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Distribution Utility-Owned Embedded 5MW AC Solar Power: A Feasibility Study

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ABSTRACT: Solar energy creates clean, renewable power from the sun and benefits the environment. Alternatives to fossil fuels reduce carbon footprint and greenhouse gases around the globe. Distribution system is a process by which electricity is transformed for the utilization of consumers. PELCO 1 conducted a Pre-Feasibility Study to determine and analyze the most viable Renewable Energy (RE) Technology to be developed in the franchise area, which resulted in the proposed development of an embedded 5MW AC solar power plant, and for the purpose of the application for Solar Energy Service Contract with the DOE. It will help, among others, in addressing the: (a) anticipated additional power demand, (b) reduction of the cost of power for the benefits of member-consumers, (c) further improvement of the technical and financial performance of PELCO I in compliance with the Performance Standards for Distribution Utilities set forth in the Philippine Distribution Code 2017 Edition (PDC); and (d) support on priority agenda of NEA and DOE consistent with the marching order of President Rodrigo R. Duterte of reducing the country's dependence on fossil fuel.

KEYWORDS: Solar Energy, Distribution System, Electricity, Renewable Energy (RE) Technology, Development, Financial Performance

INTRODUCTION

1.1 Background

The PAMPANGA 1 ELECTRIC COOPERATIVE, INC. (PELCO 1) is an Electric Cooperative duly organized, incorporated, and registered pursuant to PD No. 269, as amended by PD No. 1645 and further amended by RA 10531. It is a Distribution Utility that caters to electric service to the Member-Consumer-Owners (MCOs) in the Municipalities of Arayat, Candaba, Magalang, Mexico, San Luis, and Sta. Ana, all in the province of Pampanga.

As of March 2021, the franchise area of PELCO 1 has a total of 110,028 MCOs composed of 103,033 Residences, 6,239 Commercial Establishments, 1,450 Public Buildings, 217 Street Lights, 58 Commercial High-Voltage Facilities, 10 Industrial High-Voltage Facilities, 9 Irrigation Facilities, 5 Industrial Establishments, 1 Irrigation High-Voltage Facility, 1 Industrial Special High-Voltage 1 Facility, 1 Industrial Special High-Voltage 2 Facility and 4 Public Buildings High-Voltage Facilities.

PELCO I, a **Hall of Fame Mega Diamond** electric cooperative, is serving more than 103,000 Member-Consumer-Owners (MCOs) from six (6) Municipalities covering 112 Barangays. These Barangays are 100% energized.

PELCO I is a **Mega-Large electric cooperative** categorized by NEA as Triple-A for its exemplary performance since 2007. It has more than 39 years of experience in electricity distribution service. It has provided the least-cost, most efficient, and most reliable electricity supply to its MCOs.

PELCO 1 conducted a Pre-Feasibility Study to determine and analyze the most viable Renewable Energy (RE) Technology to be developed in the franchise area, which resulted in the proposed development of an embedded 5MW solar plant, and for the purpose of the application for Solar Energy Service Contract with the DOE, it shall be named **5MW PELCO I-Owned Embedded Escaler Solar Power Plant**.

Thus, the Pre-Feasibility Study conducted by PELCO 1 will help, among others, in addressing the: (a) anticipated additional power demand, (b) reduction of the cost of power for the benefits of member-consumers, (c) further improvement of the technical and financial performance of PELCO I in compliance with the Performance Standards for Distribution Utilities set forth in the Philippine Distribution Code 2017 Edition (PDC); and (d) support on priority agenda of NEA and DOE consistent with the marching order of President Rodrigo R. Duterte of reducing the country's dependence on fossil fuel.

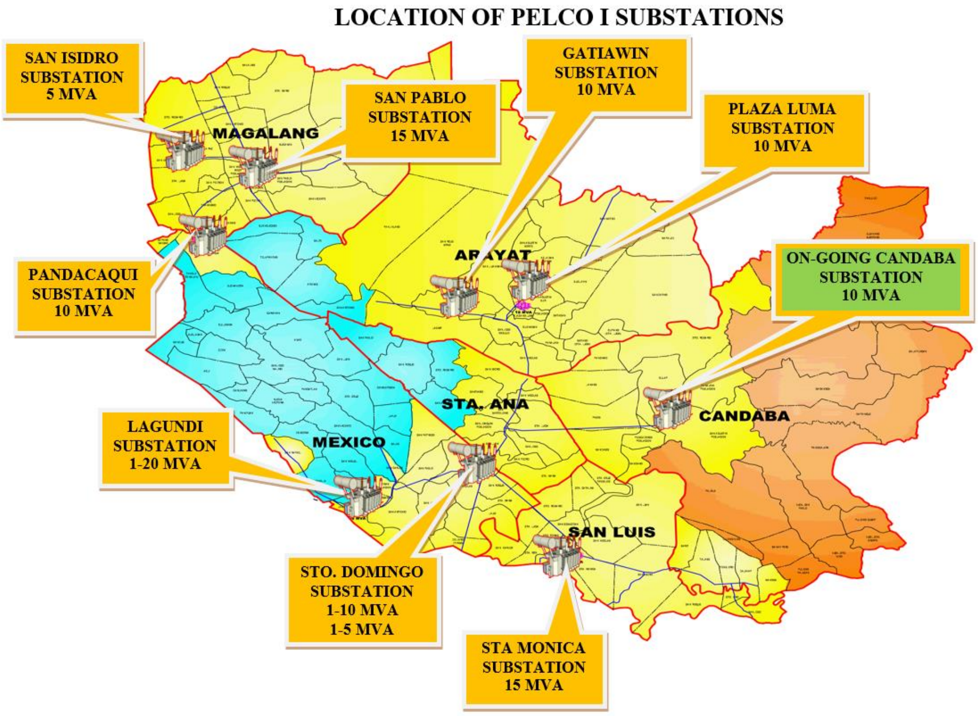


Figure 1.1.1 Coverage Area and System Map

Electricity is delivered to PELCO 1 from Masinloc Power Partners Co., Ltd (MPPCL), whose power plant is located in Masinloc, Zambales, by the National Grid Corporation of the Philippines (NGCP) through its facility located at Barangay San Jose Matulid, Mexico, Pampanga

