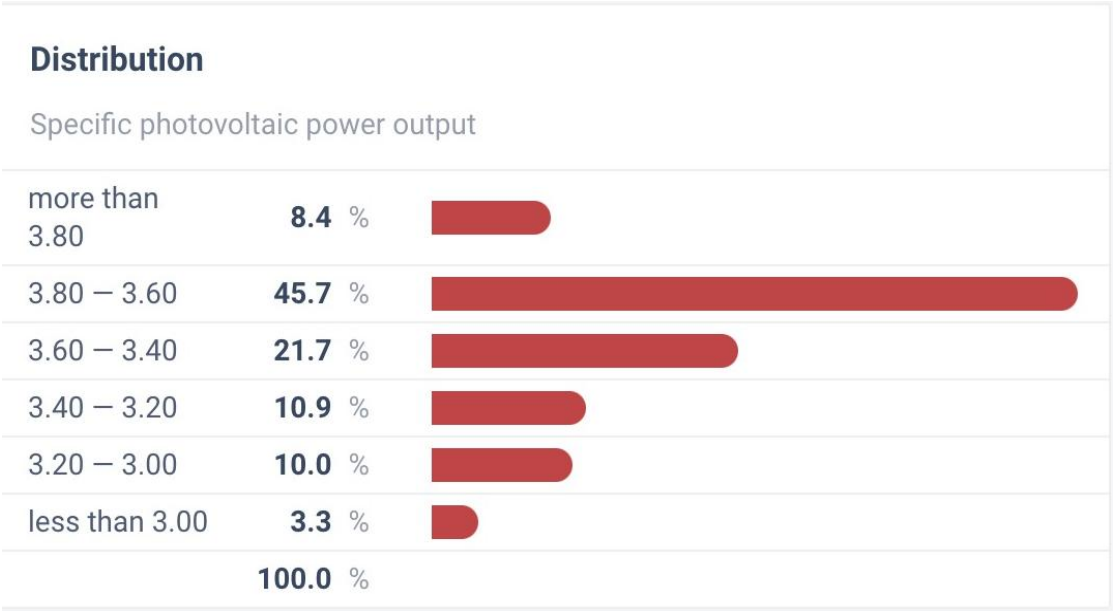
Map data (min-max range)			Per day
Specific photovoltaic power output	PVOUT	2.90 — 3.99	kWh/kWp
Direct normal irradiation	DNI	1.81 — 3.89	kWh/m^2
Global horizontal irradiation	GHI	3.58 — 5.03	kWh/m^2
Diffuse horizontal irradiation	DIF	2.15 — 2.35	kWh/m^2
Global tilted irradiation	GTI	3.58 — 5.06	kWh/m^2
Optimum tilt of PV modules	OPTA	5 — 8	°
Air temperature	TEMP	19.1 — 28.4	°C
Terrain elevation	ELE	0 — 0	m

Source: Global Solar Atlas

[23] Distance of the Philippines from Equatorial Line, https://www.distance.to/Philippines

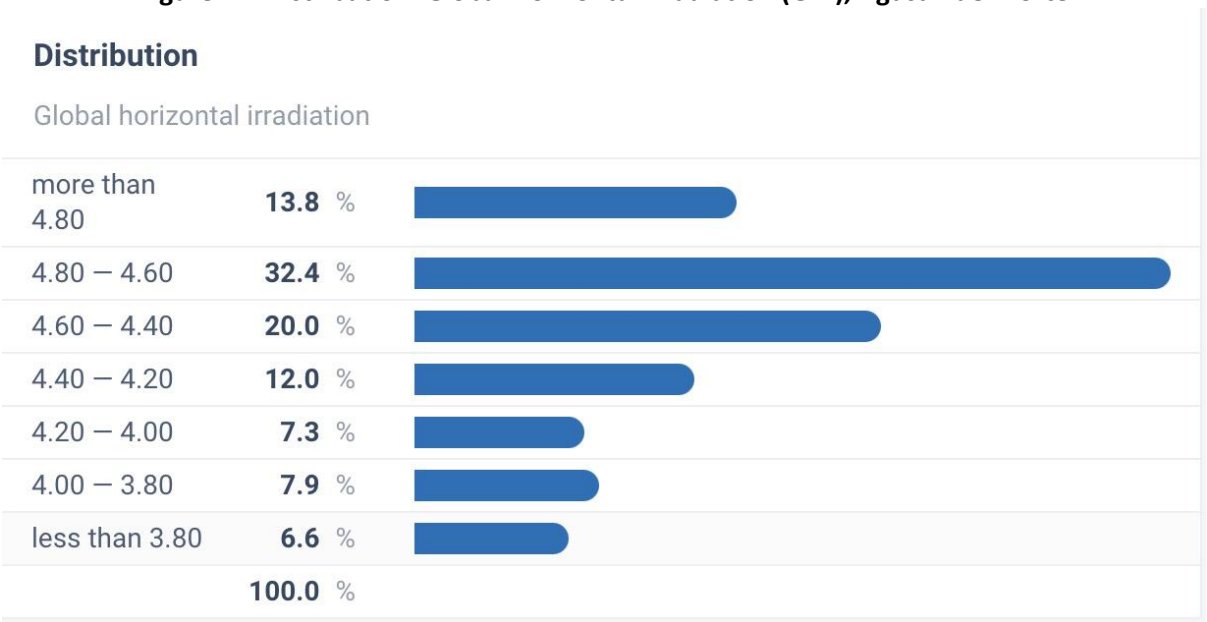
[24] Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH in cooperation with Renewable Energy Developers Center (REDC) and WWF Philippines. Policy Brief: It's More Sun in the Philippines. 2013

Figure 13. Distribution: Specific Photovoltaic Power Output, Agusan del Norte



Source: Global Solar Atlas

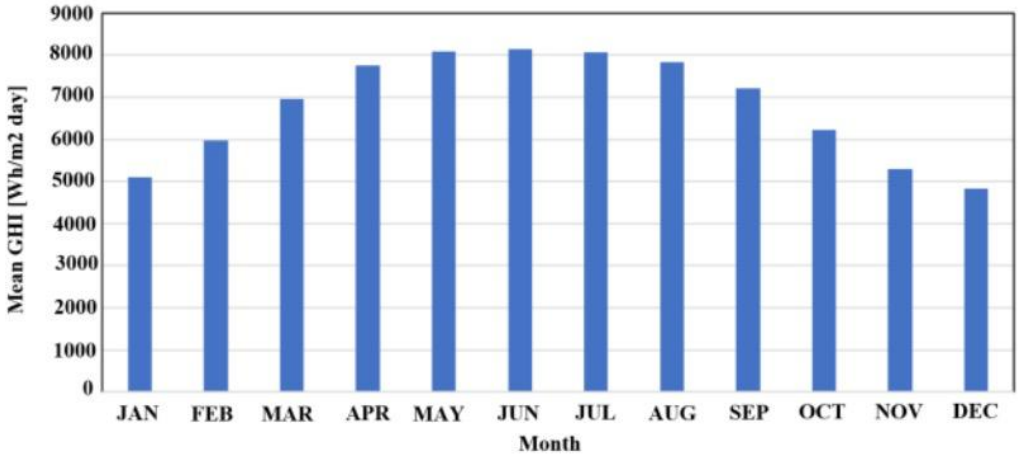
Figure 14. Distribution: Global Horizontal Irradiation (GHI), Agusan del Norte



Source: Global Solar Atlas

On the other hand, according to a specific study entitled "Renewable Energy Resource Assessment for Agusan Del Norte, Caraga Region, Philippines" which was presented at the International Exchange and Innovation Conference on Engineering & Sciences (IEICES) by Cindy May C. Belivestre and Harold Panganoron, of the University of the Philippines Diliman, the province of Agusan del Norte has a clear seasonality pattern in the amount of irradiance. The graph in Figure 15 shows this seasonal pattern, which indicates that highest solar outputs may be expected in the months of April to August, while the months of January and December has the lowest solar irradiance. This information may be used to optimize the design and operation of solar power systems.

Figure 15. Monthly Mean Global Horizontal Irradiance (GHI), Agusan del Norte



Source: Renewable Energy Resource Assessment for Agusan Del Norte, Caraga Region, Philippines, Proceedings International Exchange and Innovation Conference on Engineering & Sciences, October 2024.