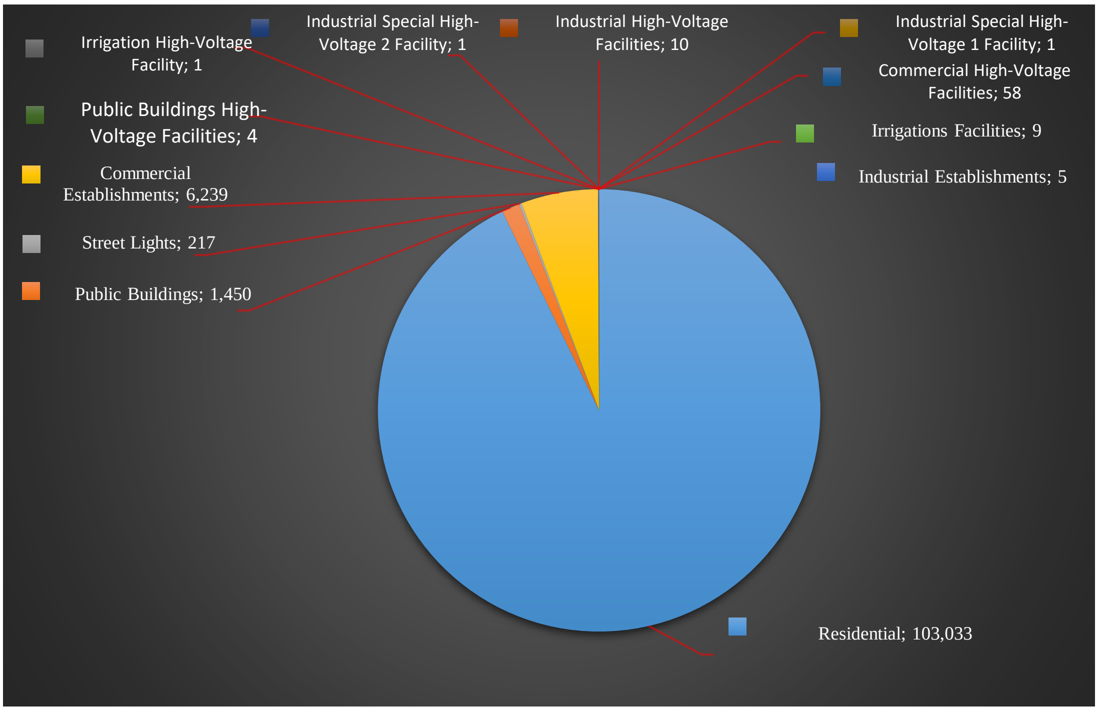


Figure 1.1.2 PELCO 1 Type of Consumers

With an approximately six hundred twenty-three (623 sq. km.) of land area within its area coverage. Currently, PELCO 1 has almost 69.11 MW peak demand in May 2021, wherein 25 MW is coming from an existing PSA with MPPCL, and the remaining was from the Wholesale Electricity Spot Market (WESM). At the same time, PELCO I have an average system loss of 7.28% last 2021.

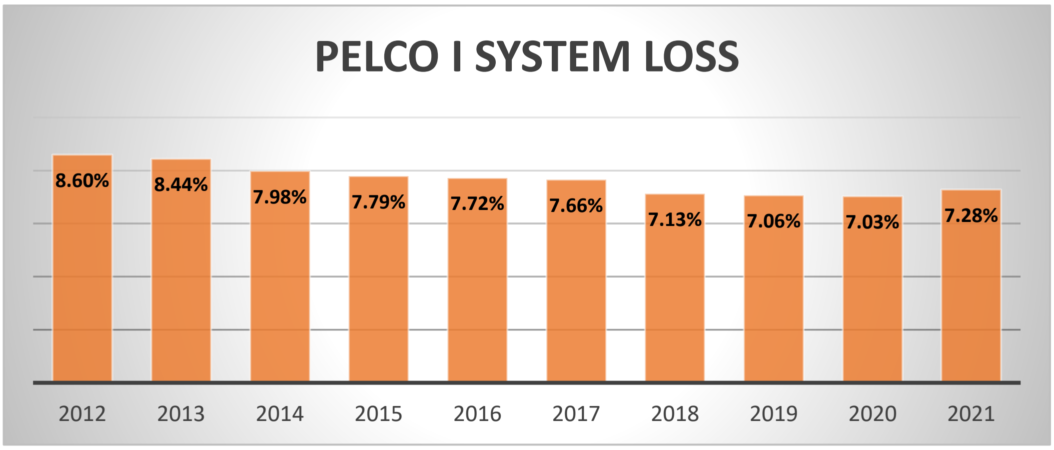


Figure 1.1.3 PELCO I System Loss

PELCO 1 is considering installing a 5 MW capacity solar farm project in Barangay Escaler, Magalang, Pampanga, in compliance with the Renewable Energy Act of 2008. The program's main objective is to promote the development of small, grid-connected solar embedded generating power plants installed in cooperation with the NATIONAL ELECTRIFICATION ADMINISTRATION (NEA) and the DEPARTMENT OF ENERGY (DOE). In addition to this, PELCO I will take this opportunity as a solution to further improve its power quality, reliability, and lower electricity rates for the benefit of its member-consumers.