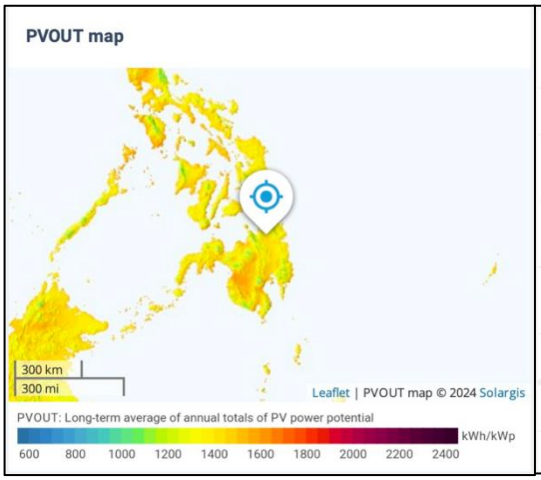
5.2 Solar Resource in Butuan City

The geographic location of Butuan City makes it suitable for the development of solar power projects. Data from the Global Solar Atlas presented in Figure 16 reveals that the city has Direct Normal Irradiation of 1,299.4 kWh/sqm per year or an average of 3.56 kWh daily and a GHI of 1,761.9 kWh per year or an average of 4.83 kWh/sqm. daily[25]. Aside from having a high GHI (second only to Magallanes town in Agusan del Norte), Butuan City is found to be the most ideal location for the development of ground-mounted solar power projects for the following reasons:

- physical aspects, including factors like land use and cover, slope, aspect, and proximity to water bodies
- risk criteria, relatively shielded from potential hazards such as floods, and inundation, reducing the vulnerability of solar installations.
- proximity to infrastructure, particularly interconnection point to ANECO substation.

[25] p. 55, Solar Energy Resources, Butuan City Energy Development Plan (2023-2050)

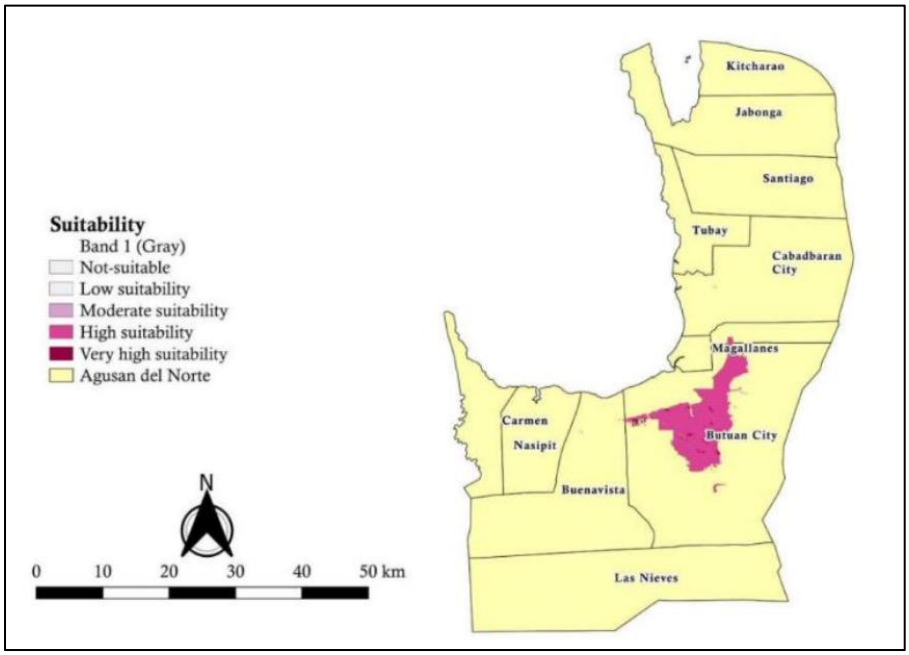
Figure 16. Solar Resource Data in Butuan City



Map data		Per year	
Direct normal irradiation	DNI	1299.4	kWh/m²
Global horizontal irradiation	GHI	1761.9	kWh/m²
Diffuse horizontal irradiation	DIF	792.9	kWh/m²
Global tilted irradiation at optimum angle	GTI opta	1773.3	kWh/m²
Optimum tilt of PV modules	OPTA	8 / 180	°
Air temperature	TEMP	25.9	°C
Terrain elevation	ELE	N/A	

Source: Global Solar Atlas

Figure 17. Site Suitability for Ground-mounted Solar Project



Source: Renewable Energy Resource Assessment for Agusan Del Norte, Caraga Region, Philippines, Proceedings International Exchange and Innovation Conference on Engineering & Sciences, October 2024.

6. TECHNICAL FEASIBILITY ASSESSMENT

This section assesses the technical feasibility of the proposed 10 MW Solar Power Project in Butuan City. The indicative 10 MW Solar Power Project is strategically designed to address the increasing energy demand within ANECO's service area. It will be connected directly to the Libertad Substation of ANECO, bypassing transmission costs and optimizing energy distribution efficiency.

Key project details include:

- **Capacity**: 10 MW (maximum allowable without Competitive Selection Process (CSP)).
- **Site**: Barangay Kinamlutan, located approximately **5 km** from ANECO's Libertad Substation.
- **Technology**: Advanced solar PV modules (>600 W capacity) with an EPC cost benchmark below **$500/kW**.
- **Land Area**: Requires **7 hectares** of land for solar panel installations and supporting infrastructure.

6.1 Power Supply and Load Profile Analysis

Power supply analysis

- ANECO's power supply is currently sourced through contracts with eight power generators and suppliers across Mindanao. The energy mix heavily relies on hydroelectric and coal-fired power plants, supplemented by diesel during peak periods. **Generation rate is relatively low considering that over 68% of power is supplied by NPC-PSALM at an average of PhP2.94/kWh in the last 2 years. (see Table 7).** However, this share in low-cost hydroelectric power is expected to decrease once their power supply contract with NPC-PSALM ends in 2025. Contract renewal is likely to be at much reduced capacity, which will result in higher tariff if replacement and additional power is not accessed from another renewable energy project.

Table 7. Percentage Share of Power Source in Energy Mix, 2023

Energy Source	Percentage
Hydroelectric Power	68.70%
Coal & Diesel	31.30%

Key insights:

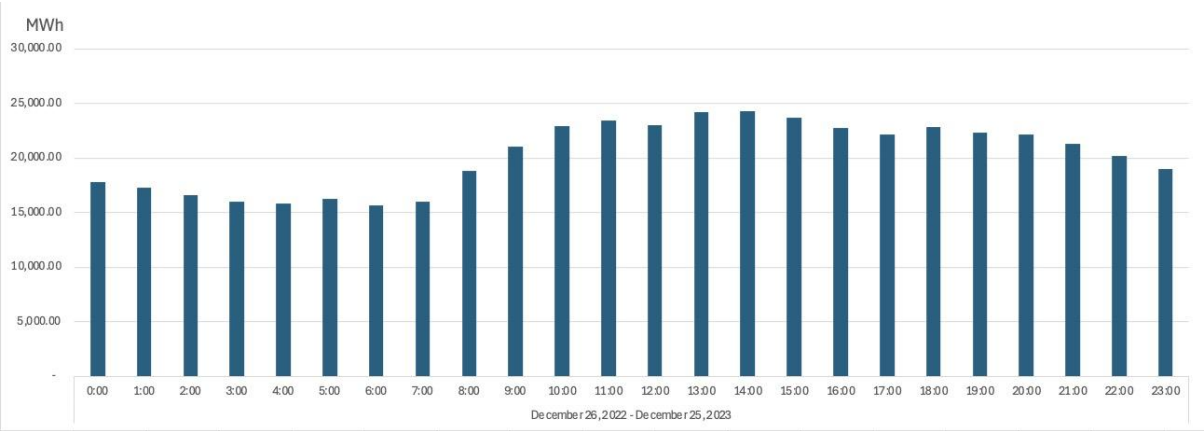
- **Renewable Energy Share**: In December 2023, **68.70%** of ANECO's purchased energy was sourced from renewable hydroelectric power. To maintain this beyond 2025, there is a need for more RE power supply to replace the reduced capacity from NPC-PSALM.
- **Transmission Costs**: ANECO incurs transmission charges of **PhP0.692/kWh**, that will be avoided with the proposed solar power plant.
- **Over-contracting Issues**: ANECO's contracted capacity exceeds demand during off-peak periods, with excess energy sold to Wholesale Electricity Spot Market (WESM) at a **net loss of PHP 2.6355/kWh** in December 2023.

Load profile analysis

ANECO's projected power demand reveals a steady increase over the 2024-2040 period, driven by population growth and economic activity in Butuan City. Peak Demand will grow from **84.7 MW** to **1.4 GW by 2033.** Specific to Butuan City, the average growth rate of demand is projected to grow at 7.90% annually, higher than the national average of **6.60%**.

ANECO's hourly load profile presented in Figure 18 shows that it has a relatively long daytime peak from 9:00 AM to 5:00 PM. This shows a very good match to solar energy production which usually peaks from 10:00 AM to 3PM.

Figure 18. ANECO Hourly Load Profile,
Average from December 26, 2022, to December 25, 2023



Source: ANECO

The hourly load profile shows:

- **Daytime Load occurs from 9:00 AM – 5:00 PM.** This can be attributed to the high demand due to commercial and industrial activities, aligning with solar energy generation hours.
- **Evening Peak which is** driven by residential consumption occurs from **6:00 PM – 9:00 PM;** and,
- **Nighttime Load occurs from 11:00 PM – 6:00 AM** when there is minimal activity, resulting in reduced demand.

6.2 Site Selection and Characteristics

The choice of the site for development of a solar generation facility is critical to the project's sustainability and cost.

In this regard, PEI shortlisted potential sites for the SPP using the following criteria:

- Location: Parcel of land in a rural barangay preferably continuously flat terrain with access roads; little to no existing endemic flora and fauna species; outside the geohazard-identified area or minimum geohazard impact area; converted agricultural land or commercial/industrial-classified land. It is situated **5 km from ANECO's Libertad Substation**, ensuring efficient grid connection.
- Infrastructure: Little to no existing large structure or infrastructure/s that can obstruct irradiation; adjacent or within 10m to 50m radius from a local power distribution line.

- Power off-taker: assumed to be ANECO; project will be embedded to the nearest power substation with sufficient capacity (preferably within 1-5 km distance) that is readily available with upgraded distribution lines.
- Security: Community or socially acceptable project site; relatively peaceful without any threats to the project facility and safety of project personnel.
- Regulatory Compliance: Adherence to zoning regulations and land-use conversion policies.
- Construction Feasibility: Low-cost site preparation due to minimal grading and clearing requirements.

Utilizing the data from the BCEDP, MPSUID and CLUP, there were two initially identified sites for the SPP. These two locations are named in Table 8 below.

Table 8. Identified Sites for the SPP with Criterias

Location 1	Location 2
Ambago-Masao Area	Barangay Kinamlutan
Criteria: ➢ Within Solar RE Zone ➢ Available land within SEDZ 1 ➢ Proposed ANECO substation in Masao but no timeline yet	Criteria: ➢ Within Solar RE Zone ➢ Available 7 has. continuous flat terrrain ➢ Adjacent access roads ➢ Within 5 km radius from existing available ANECO Libertad substation ➢ To be connected to existing ANECO Libertad substation

Upon consultation with the BXU TWG, the suitable potential site for the SPP based on the above-listed criteria is in Location 2, Barangay Kinamlutan. The area has relatively flat land of 20 has. to 30 has. with a distance of approximately 5 km from ANECO's existing Libertad substation. Barangay Kinamlutan is located within what the BCEDP indicated as the solar RE zone. Having an existing substation will significantly reduce the developmental cost for the project's transmission and ancillary facilities and timeline for project execution.

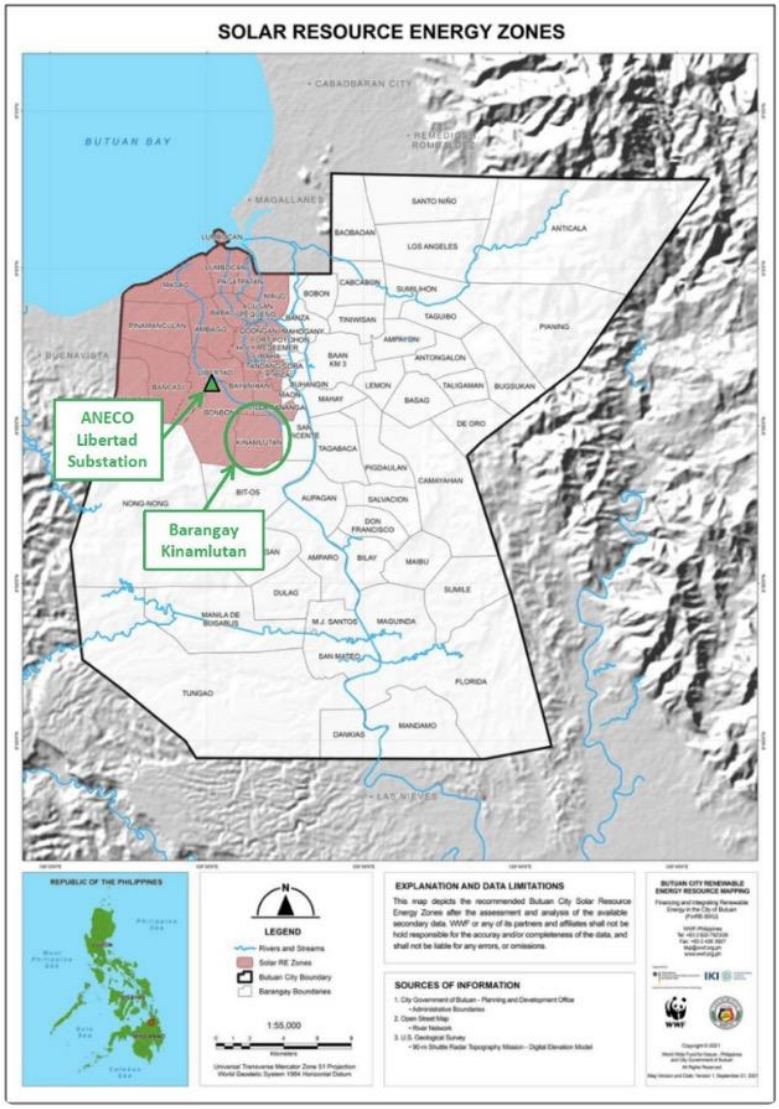
Site Characteristics

Barangay Kinamlutan meets the criteria for solar development with **7 hectares** of contiguous land. The area is within the solar renewable energy (RE) zone identified in the Butuan Energy Development Plan (BCEDP). Additionally, the flat terrain minimizes construction costs, and the site's flood-free status ensures climate resilience.

Solar resource assessments indicate high potential, with:

- **Annual Direct Normal Irradiance (DNI)**: **1,299.4 kWh/m²/year**.
- **Annual Global Horizontal Irradiance (GHI)**: **1,761.91 kWh/m²/year**.

Figure 19. Locations of Barangay Kinamlutan and ANECO Libertad Substation



Source: Butuan City Energy Development Plan 2023-2050

6.3 Solar Technology and System Design

Solar PV Module Technology

This study uses the cost and performance assumptions of available high performance silicon modules. However, PEI is also aware of the expected commercial availability of hybrid silicon and perovskite modules. (see https://www.longi.com/en/news/2024-snec-silicon-perovskite-tandem-solar-cells-new-world-efficiency/) These solar modules that use a hybrid of silicon and this new technology will have over 40 percent higher efficiency.

System Design and Configuration

The **10 MW Solar Power Project** in Barangay Kinamlutan is designed to deliver reliable, efficient, and sustainable solar energy while maximizing energy yield and minimizing operational costs. The system's components and configuration were carefully selected to optimize performance and ensure compliance with local regulations and industry standards. The SPP system components and configuration are provided in Table 9.

Table 9. Solar Power Plant Components and Configuration, 10-MWs

Component	Description
Solar Panels	
No. of Panels	**23,492 panels** arranged in 839 strings, with 28 modules per string.
Module Power Type	Advanced PV modules with 600~700 W capacity per panel
Module Dimensions	2278 mm x 1134 mm x 35 mm.
Total DC Capacity	**12.9206 MWp**, ensuring sufficient energy generation for the project.
Inverters	
Number of Inverters	**37 units,** strategically placed across the site to optimize performance.
Inverter Type	**CPS SCH275KTL-DO-EU-800,** with >98% efficiency, enabling effective DC to AC power conversion.
Total AC Power	**10.175 MWac**, synchronized with ANECO's grid voltage and frequency.
Transformers	
Number of Transformers	**2 units,** each with a capacity of 5000 kVA, ensuring smooth voltage step-up for grid integration.
Grid Voltage Output	**33 kV,** meeting ANECO's distribution requirements

MWp = megawatt peak
MWac = megawatt AC power

System Description

The project is strategically located in **Barangay Kinamlutan**, Butuan City, to take advantage of the area's favorable geographic and climatic conditions. The project will have a **tilt angle of 8°** and a **pitch gap of 5.1 meters** designed to maximize solar irradiation capture while minimizing shading and land use conflicts. These design choices will ensure efficient energy generation and optimal utilization of the project area.

The solar modules, the core of the energy generation system, will be high-efficiency units capable of producing more than **600 W of power per panel**. Each module measures **2278 mm x 1134 mm x 35 mm** and is mounted on a fixed-tilt or single-axis tracking system to optimize energy capture throughout the day. The project will deploy **23,492 solar modules**, arranged in **839 strings with 28 modules per string**, resulting in a total DC power capacity of **12.9206 MWp**. These modules were chosen for their proven performance and durability, ensuring reliable operation over the project's lifespan.

The system will incorporate **37 CPS SCH275KTL-DO-EU-800 inverters**, which are highly efficient, boasting a conversion efficiency of over **98%**. These inverters convert the direct current (DC) generated by the solar panels into alternating current (AC), suitable for distribution to the grid. The total AC power output from the inverters is **10.175 MWac**, which is synchronized with the grid's voltage and frequency for seamless integration with ANECO's distribution network.

To facilitate the connection to the grid, the project will use two **5,000 kVA transformers**, each capable of stepping up the AC voltage to **33 kV**, the required output for grid transmission. These transformers are engineered for reliability and minimal energy losses

during operation, ensuring stable energy delivery to ANECO's Libertad Substation.