1.2 Project Description

PELCO I have a 110 MVA substation capacity, namely: Sto. Domingo, Plazang Luma, Gatiawin, Sta. Monica and Lagundi Substation receive power from the NGCP's Lagundi Mexico Switchyard. Meanwhile, Pandacaqui, San Isidro, and San Pablo Substation draw power from the NGCP's 69kV Clark Line 1.

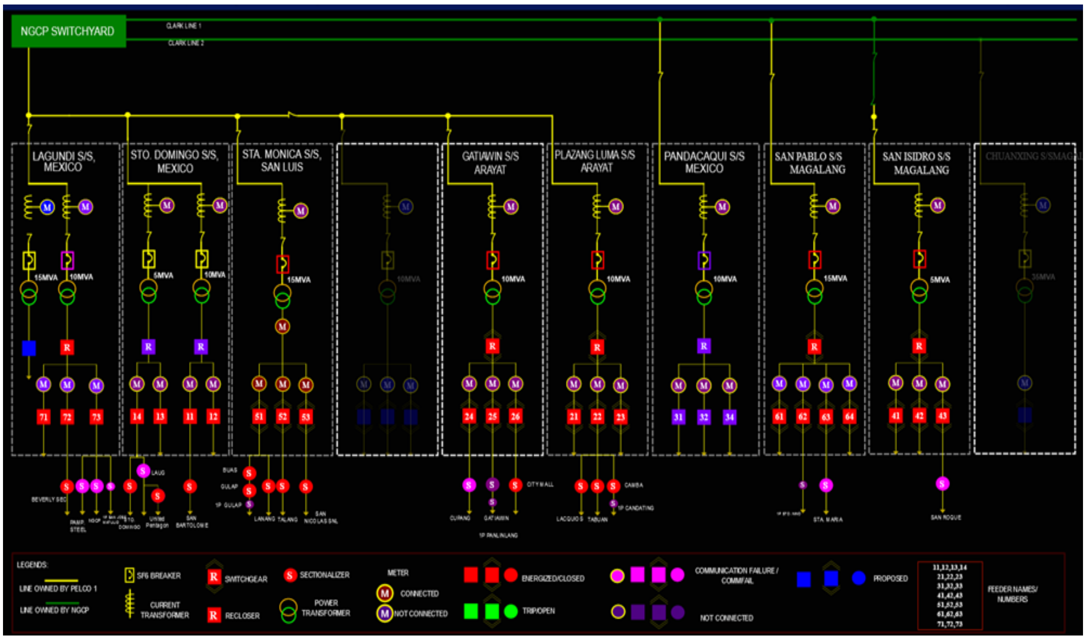
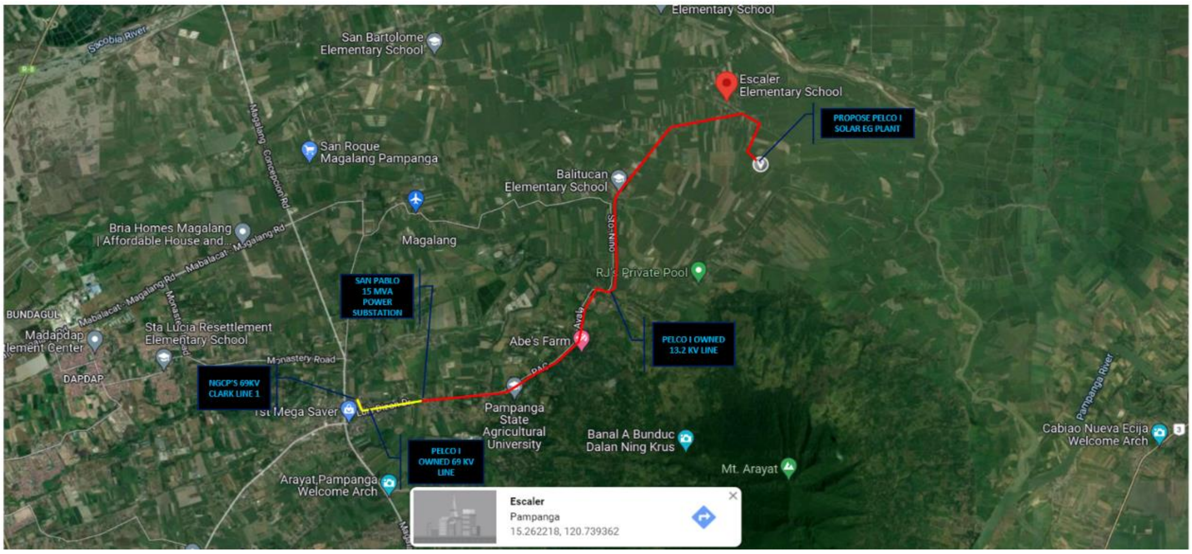


Figure 1.2.1. Single Line Diagram of PELCO I

The proposed PELCO I-Owned Solar Power Plant will be situated in Barangay Escaler, Magalang, with a total land area of Sixty-Three Thousand Five Hundred Nineteen sq. meters (63, 519 sq.m.), enough for a 6.828 MWp plant capacity. The Solar Power Plant will be tapped directly to the 13.2 kV backbone Primary Line of Feeder 62, 11.57km from the existing 15 MVA San Pablo Substation in the Municipality of Magalang.