The overall system configuration reflects a thoughtful integration of components, balancing energy production efficiency with cost-effectiveness. The design adheres to the **Philippine Grid Code** and local regulatory requirements, ensuring compliance and operational safety.

The system's design also considers future scalability. The inclusion of advanced solar modules, efficient inverters, and high-capacity transformers will enable the project to accommodate potential upgrades, such as battery energy storage systems, to further enhance grid stability and reliability. Additionally, the use of fixed-tilt or tracking systems allows for potential adjustments to optimize performance over time.

In summary, the **10 MW Solar Power Project** is designed to integrate advanced solar technologies, efficient inverters, and reliable transformers to achieve an optimal balance of performance, cost, and sustainability. Its strategic location, coupled with meticulous design and configuration, ensures that the project will generate clean and reliable energy for Butuan City while setting a benchmark for future renewable energy initiatives in the region.

6.4 Grid Interconnection

The grid interconnection of the 10 MW Solar Power Project ensures seamless integration into ANECO's distribution system while complying with the **Philippine Grid Code** and technical standards. The interconnection infrastructure is designed to optimize energy delivery, enhance grid stability, and minimize losses during transmission. The interconnection design addresses:

- **Voltage Regulation**: Maintains steady voltage within a ±5% range to prevent grid instability.
- **Compliance Testing**: Comprehensive synchronization tests to align solar output with grid frequency and phase.
- **Safety Features**: Installation of protection devices, such as circuit breakers, surge arresters, and isolation switches.

Key Interconnection Features

- **Connection Point**:
  The project connects directly to ANECO's **Libertad Substation**, located **5 km** from the project site in Barangay Kinamlutan.
- **Voltage and Frequency Standards**:
  Output stepped up to 33 kV to match ANECO's distribution system voltage.
  Synchronization with a **60 Hz frequency** to ensure compatibility with the grid.
- **Transmission Line**:
  A 5 km transmission line will be constructed, incorporating advanced conductors to reduce energy losses.
- **Protection Systems**:
  Installation of circuit breakers, surge arresters, and isolation switches to safeguard the grid and solar plant infrastructure.

Strategic Implications for Solar Integration

The proposed solar power plant design addresses critical challenges in ANECO's supply-demand dynamics:

- **Peak Load Alignment**: Solar generation during **9:00 AM – 3:00 PM** offsets reliance on hydroelectric and coal-fired power plants during high-demand periods.
- **Transmission Cost Reduction**: Embedded generation eliminates transmission charges and associated losses, enhancing cost efficiency. A solar plant will be priority dispatch with zero VAT charges.
- **Grid compliance:** interconnection adheres to the Philippine Grid Code and addresses the issues of maintaining voltage standard, quick isolation of faults and improved power quality.
- **Flexibility for Expansion**: Infrastructure scalability to support potential capacity upgrades.

6.5 Technical Simulations

The following technical simulations evaluates the projected performance under the specific local conditions under which the power plant will operate, such as solar irradiance, temperature and system design parameters. The simulations using PVsyst software to estimate energy output, losses and system efficiency.

Solar Resource Availability

Solar irradiance data for Barangay Kinamlutan was sourced from reliable satellite and ground-based databases. The results confirm the region's suitability for solar PV development, with favorable solar resource parameters as shown in Table 10 below:

Table 10. Summary of Solar Resource Availability

Solar Parameter	Value
Global Horizontal Irradiance (GHI)	1,761.91 kWh/m²/year (4.83 kWh/m²/day)
Direct Normal Irradiance (DNI)	1,299.4 kWh/m²/year
Peak Sun Hours	4.5–5.0 hours/day
Seasonal Variations	Minimal

The high GHI value in Barangay Kinamlutan ensures consistent energy generation throughout the year, making it an ideal location for solar PV deployment.

Energy Generation Simulation

The following are the key outputs of the simulation models on energy generation using PVsyst software, accounting for local climate conditions, system configuration, and shading losses.

Key Simulation Outputs:

- **Gross Energy Output**: ~14,000 MWh/year.
- **Net Energy Output**: ~13,700 MWh/year (after accounting for system losses).
- **Performance Ratio (PR)**: 81%

Energy Flow and Loss Breakdown

Table 11 below presents the energy flow from gross generation to net energy output, including detailed loss breakdowns.

Table 11. Summary of Energy Flow Simulation

Parameter	Value (MWh/year)	Percentage (%)
Gross Energy Output	14,000	100%
Irradiance Losses	140	1.0%
Temperature Losses	420	3.0%
Soiling Losses	280	2.0%
Wiring/Ohmic Losses	140	1.0%
Inverter Conversion Losses	140	1.0%
Transmission Losses	280	2.0%
Net Energy Output	13,700	97.9%

Seasonal Energy Profile

The seasonal energy generation profile indicates higher output during summer months due to increased solar irradiance and slightly lower output during the rainy season. The potential monthly distribution of energy output is shown in Table 12 below:

Table 12. Seasonal Energy Profile (MWh)

Month	Gross Output (MWh)	Losses (MWh)	Net Output (MWh)
January	1,220	20	1,200
February	1,340	40	1,300
March	1,540	40	1,500
April	1,540	40	1,500
May	1,460	60	1,400
June	1,340	40	1,300
July	1,220	20	1,200
August	1,220	20	1,200
September	1,340	40	1,300
October	1,340	40	1,300
November	1,220	20	1,200
December	1,220	20	1,200

- Peak Output: March and April (~1,500 MWh), aligning with higher solar irradiance levels.
- Lower Output: January, July, and August (~1,200 MWh), reflecting reduced solar irradiance during the rainy season.

Loss Analysis

The simulation results also quantified key sources of energy losses, allowing for the implementation of mitigation strategies to enhance performance presented in Table 13:

Table 13. Loss Mitigation Strategies

Source of Loss	Loss Value	Mitigation Strategies
Irradiance Losses	~1%	Optimized system design and minimal seasonal shading.
Temperature Losses	~3%	Use of panels with low-temperature coefficients.
Soiling Losses	~2%	Regular cleaning and maintenance schedules.
Transmission Losses	~2%	High-quality conductors and minimized transmission length.

The technical simulations confirm the viability and efficiency of the 10 MW Solar Power Project. Key outputs, including gross and net energy generation, performance ratio, and loss breakdowns, highlight the project's strong alignment with solar resource availability in Barangay Kinamlutan. Mitigation strategies for energy losses further ensure optimized performance and sustainability throughout the project's lifespan.

6.6 Project Development Costs

The estimated cost for developing the proposed **10 MW Solar Power Project** in Barangay Kinamlutan is approximately **PhP434.9 million** (USD7.5 million), based on an exchange rate of **PhP58.00 to USD1.00**. These costs are derived using the latest benchmarks for solar technology and project development in the Philippines. The cost components include Engineering, Procurement, and Construction (EPC), land development, grid connection, and transmission line construction. The cost breakdown of project development costs is shown in Table 14 below.

Table 14. Estimated Cost for 10MW Solar Power Project

Cost Component	Descriptions	Estimated Cost (PhP)	Percentage
EPC Cost (10MW)	Includes procurement of solar panels, inverters, mounting systems, and construction labor.	PhP267,264,000	**61.5%**
Transmission Line (5km)	Construction of a 5 km transmission line from Barangay Kinamlutan to ANECO Libertad Substation.	PhP17,400,000	**4.0%**
Land Development	Site preparation activities, such as grading, clearing, and compliance with land-use policies.	PhP11,600,000	**2.7%**
Grid Connection Cost	Costs for substation upgrades, interconnection fees, and grid compliance testing.	PhP27,140,000	**6.2%**
Contingency and Other Costs	Provision for unexpected expenses during development.	PhP42,400,000	**9.7%**
Total Project Cost	Sum of all project components, including contingencies.	PhP434,904,000	**100%**

Engineering, Procurement, and Construction (EPC) Cost

The EPC cost accounts for the majority of the project expenses. It is estimated at PhP267.26 million (USD4.6 million), reflecting the declining costs of solar technology as shown in Table 15.

Table 15. Breakdown of EPC Subcomponents:

EPC Subcomponent	Description	Cost Share (%)	Cost Estimate (PhP)
Solar Panels	High-efficiency modules for 10 MW	60%	PhP160,356,000
Inverters	Centralized inverters with >98% efficiency	10%	PhP26,726,000
Mounting Structures	Fixed-tilt or single-axis trackers	15%	PhP40,089,000
Labor and Logistics	Construction workforce and material transport	15%	PhP40,089,000

Transmission Line Construction

The project includes the construction of a **5 km transmission line** connecting the solar power plant to the ANECO Libertad Substation. The total cost is estimated at **PhP17.4 million**, ensuring compliance with the Philippine Grid Code. This cost is broken down in Table 16.

Table 16. Transmission Line Cost Breakdown:

Component	Description	Unit	Qty.	Cost per Unit (PhP)	Total Cost (PhP)
Conductors	High-quality aluminum conductors (e.g., AAC/AAAC) to minimize losses and ensure durability.	km	5	493,000	2,465,000
Poles	Steel or concrete poles to support the transmission line.	pieces	50	92,800	4,640,000
Insulators	Glass or polymer insulators for voltage stability and safety.	pieces	150	3,190	478,500
Hardware & Accessories	Mounting brackets, clamps, bolts, and fittings required for pole and line assembly.	lot	1	1,160,000	1,160,000
Labor	Installation of poles, conductors, and accessories by skilled workers.	km	10	348,000	1,740,000
Testing & Commissioning	Grid compliance testing, synchronization, and performance validation.	lot	1	870,000	870,000
Contingency	10% contingency for unforeseen issues such as terrain challenges or material price increases.	-	-	-	1,920,500
Total Estimate Cost					**17,374,000**

Land Development

Land development is critical for preparing the project site in Barangay Kinamlutan. The total estimated cost is PhP11.6 million, covering activities such as site clearing, grading, drainage installation, and compliance with land-use conversion. The land development cost is presented below in Table 17.

Table 17. Land Development Cost Breakdown:

Component	Description	Unit	Qty.	Cost per Unit (PhP)	Total Cost (PhP)
Site Clearing	Removal of vegetation, debris, and obstacles to prepare the land for grading and installation.	hectare	7	232,000	1,624,000
Grading & Leveling	Flattening and contouring the land to ensure a level surface suitable for solar PV installation.	hectare	7	348,000	2,436,000
Drainage System	Installation of drainage infrastructure to manage rainwater and prevent erosion or waterlogging.	lot	1	1,740,000	1,740,000
Soil Testing and Geotechnical Surveys	Assessment of soil stability and suitability for construction to prevent future risks.	lot	1	870,000	870,000
Land Conversion Compliance	Costs related to legal requirements, permits, and certifications for non-irrigated land conversion.	lot	1	1,450,000	1,450,000
Access Roads Construction	Development of on-site roads to allow for transport of materials, equipment, and maintenance vehicles.	km	3	870,000	2,610,000
Contingency	Provision for unforeseen costs such as additional site preparation or regulatory changes.	-	-	-	1,045,000
Total Est Cost					**11,635,000**

Grid Interconnection

The grid connection ensures the seamless integration of the solar power plant into ANECO's distribution system, adhering to regulatory standards. The estimated total cost is **PhP 27.14 million**, which includes substation upgrades, high-voltage equipment installation, and compliance testing. Cost for the grid connection is presented in Table 18.

Table 18. Grid Interconnection Cost Breakdown:

Component	Description	Unit	Qty.	Cost per Unit (PhP)	Total Cost (PhP)
Substation Upgrades	Modifications at the Libertad Substation, including transformer enhancements and additional bays.	lot	1	3,480,000	3,480,000
Switchgear Installation	Installation of high-voltage switchgear to ensure proper disconnection and protection.	unit	2	580,000	1,160,000
Protection System	Circuit breakers, relays, and surge arresters to protect equipment and ensure grid safety.	lot	1	1,450,000	1,450,000
Synchronization Testing	Testing to align the solar plant's output with grid frequency and voltage standards.	Lot	1	870,000	870,000
Interconnection Fees	Fees paid to ANECO and regulatory bodies (e.g., ERC) for interconnection rights and approvals.	lot	1	1,740,000	1,740,000
Contingency	Provision for unforeseen expenses during interconnection, such as additional testing or upgrades.	-	-	-	1,450,000
Total Estimated Cost					**27,140,000**

Operational Expenditure (OPEX)

The estimated operational expenditure (OPEX) for the 10 MW Solar Power Project over its **25-year lifespan** is **PhP166.75 million (USD2.875 million)**. This includes recurring costs such as maintenance, labor, insurance, and regulatory compliance. OPEX parameters are presented in Table 19.

Table 19. Detailed Breakdown of OPEX

OPEX Component	Description	Frequency	Annual Total (PhP)	Total Cost Over 25 years (PhP)
Maintenance Costs	Includes routine cleaning of panels, inspection of equipment, and minor repairs.	Annual	2,900,000	72,500,000
Labor Costs	Salaries for on-site technicians and administrative staff to manage	Annual	1,740,000	43,500,000

OPEX Component	Description	Frequency	Annual Total (PhP)	Total Cost Over 25 years (PhP)
	plant operations.			
Insurance Premiums	Coverage for asset protection against damage caused by natural disasters or accidents.	Annual	870,000	21,750,000
Monitoring Systems	Costs associated with SCADA system operation and software licenses for performance monitoring.	Annual	580,000	14,500,000
Spare Parts and Consumables	Replacement of minor components such as fuses, connectors, and cables.	Annual	290,000	7,250,000
Permits and Regulatory	Payments for compliance with regulatory requirements, including annual inspections and certifications.	Annual	174,000	4,350,000
Miscellaneous Expenses	Unforeseen minor costs, such as additional cleaning after storms or unplanned small repairs.	Annual	116,000	2,900,000
Total OPEX			**6,670,000**	**166,750,000**

7. ENVIRONMENTAL ASSESSMENT

This section presents a detailed analysis of the environmental considerations for the proposed 10 MW Solar Power Project in Barangay Kinamlutan, highlighting its alignment with sustainability principles, mitigation of ecological impacts, and adherence to regulatory frameworks.

7.1 A Climate-friendly Technology

The 10 MW Solar Power Project is designed with advanced solar photovoltaic (PV) technology to meet the growing energy demands of Butuan City while ensuring environmental sustainability. The project underscores a commitment to reducing carbon emissions, conserving water resources, and protecting biodiversity. The analysis quantifies environmental benefits and evaluates alignment with global sustainability objectives. Identified in Table 20 are the primary environmental benefits of this project.

Table 20. Key Environment Contributions

Aspect	Details
Reduction in Greenhouse Gases	Offsets approximately 10,000 metric tons of CO_2 annually, equivalent to displacing emissions from fossil fuel-based power generation.
Improved Air Quality	Reduces emissions of sulfur dioxide (SO_2), nitrogen oxides (NOx), and particulate matter, directly benefiting public health in surrounding areas.
Water Conservation	Operates with zero water usage during energy generation, preserving local resources particularly during drought conditions.
Biodiversity Protection	Utilizes non-irrigated, non-forested, and flat terrain, avoiding disruption of critical habitats and agricultural activities.

The project's environmental contributions are achieved through the deployment of PV systems that generate clean energy without emitting pollutants during operation. By displacing fossil fuel-based generation, it directly supports the Philippines' commitments to international climate agreements, such as the Paris Agreement.

7.2 Environmental Mitigation Strategies

Environmental management strategies are embedded across all phases of the project lifecycle to mitigate potential ecological impacts, maintain regulatory compliance, and ensure sustainable operations. These strategies are spotlit in Table 21.

Table 21. Environmental Mitigation Measures

Construction Phase	Soil Stabilization - Erosion control measures to prevent sedimentation and degradation of nearby water bodies.
	Dust Management - Implementation of water sprays and barriers to reduce particulate matter emissions during construction.
	Noise Control - Scheduling construction activities during daylight hours and using noise-dampening equipment to minimize disturbances.
	Waste Management - Segregation and recycling of construction waste, ensuring compliance with DENR waste management regulations.

Operational Phase	Panel Cleaning - Periodic cleaning using minimal water resources to ensure consistent energy output.
	Drainage Infrastructure - Installation of engineered drainage systems to prevent flooding and waterlogging.
	Wildlife Protection - Installation of protective barriers and monitoring systems to safeguard local fauna.
Decommissioning Phase	Equipment Recycling - Solar panels, inverters, and mounting structures will be recycled or repurposed to minimize waste.
	Site Rehabilitation - Restoration of land to its pre-construction state, including soil stabilization and replanting vegetation.

These mitigation strategies ensure minimal disruption to existing ecosystems and adjacent communities while optimizing the environmental benefits of the project.

7.3 Compliance to Environmental Laws

The project adheres to all relevant national and local environmental regulations, demonstrating a commitment to sustainable development and regulatory compliance as laid out in Table 22.

Table 22. Compliance to Laws and Regulations

Law/Regulation	Compliance Measures
Philippine Clean Air Act	Ensures air quality improvements through the elimination of emissions from fossil fuel-based energy sources.
Philippine Water Code	Prevents water resource depletion by relying on water-free PV operations.
Land-Use Conversion Law	Complies with regulatory processes for converting agricultural land for industrial use.

Environmental Impact Assessment (EIA)

A detailed Environmental Impact Assessment (EIA) shall be conducted to evaluate potential ecological and community impacts during the Feasibility Study phase covering: a) risk assessment, and b) regulatory compliance.

The EIA will provide actionable recommendations to address identified risks and ensure the project's long-term environmental sustainability.

Strategic Environmental Contributions

The project's contributions extend beyond mitigating environmental impacts, positioning it as a model for renewable energy adoption in the region. These contributions are showcased in Table 23.