The said project will comply with the **“Renewable Act of 2008”** under section 6, Renewable Portfolio Standards (RPS). All stakeholders in the electric power industry shall contribute to the growth of the country's renewable energy industry.

Consequently, the development of the PELCO I-owned embedded 5MW Escaler solar power plant is consistent with its Distribution Development Plan (DDP), Power Supply Procurement Plan (PSPP), RPS requirements, and compliance that NEA and DOE approved. It will create an impact when it comes to improving voltage variation from the farthest consumer being served. At the same time, it will contribute to the improvement of substation loading wherein San Pablo Substation is experiencing a high percentage load due to the fast growth of load demand in the said area.

Substation Name	Installed Capacity (MVA)	Feeder	Area Served	Substation Loading (%)
Sto. Domingo S/S	10	F11 & F12	Some part of Mexico, Sta. Ana	73.28%
	5	F13 & F14	Some part of Mexico and Sta. Ana	84.01%
Lagundi S/S	20	F74	Some part of Mexico	31.00%
Plazang Luma S/S	10	F21, F22 & F23	Most part of Arayat	82.42%
Gatiawin S/S	10	F24, F25 & F26	Most part of Arayat	63.73%
Sta. Monica S/S	15	F51, F52 & F53	Whole town of San Luis and Candaba	85.75%
Pandacaqui S/S	10	F31, F32 & F33	Some part of Mexico, Magalang & Arayat	84.92%
San Isidro S/S	5	F41, F42 & F43	Some part of Magalang	45.30%
San Pablo S/S	15	F61, F62 & F63	Most part of Magalang	74.39%

Table 1.2.2. 2021 PELCO 1 Day Peak Substation Loading

In this table, San Pablo S/S recorded 74.39% substation loading, which exceeds the standard of 70% under the Philippine Distribution Code (PDC). Hence, a need for an additional generating capacity can be considered. Gathered data were taken on an hourly reading of substation metering wherein it is the Day Peak of PELCO 1 and the peak production of the proposed EG Plant.

1.3 Project Objectives

This project proposal aims to create a systematic impact analysis and simulation that can be used for future Renewable Energy projects of PELCO 1. It can also serve as guidelines and references to other organizations that undergo project proposals regarding Renewable Energy in Solar Power Plant.

- To provide information for the application and compliance with existing international and local standards such as the Philippine Distribution Code, IEEE, and IEC.
- To provide a basis for electrical simulations such as but not limited to voltage drop calculation and short circuit analysis.

- To provide a basis for financial simulations such as but not limited to rate impact analysis and payback period of the investment.
- To determine the potential effect of the Embedded Generating Plant on the coop's sub-transmission and distribution system.
- To come up with the appropriate connection scheme.
- To determine the required asset reinforcements, if there are any.
- To define the asset boundary.
- To share PV System design with the use of simulation tools such as but not limited to Homer, RETScreen, Simplified Planning Tool (SPT), SketchUp, Helioscope, and PVsyst concerning the required parameters.

ENERGY DEMAND AND SUPPLY

2.1 Power Supply Procurement Plan (PSPP)

Historical Consumption Data

	Coincident Peak MW	MWh Offtake	WESM	MWh Input	MWh Output	MWh System Loss	Load Factor	Discrepancy	Transm'n Loss	System Loss
2000	17.00	91,211	0	91,211	63,343	27,868	61%	0.00%	0.00%	30.55%
2001	18.43	96,010	0	96,010	71,180	24,830	59%	0.00%	0.00%	25.86%
2002	22.48	100,885	0	100,885	79,131	21,753	51%	0.00%	0.00%	21.56%
2003	24.41	121,365	0	121,365	90,179	31,186	57%	0.00%	0.00%	25.70%
2004	23.66	128,767	0	128,767	101,982	26,785	62%	0.00%	0.00%	20.80%
2005	23.96	127,042	0	127,042	103,078	23,964	61%	0.00%	0.00%	18.86%
2006	24.68	124,321	0	124,321	104,618	19,703	57%	0.00%	0.00%	15.85%
2007	24.24	125,769	0	125,769	108,338	17,431	59%	0.00%	0.00%	13.86%
2008	26.53	132,583	0	132,583	116,423	16,160	57%	0.00%	0.00%	12.19%
2009	25.59	144,962	0	144,962	129,886	15,076	65%	0.00%	0.00%	10.40%
2010	31.18	164,958	0	164,958	148,805	16,153	60%	0.00%	0.00%	9.79%
2011	31.21	159,826	0	159,826	145,719	14,107	58%	0.00%	0.00%	8.83%
2012	30.98	169,228	0	169,228	154,678	14,550	62%	0.00%	0.00%	8.60%
2013	35.54	185,027	0	185,027	169,409	15,618	59%	0.00%	0.00%	8.44%
2014	37.94	200,151	0	200,151	184,187	15,964	60%	0.00%	0.00%	7.98%
2015	39.66	221,442	0	221,442	204,189	17,252	64%	0.00%	0.00%	7.79%
2016	45.31	249,455	0	249,455	230,199	19,256	63%	0.00%	0.00%	7.72%
2017	47.77	266,290	0	266,290	245,897	20,393	64%	0.00%	0.00%	7.66%
2018	52.23	284,426	0	284,426	264,150	20,277	62%	0.00%	0.00%	7.13%
2019	56.36	310,343	0	310,343	288,424	21,918	63%	0.00%	0.00%	7.06%
2020	65.62	337,668	0	337,668	313,936	23,731	59%	0.00%	0.00%	7.03%
2021	69.11	364,334	0	364,334	337,801	26,533	60%	0.00%	0.00%	7.28%

Figure. 2.1.1 20-Year Historical Consumption Data of PELCO I

The Peak Demand increased from 65.62 MW in 2020 to 69.11MW in 2021, at a rate of 5.31%. This increase was caused by the additional consumers, particularly the residential and other big loads. The MWh Offtake increased from 337,668 MWh in 2020 to 364,334 MWh in 2021 at a rate of 7.90% due to the influx of different additional consumers. Within a 10-year period, the Load Factor ranged from 58% to 65%. The MWh Output had increased from the year 2020 to the year 2021 at a rate of 7.60%, while MWh System Loss increased at a rate of 11.80% within the same period. PELCO I is able to minimize the total system loss in its distribution system. In 2021, the total system loss is 7.28%. The reduction was attributed to various improvements and rehabilitation of distribution lines and facilities.

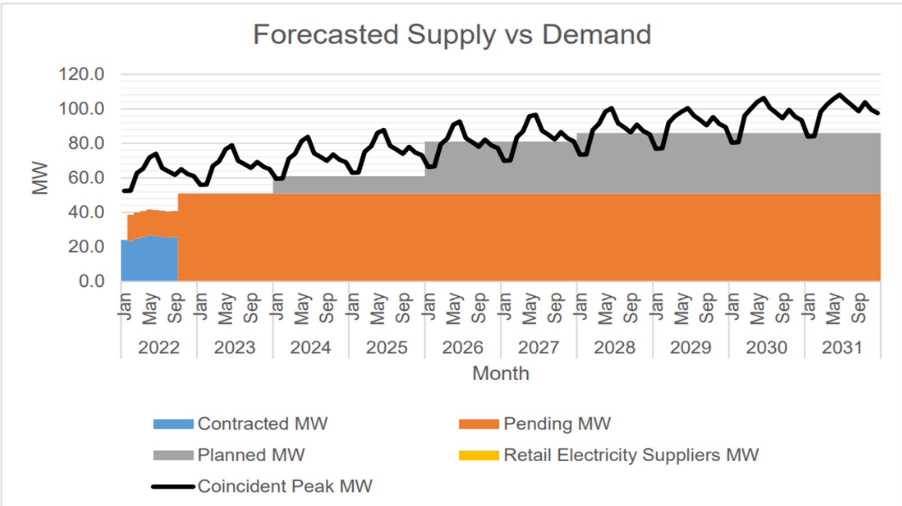


Figure: 2.1.2. 10-Year Forecasted Supply vs. Demand of PELCO I

***Note**.The uncontracted demand, i.e., part of peaking, will be taken from the WESM.

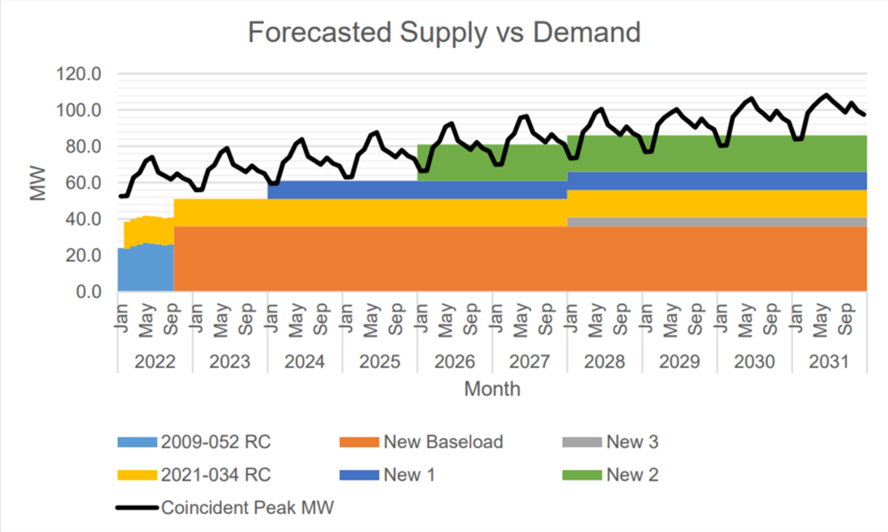


Figure: 2.1.3. 10-Year Forecasted Supply vs. Demand of PELCO I

***Note:** The contracting levels consider the schedule of the CSP.

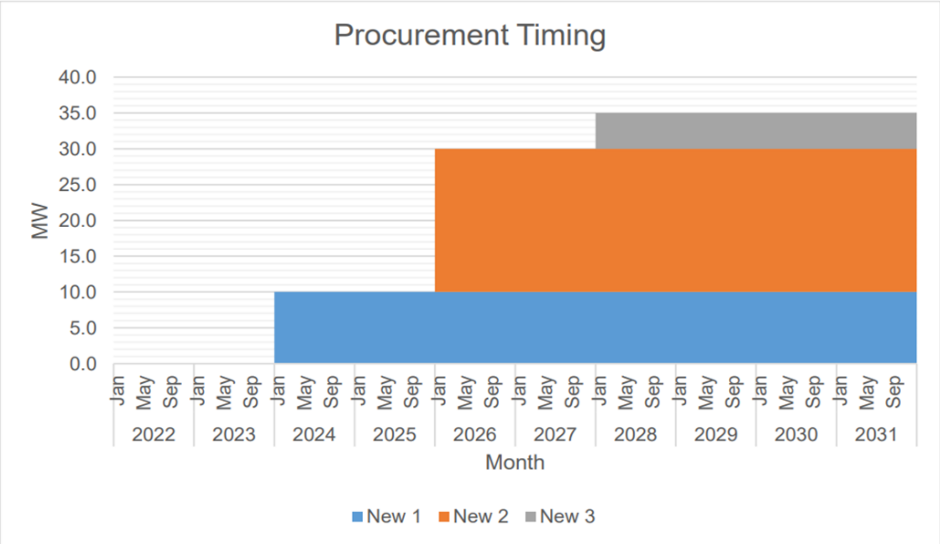


Figure: 2.1.4. 10-Year Procurement Timing of PELCO I

The first wave of supply procurement will be for 10 MW, planned to be available by the month of January 2024. This will be followed by 20 MW and 5 MW in January 2025 and January 2028, respectively.