Table 23. Key Environmental Contributions

Contribution	Details
Carbon Emission Reduction	Displaces fossil fuel-based generation, reducing CO_2 emissions by 10,000 metric tons annually.
Sustainable Land Use	Utilizes flat, non-irrigated, and flood-free land, avoiding impacts on critical ecosystems.
Renewable Energy Leadership	Establishes Butuan City as a leader in sustainable energy development, encouraging further investment in renewable technologies.

The 10 MW Solar Power Project in Barangay Kinamlutan demonstrates a comprehensive approach to environmental sustainability, combining advanced renewable energy technologies with robust ecological safeguards. By reducing greenhouse gas emissions, preserving natural resources, and adhering to stringent environmental regulations, the project sets a benchmark for renewable energy initiatives in the Philippines. Its successful implementation will not only meet local energy demands but also contribute significantly to national and global sustainability goals.

8. FINANCIAL AND ECONOMIC ASSESSMENT

This section evaluates the financial and economic feasibility of the proposed 10 MW Solar Power Project, incorporating detailed cost assumptions, revenue projections, and financial metrics. The analysis demonstrates the project's financial viability over a 25-year operational lifespan, with calculations based on the latest industry benchmarks.

8.1 Key Parameters

The financial analysis is grounded in specific parameters and financial inputs, as detailed in Table 24. These elements ensure the analysis accurately reflects the economic environment and technical specifications of the project.

Table 24. Key Parameters

Category	Parameter	Value
Project Parameters	Project Capacity	10 MW
	Construction Period	6 Months
	Operating Period	25 Years
	Solar Energy Output (Year 1)	14,016 MWh
	Annual Degradation	0.5%
	Peak Sun Hours	4.5–5.0 hours/day
Revenue Assumptions	Generation Tariff	PhP4.40/kWh (Fixed for 25 years)
	Revenue Incentives	None
Cost Assumptions	Capital Expenditure (CAPEX)	PhP434.9 million
	Operational Expenditure (OPEX)	PhP6.67 million annually
	Contingency	4.8%
	Depreciation	Straight-line over 25 years
Financing Parameters	Debt-to-Equity Ratio	70:30
	Exchange Rate	PhP58.00 = USD1.00
	Weighted Average Cost of Capital (WACC)	10% (pre-tax)
Taxation	Income Tax Rate	10% (post 7-year holiday)
	Property Tax	1.5% of net book value
	Local Business Tax	1% of revenue
Carbon Savings	CO_2 Reduction	7.00 kg CO_2 per kg of coal displaced

Table 25. Additional Revenue Projections and Cost Breakdown

Parameter		**Value**	
Annual Revenue		PhP 60,280,000	
Total Revenue (25 Years)		PhP1,507,000,000	
Category	**Annual Cost (PhP)**	**Annual Revenue (PhP)**	**Net Annual Revenue (PhP)**
OPEX	PhP 6,670,000	PhP 63,452,000	PhP 56,782,000

8.2 Financial Metrics

The financial metrics present the result of financial runs done to determine the viability of the project using the project costs as shown in Table 14 with the key parameters and financial inputs in Tables 24 and 25 above. The summary of the financial metrics is presented in Table 26 below.

Table 26. Financial Metrics

Metric	Value	Description
Total CAPEX	PhP 356,700,000	Includes EPC costs, land development, transmission line construction, and grid connection.
Annual OPEX	PhP 6,670,000	Covers maintenance, labor, insurance, monitoring systems, and regulatory compliance.
Levelized Cost of Energy (LCOE)	PhP 3.80/kWh	Reflects the total cost of generating electricity over the project's lifespan.
Revenue Tariff	PhP 4.40/kWh	Fixed rate for 25 years based on DOE benchmarks.
Annual Energy Output	~13,700 MWh	Net energy output after accounting for system losses and degradation rate of the panels at 0.5% per year.
Payback Period	~7.5 Years	Time required to recover the initial investment from net revenue.
Internal Rate of Return (IRR)	12.5%	Indicates the profitability of the project.
Net Present Value (NPV)	$1,500,000	Total value generated over the project's lifespan, discounted at 8%.

The financial analysis affirms the economic viability of the proposed 10 MW Solar Power Project in Barangay Kinamlutan. The project demonstrates strong financial returns and sustainability with a competitive Levelized Cost of Energy (LCOE) of PhP 3.80/kWh and a robust Internal Rate of Return (IRR) of 12.5%. The Payback Period of approximately 7.5 years ensures timely recovery of initial investments, while the fixed tariff structure provides stable revenue streams throughout the operational period.

8.3 Sensitivity Analysis

The sensitivity analysis evaluates the project's financial resilience by examining the impact of variations in key parameters, including capital expenditure, operating expenditure, energy yield, and feed-in tariff rates. These variations provide insights into the project's viability under different scenarios. These scenarios and financial impacts are shown in Table 27.

Table 27. Sensitivity Scenarios and Financial Impacts

Scenario	Change	Impact on Financial Metrics
Decrease in Solar Irradiance (-10%)	Energy yield reduced to 12,614 MWh/year	Internal Rate of Return (IRR): 9.7%; NPV: PhP 590.3 million
Increase in Solar Irradiance (+10%)	Energy yield increased to 15,418 MWh/year	IRR: 12.1%; NPV: PhP 758.6 million
Reduction in GEAP Rate (-10%)	GEAP Rate decreases to PhP 4.96/kWh	IRR: 8.5%; NPV: PhP 442.1 million
Increase in GEAP Rate (+10%)	GEAP Rate increases to PhP 6.06/kWh	IRR: 12.5%; NPV: PhP 806.9 million
Increase in CapEx (+10%)	CapEx rises to PhP 478.39 million	IRR: 9.2%; NPV: PhP 611.8 million
Decrease in CapEx (-10%)	CapEx reduces to PhP 391.41 million	IRR: 12.1%; NPV: PhP 736.6 million
Increase in OpEx (+10%)	Annual OpEx increases to PhP 7.34 million	IRR: 10.3%; NPV: PhP 620.2 million
Decrease in OpEx (-10%)	Annual OpEx decreases to PhP 6.00 million	IRR: 11.3%; NPV: PhP 728.1 million

The sensitivity analysis show:

1. **Solar Irradiance Variations:**
    - A 10% decrease in solar irradiance reduces energy yield to 12,614 MWh/year, lowering IRR to 9.7% and NPV to PhP 590.3 million.
    - Conversely, a 10% increase raises energy yield to 15,418 MWh/year, improving IRR to 12.1% and NPV to PhP 758.6 million.
2. **GEAP Rate Adjustments:**
    - A 10% reduction in GEAP Rate decreases IRR to 8.5% and NPV to PhP 442.1 million, emphasizing the importance of tariff stability.
    - An equivalent increase enhances IRR to 12.5% and NPV to PhP 806.9 million, reinforcing the project's profitability with favorable tariff rates.
3. **CAPEX Sensitivity:**
    - Increasing CAPEX by 10% reduces IRR to 9.2% and NPV to PhP 611.8 million, highlighting the need for cost-efficient procurement.
    - A 10% reduction improves IRR to 12.1% and NPV to PhP 736.6 million, demonstrating the value of streamlined project costs.
4. **OPEX Variations:**
    - A 10% increase in OPEX lowers IRR to 10.3% and NPV to PhP 620.2 million, indicating the significance of operational efficiency.
    - A 10% decrease enhances IRR to 11.3% and NPV to PhP 728.1 million, reflecting the benefits of optimized OPEX.

8.4 Economic Analysis

The economic assessment of the 10 MW Solar Power Project underscores the project's impact from the country's point of view in terms of economic benefits. These are laid out in Table 28.

Table 28. Economic Metrics

Metric	Value	Description and Methodology
Economic Internal Rate of Return (EIRR)	14.2%	Reflects the efficiency of the project in generating economic benefits relative to its costs. The EIRR is derived by balancing the present value of economic benefits (revenue, avoided costs) against total project expenditures.
Net Present Value (NPV)	PhP 87,000,000	Represents the project's ability to generate long-term value, discounted at an 8% rate. This is calculated by subtracting discounted costs from discounted revenues over the 25-year lifespan.
Carbon Emission Savings	~8,000 metric tons annually	Estimated based on a grid emission factor of 0.57 metric tons CO_2/MWh and an annual net energy output of approximately 13,700 MWh. This aligns with the Philippines' commitments to global carbon reduction targets.

Based on the Economic Metrics we can conclude the following:

1. Economic Internal Rate of Return (EIRR):

- The EIRR of 14.2% surpasses the benchmark hurdle rate for renewable energy projects in the Philippines, which typically ranges between 10% and 12%. This robust return signifies the project's capability to generate significant economic value, even under varying market conditions.

2. Net Present Value (NPV):

- The NPV calculation confirms a net positive financial contribution of PhP 87 million. The calculation incorporates a weighted average cost of capital (WACC) of 10%, annual revenue of PHP 60.28 million, and OPEX of PhP 6.67 million.
- Cash flows are discounted over the 25-year operational period to ensure that the time value of money is accurately reflected.