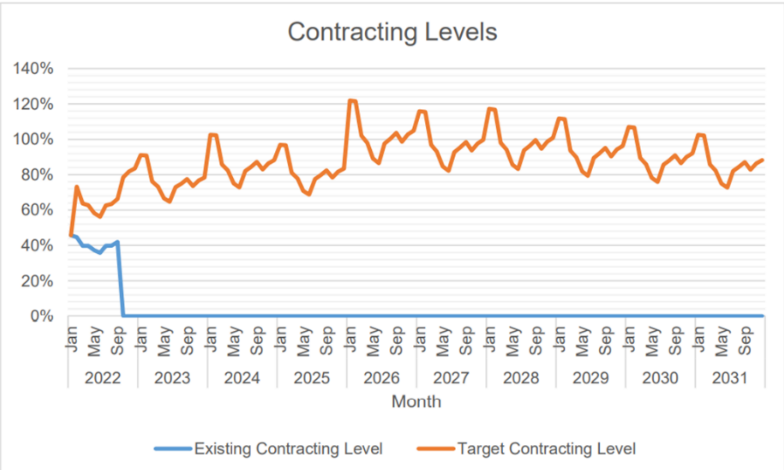


Figure: 2.1.5. 10-Year Contracting Levels of PELCO I

Currently, there is no under/over-contracted because energy imbalances are provided by the existing supplier. The highest target contracting level is 122% which is expected to occur in January 2026. The lowest target contracting level is 46% which is expected to occur in January 2022

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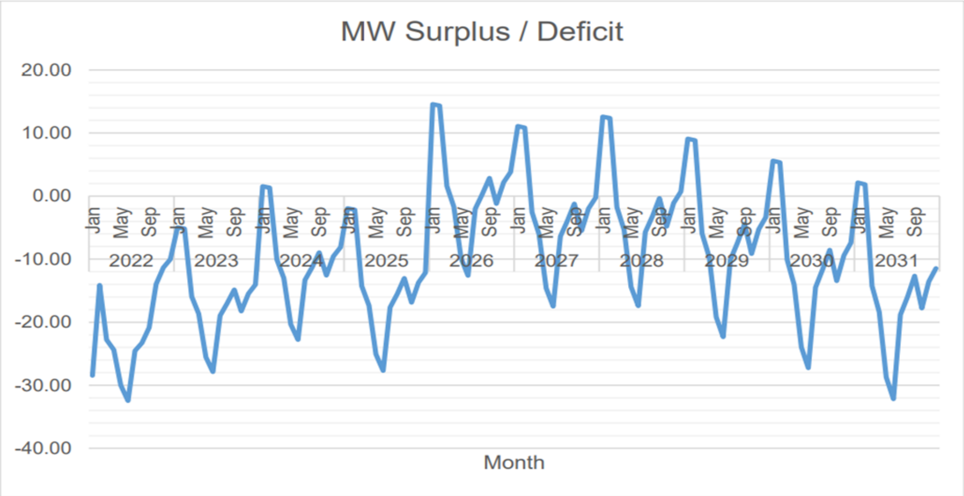


Figure: 2.1.5. 10-Year MW Surplus / Deficit of PELCO I

Currently, there is no under/over-contracted because energy imbalances are provided by the existing supplier. The highest MW deficit is 32.47 MW which is expected to occur in the month of June 2022. The highest MW surplus is 14.58 MW which is expected to occur in the month of January 2026.

POWER SUPPLY

Case No.	Type	GenCo	Minimum MW	Minimum MWh/yr	PSA Start	PSA End
2009-052 RC	Base	Masinloc Power Partners Company, Ltd.	22.00	137,300	10/26/2009	09/25/2022

This PSA was procured thru negotiation in 2009. It serves as a base load and peaking since its execution. PELCO 1 entered into a power supply agreement with MPPCL. MPPCL has maintained a good operational performance. The provisionally approved rate is 4.38 Ph/kWh subject to indexation on forex, us cpi, and coal price. The average generation rate of PELCO I is 3.98 Ph/kWh.

Case No.	Type	GenCo	Minimum MW	Minimum MWh/yr	PSA Start	PSA End
2021-034 RC	Peaking	Bac-Man Geothermal, Inc.	15.00	65,700	1/26/2022	12/25/2032

The PSA with Bac-man Geothermal, Inc. filed with ERC under Case No. 2021-034 RC was procured through the Competitive Selection Process (CSP). It was selected to provide for peaking requirements and RPS compliance.

Case No.	Type	GenCo	Minimum MW	Minimum MWh/yr	PSA Start	PSA End
New Baseload	Base	Masinloc Power Partners Company, Ltd.	36.00	308,000	9/26/2022	12/25/2033

The PSA with MPPCL was procured through the Competitive Selection Process (CSP). It was selected to provide for baseload requirements of PELCO 1 since the existing baseload contract will expire in September 2022. The PSA contract is under evaluation by NEA through EVOSS.

2.2 Load Profile of the Area

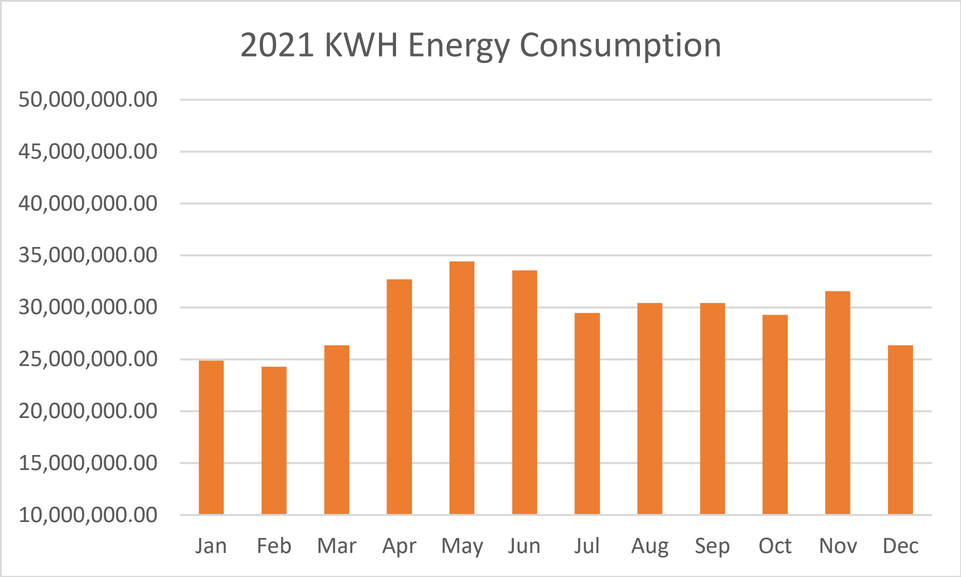


Figure: 2.1.2 2021 Monthly Energy Consumption of PELCO I

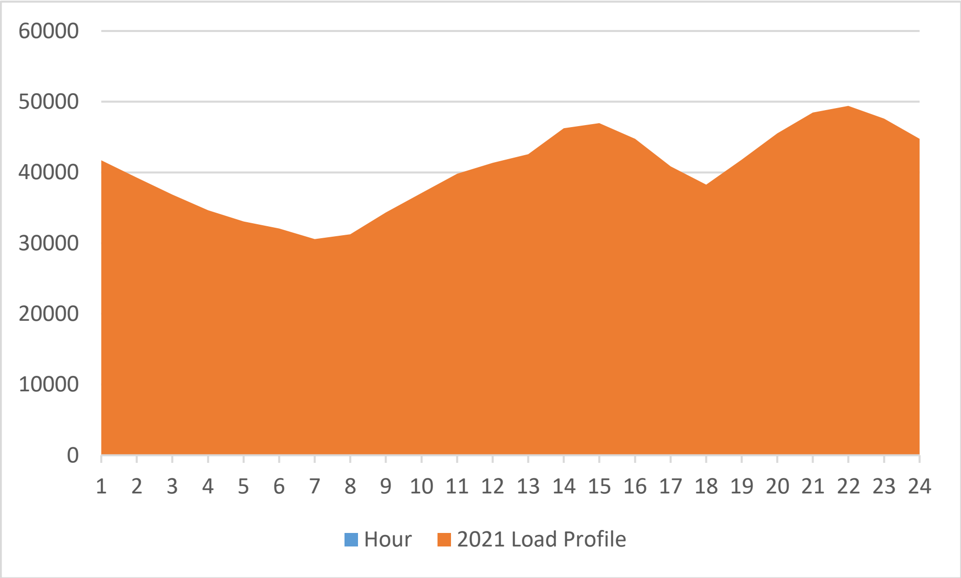


Figure: 2.1.3 2021 Load Duration Curve of PELCO I

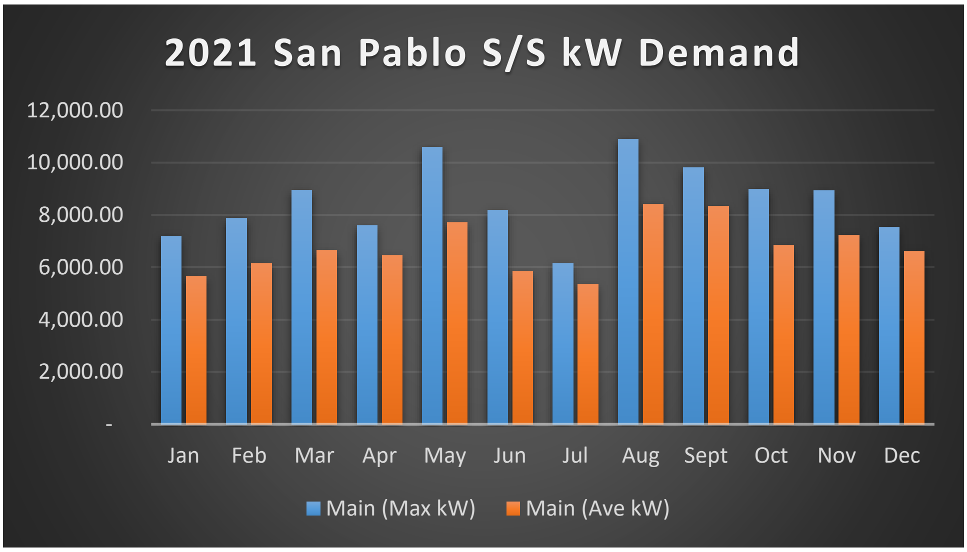


Figure: 2.1.4 2021 Demand in kW of San Pablo S/S (Peak vs. Off-Peak)