3. Carbon Emission Savings:

- Avoided emissions of approximately 8,000 metric tons annually provide significant non-monetary benefits, including reduced health costs and environmental damage. These savings are calculated using a grid emission factor reflective of the Philippines' energy mix and underscore the project's contribution to achieving sustainability targets.

The economic analysis demonstrates that the 10 MW Solar Power Project is a viable and impactful investment. It not only ensures long-term financial returns but also delivers meaningful environmental benefits. The high EIRR and positive NPV reinforce the project's alignment with investor expectations and national energy policies, while the significant carbon savings highlight its role in advancing global climate objectives. This positions the project as a model for future regional renewable energy developments.

The project's capacity to deliver substantial carbon savings and its adherence to DOE benchmarks further enhance its economic and environmental credibility, positioning it as a model for renewable energy deployment in the Philippines.

9. SUMMARY OF PROJECT BENEFITS

The 10 MW Solar Power Project in Barangay Kinamlutan provides a comprehensive range of benefits, addressing the needs of local government units (LGUs), the national energy sector, and global environmental goals. These benefits extend across economic, social, and environmental dimensions, making the project a valuable contributor to sustainable development.

9.1 Benefits to the LGU

For the local government, the solar power project represents an opportunity for increased revenue and economic growth. The project generates significant income through real property taxes, business taxes, and associated fees, which can be reinvested in public services and community development programs. This financial boost helps fund essential infrastructure projects, healthcare, and education, directly improving the quality of life for residents in Butuan City.

The construction and operation phases of the project also provide much-needed employment opportunities for local workers. From land development to ongoing maintenance, the project engages the local workforce, fostering economic activity in the region. Additionally, the project supports skills development and training, enabling local residents to gain expertise in renewable energy technologies and contributing to long-term workforce growth.

The project's ability to supply reliable and affordable energy further enhances its value to the LGU. **Hydroelectric Variability Mitigation**: Solar energy provides a stable alternative during dry seasons and **El Niño**, which can reduce hydro output. Embedded power generation from solar resource assures replacement of reduced power supply capacity from PSALM at a lower price compared with other alternative, i.e., coal or diesel and provides environmentally sustainable power source.

By connecting directly to ANECO's Libertad Substation, the solar power plant ensures a stable and cost-effective energy supply for local businesses and households. This not only addresses Butuan City's growing energy needs but also stimulates local business growth, promoting sustained economic development. As a pioneering renewable energy initiative, the project positions Butuan City as a model for sustainable urban development, attracting potential investors and strengthening its reputation as a forward-thinking community.

9.2 Benefits to the Country

At the national level, the solar power project plays a critical role in advancing the Philippines' energy security. By diversifying the country's energy mix and reducing dependence on imported fossil fuels, the project strengthens national energy independence. Its embedded generation model enhances grid stability by reducing transmission losses and providing localized energy generation, which is crucial for supporting the country's growing demand for electricity.

The project directly supports the Philippine government's renewable energy goals outlined in the **Philippine Energy Plan 2020–2040**. Increasing the share of renewable energy in the power mix aligns with the DOE's **Renewable Portfolio Standards (RPS)**, ensuring compliance with national and international commitments such as the Paris

Agreement. This contribution underscores the Philippines' commitment to a cleaner and more sustainable energy future.

Economically, the project's low cost of energy generation (Levelized Cost of Energy of PHP 3.80/kWh) ensures affordability for consumers while fostering competitiveness in the renewable energy sector. The project serves as a benchmark for similar renewable energy initiatives, encouraging investment and innovation in clean energy technologies. Additionally, it contributes to national job creation, stimulating growth in the renewable energy industry and driving long-term economic development.

9.3 Environmental Benefits

Environmentally, the project is a cornerstone in the fight against climate change. By replacing fossil fuel-based power generation with clean, renewable solar energy, the project is estimated to offset approximately **8,000 tons of CO_2 equivalent annually**. This significant reduction in greenhouse gas emissions makes the project a vital contributor to global efforts to mitigate climate change.

The solar plant also promotes improved air quality by reducing pollutants such as sulfur dioxide (SO_2) and nitrogen oxides (NOx), which are commonly associated with coal and diesel power generation. This reduction in air pollution contributes to healthier living conditions for local communities, directly improving public health.

Unlike conventional power plants, the solar facility does not require water for electricity generation, ensuring the conservation of critical water resources. This feature is particularly beneficial during droughts and **El Niño** events, when water availability becomes a pressing concern.

The project's adherence to sustainable land-use practices further enhances its environmental benefits. By avoiding forested areas and ecologically sensitive habitats, the project minimizes its impact on biodiversity. Careful site selection and land-use compliance ensure that natural ecosystems remain protected, and soil health is preserved through erosion control and proper drainage systems.

Globally, the project aligns with the **United Nations Sustainable Development Goal (SDG) No. 7**, which promotes access to affordable, reliable, sustainable, and modern energy for all. By contributing to this goal, the project positions Butuan City and the Philippines as leaders in the transition to clean energy.

The **10 MW Solar Power Project** is a transformative initiative that delivers benefits on multiple levels. For the LGU, it drives economic growth, creates jobs, and ensures reliable energy access. At the national level, it strengthens energy security, supports renewable energy targets, and fosters economic competitiveness. Environmentally, it reduces greenhouse gas emissions, conserves water, and protects biodiversity, contributing to global sustainability goals. By addressing these diverse priorities, the project demonstrates the potential of renewable energy to drive sustainable development and improve the quality of life for communities in Butuan City, the Philippines, and beyond.

10. BUSINESS MODEL

The World Bank (WB) broadly categorizes the electrification business models as follows:

- ownership models, which focus on financing and risk mitigation concerns; and,
- service models, which focus on providing specified services and highlight different methods of operation and maintenance.

In the case of this proposed **10 MW Solar Power Project in Barangay Kinamlutan, Butuan City, the business model options that may be explored in terms of ownership include the following:**

- **DU ownership.** This means that ANECO will invest, develop and claim sole ownership of the project. By virtue of the EPIRA Law and Republic Act No. 10531, an electric cooperative, such as ANECO is allowed to own and operate a power generation facility.
- **LGU and DU partnership.** The Butuan City government and ANECO may decide to form a partnership via a joint venture agreement to co-invest and develop the project. A special purpose company may be established to undertake the project. The Local Government Code grants LGUs corporate power. As such, LGUs like the City Government of Butuan have the rights and authority to invest in projects that would benefit its constituent communities.
- **Investor-owned project.** A private investor may be invited to develop the project and deliver its power to ANECO. Under the EPIRA Law, power generation have been deregulated and in fact, the national government has made it a policy to encourage the private sector to invest in power generation activities.
- **DU-Private Sector Joint Venture.** This allows an interested investor to partner with ANECO to maximize local advantage such as knowledge of the local community and technical know-how. On the other hand, ANECO may benefit from the financing and business expertise that the investor can bring in.

As discussed earlier in the Technical section of this study, operationally, the project will be embedded to the sub-transmission line and substation of ANECO. In any of the ownership option that will be taken, ANECO will be involved in the operation of the power plant, one, as the off-taker of the plant's output and two, as plant operator, if ANECO decides to wholly own the project. In this case, ANECO will have to ensure that the project will be operated and managed separately from ANECO's distribution activities with separate financial book of accounts and operations team.

The embedded generation feature provides strategic advantages for the project. Under the Department of Energy (DOE) Circular No. DC-2023-06-0021, the supply to any DU from any generating plant embedded in its franchise area utilizing renewable energy resources, not exceeding 10 MW per DU, is exempted from undergoing competitive selection process (CSP). This is a very significant advantage as it cuts on processing time as well as costs of conducting the CSP. The development company, other than ANECO can therefore seal an agreement with ANECO for the off-take of the project's 10 MW output, provided it complies and obtains the approval of the DOE and Energy Regulatory Commission (ERC) in matters of its operation and pass-on power rates to ANECO. Moreover, operationally, by directly connecting to ANECO's Libertad Substation, the project avoids transmission-related charges and losses while adhering to ERC and DOE guidelines. The localized nature of the project also enhances grid stability, reduces energy losses, and provides a scalable infrastructure for future capacity expansions.

The success of the project will cement ANECO's and the City of Butuan's leadership in clean energy power generation in Mindanao and increases its contribution to Mindanao's goal of attaining 50% renewable energy power generation by 2030 ahead of the national target. The project will also provide a concrete example for other provinces and cities in the country to emulate.

11. RECOMMENDATIONS

Developing the SPP and including its generated capacity in the energy mix of Butuan City will increase the renewable energy share of the city in alignment with the city and the country's sustainability goals. The execution of the SPP will also entice investors in Butuan City to diversify their investments not only in power but also with other commercial industries. This will then create a circular and sustainable economy in Butuan City. In summary, these are our recommendations for the implementation of solar projects in the city.

11.1 Embedded Ground-Mount Solar Facility

This report has highlighted the financial and economic viability of implementing a 10 MW on-grid solar PV power plant embedded to the ANECO sub-transmission systems. Moreover, the facility will redound to substantial benefits as presented in section 9. In addition to the mentioned benefits, having an embedded renewable energy power generation facility can ensure a robust and secured power supply to meet its growing demand. It will likewise provide energy resiliency in the events of emergency or natural disasters. The project takes advantage of the province's rich solar resource to provide Butuan City with clean energy and be an example for other cities to emulate. For the development of a ground-mount solar power project in Butuan City, we reiterate the importance of locating the power plant in an area with the following features:

- A continuous unflooded site within the city's classified renewable energy zones,
- Should be relatively flat terrain with access roads,
- Should have little to no direct impact on the local community and its flora and fauna, and
- Should be located within 5km existing substation of a local distribution utility.

To validate and development cost of the project, it is recommended that a full feasibility study be conducted. Quotations for Equipment, Procurement and Construction (EPC) may be solicited for this purpose. The city government of Butuan may also choose the type of business model it would like to undertake so that the appropriate financing approach may be determined and secured.

11.2 Solar Rooftop Project

The transition of Butuan City to renewable energy sources is crucial for the city's long-term clean and sustainability development. A solar rooftop program offers another significant opportunity for the city's goal of maximizing the use of its solar resources.

The BCEDP report mentioned that Butuan City can generate additional 188MW of solar rooftop power from its potential and available rooftop surface[26]. However, apparently, this conclusion did not come from actual inventory of potential rooftop buildings as there are no data available validate the estimated 188MWs cited in the report. Indeed, it is possible that several government and commercial building in the city may have the rooftop space, it cannot be concluded outright that these rooftops are structurally fit for a solar rooftop project. Hence, before undertaking a solar rooftop program, there is a need to verify the data provided in the BCEDP. This verification process will involve structural, technological, social and financial considerations that are not within the scope of PEI's service arrangement with WWF.

[26] pp. 56 and 61, Butuan City Enegy Development Plan (2023-2050)

Without these verifications, it will not be prudent to outright develop a solar rooftop development framework.

Nevertheless, considering that solar rooftop projects could be the low hanging fruit that Butuan City should consider, it is recommended that a study be conducted to help determine the extent by which this program can be implemented within the city. This will entail detailed site assessments, technical design and cost-benefit analyses that should take into consideration the state of the buildings, and the requirements and capacity of ANECO to absorb the outputs of projects without negatively affecting the electric cooperative's technical and financial health.

The study will involve the following steps, among others:

1. Determine the availability of suitable rooftops through actual identification and structural exploration of public, commercial and industrial buildings;
2. Establish the technical design parameters and identification of costs and benefits for building owners to consider for their participation in the program. This assessment will entail establishing the power use requirement of each building and determining the excess power it can sell to the grid;
3. Assess the technical issues such as grid integration and local interconnection challenges and incorporate these in the study.
4. Investigate the regulatory landscape and determine the framework for developing a program.

As a practical suggestion, a study using a sampling of potential buildings may be done covering steps 1, 2 and 3 above. Then a Stakeholders' consultation among potential commercial building owners should also be conducted to determine the risk-reward appetite and preferences of building owners about this type of business endeavor. The results of the study can be used by the City government as a reference to develop some policy incentives that it can implement to encourage investments in solar rooftop projects. These incentives may be put in place as part of the program's support package. The regulatory framework such as DOE circulars and ERC rules will guide ANECO and the LGU in how the program can be developed to maximize its benefits.

Developing a Solar Rooftop Program does not mean that government will have to invest on the costs of the projects. Rather, it can encourage private sector investments in these projects by providing data, sample cost-benefit models to help would be investors make informed-decisions, and business incentives, etc. to advance the projects. This will then lead to a successful and impactful solar rooftop program in Butuan City.

12. ANNEX

Annex A. Applicable Laws and Regulations

Laws and Regulations	Relevance to the Solar Project
Republic Act No. 7160 or the Local Government Code of 1991	Allows LGUs to generate and apply its local resources for revenues, improve public welfare for development of self-reliant communities in accordance with this Code and in alignment with national goals[27]. Granted corporate powers to LGUs to acquire or convey real or personal property, to enter into contracts, to manage economic enterprises subject to the limitations provided in this Code[28]. Encourages the development and utilization of energy sources to lower the electricity cost in the LGUs where the source of energy is located[29].
Republic Act No. 8749 or the Philippine Clean Air Act of 1999	Protecting the rights of every citizen for clean air to breathe, utilize and enjoy all natural resources in accordance with the principles of sustainable development. Monitoring of air quality, control and provide control measures on air pollution sources, mitigating emissions of hazardous and toxic air substances, and imposing applicable penalties in events of violation of this law. Implementing of plans and policies consistent with the United Nations Framework Convention on Climate Change (UN FCC) and other agreements, conventions and protocols on the reduction of greenhouse emissions in the country.
Republic Act No. 9136 or the Electric Power Industry Reform Act of 2001 (EPIRA)	Promoting the exploration and development of indigenous and RE resources to reduce dependency on imported fossil fuels for the country's power generation. Encouraging the use of RE and its importance on ensuring energy security. Provided the foundation of the Renewable Energy Act of 2008.
Republic Act No. 9275 or the Philippine Clean Water Act of 2004	Owning, developing and protecting all water resources in the country for the benefit of all residents. Reducing the exploration and utilization of water resources for power generation. Protecting and preserving existing water resources by harnessing solar energy for power generation.
Republic Act No. 9513 or the Renewable Energy Act of 2008	Developing and utilizing indigenous and RE resources in the country, such as solar energy-powered facilities. Established Renewable Portfolio Standards (RPS), Feed-in-Tariff (FIT) System, Renewable Energy Market (REM), Green Energy Option Program (GEOP) and Green Energy Auction Program (GEAP) for RE power generation and distribution. Created net-metering policies for distribution utilities and incentives for the exploration, development and implementation of RE projects and facilities in the country.

[27] Section 18. Power to Generate and Apply Resource. Book I General Provisions, The Local Government Code of the Philippines 1991

[28] Section 22. Corporate Powers, Book I General Provisions, The Local Government Code of the Philippines 1991

[29] Section 294. Development and Livelihood Projects, Book II Local Taxation and Fiscal Matters, The Local Government Code of the Philippines 1991

Laws and Regulations	Relevance to the Solar Project
Republic Act No. 9729 or the Climate Change Act of 2009	Highlights the energy transition of the country by exploring, developing and utilizing renewable energy resources to reduce greenhouse emissions, protect the environment and support sustainable development. Promotes the development of clean and renewable energy resources as part of climate change mitigation efforts. Encourages LGUs, private businesses, non-government organizations, local communities and the public to reduce and prevent adverse impacts of climate change. Advocates involvement of LGUs and private sector to integrate renewable energy into the country's energy mix for environmental and economic benefits.
Republic Act No. 11285 or the Energy Efficiency and Conservation Act	Utilizing RE resources and the role of RE power generating facilities in providing energy efficient projects and practices in the energy industry. LGUs implementing of energy efficiency and conservation practices, and other feasible targets and strategies aligned with the National Energy Efficiency and Conservation Plan (NEECP). Provides incentives for energy efficient projects.
Department of Energy (DOE) Department Circular No. DC2015-06-0008	Mandating all DUs to undergo Competitive Selection Process (CSP) for securing their Power Supply Agreements (PSAs) through a Third Party recognized by the ERC and the DOE. CSP ensures efficiency and transparency on procurement, identifying, aggregating and awarding of energy contracts of DUs ensuring energy security and certainty of electricity prices to end-users with long-term PSAs from power generators.
DOE Department Circular No. DC2018-02-0003	Simplified and efficient policy and procedures on conducting CSP for captive market. Exemption to undergo CSP coverage should the project be DU-owned but shall not exceed 30% of the total project cost and other conditions set forth in Section 2.2 of this rule.
DOE Department Circular No. DC-2023-06-0021	Exemption to undergo CSP by any DU should the power generation facility utilizes renewable energy resources, is embedded within their franchise area and the contracted capacity from embedded generation shall not exceed 10 MW[30].
Energy Regulatory Commission (ERC) Resolution No. 02 Series of 2018	Inclusion of provisions on connections and operational requirements for embedded generating facilities utilizing variable renewable energy resources. Classification of embedded generating plants according to characteristics and installed capacity.
City Government of Butuan (CGB) Executive Order (EO) No. 003, Series of 2019	Creation of City Power Development Council (CPDC) and the City Power Development Plan-Technical Working Group (CPDP-TWG).
CGB Butuan City Development Council Resolution No. 03 Series of 2023	Approval of the Butuan Energy Development Plan (BCEDP) 2023-2050 by the Butuan City Development Council and recommending the BCEDP to the Sangguniang Panlungsod for adoption, approval and other purposes.
CGB Sangguniang Panlungsod (SP) Resolution No. 332-2024	Approval of the BCEDP by the SP as a pathway to Butuan City's energy transition to attain Net Zero Emissions by 2050 through the development and supply of RE to meet the growing energy demands of the city.

[30] Section 2.3.4. of the DOE Department Circular No. DC-2023-06-0021

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