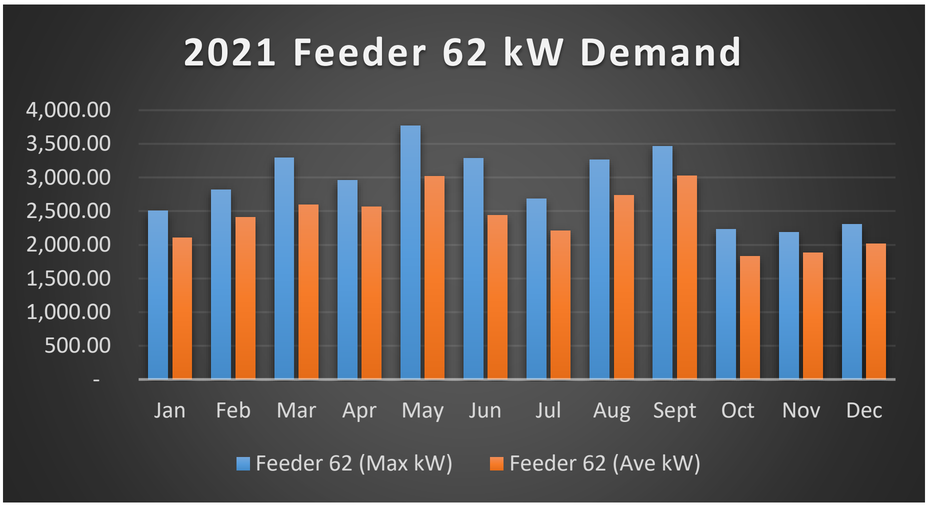


Figure: 2.1.5 2021 Demand in kW for Feeder 62 (The Tapping Point of the Proposed 5MW Solar Power Project)

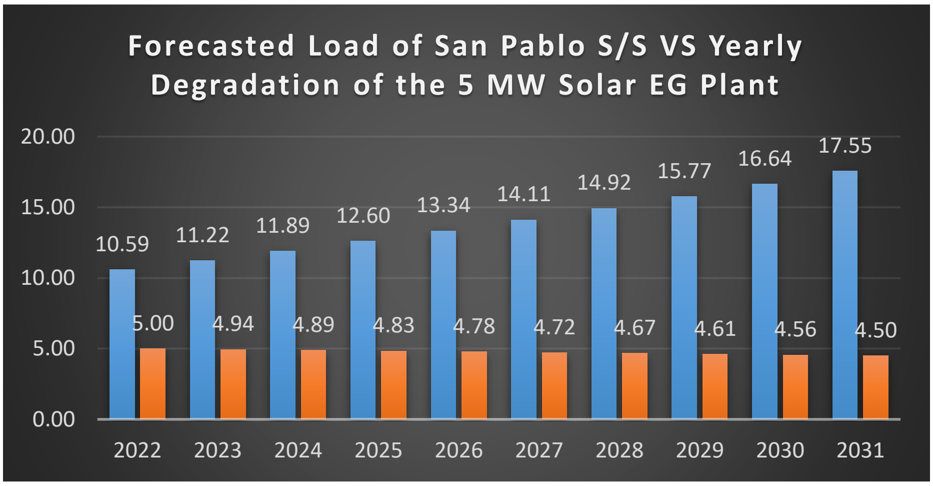
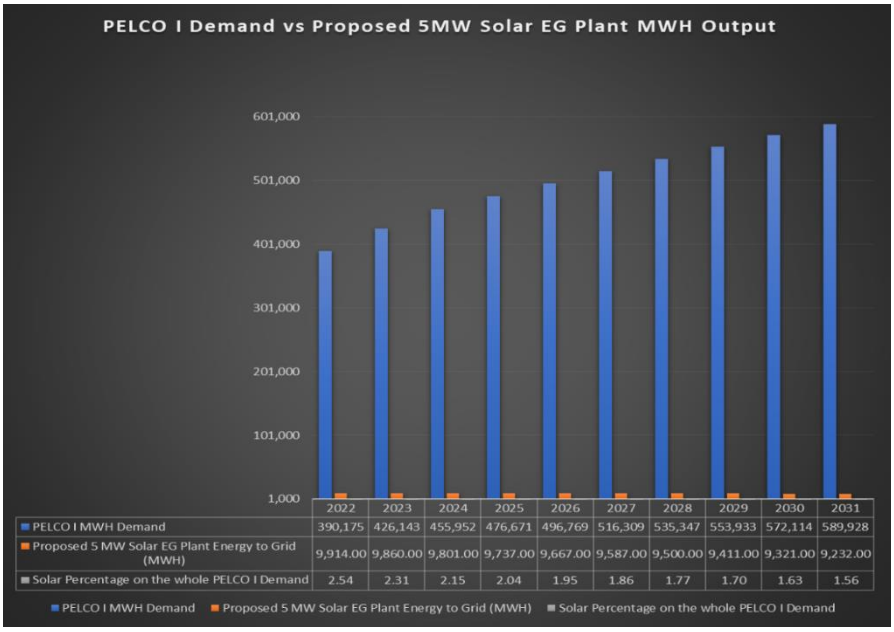


Figure: 2.1.6 2021 Forecasted Load of San Pablo S/S VS Yearly Degradation of the 5 MW Solar EG Plant

The figure shows that the simulated production of the proposed project does not exceed the forecasted load requirement of the area. Thus, an over-production or a reverse power flow on the sub-transmission line is imminent.



	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
PELCO I MWH Demand	390,175	426,143	455,952	476,671	496,769	516,309	535,347	553,933	572,114	589,928
Proposed 5 MW Solar EG Plant Energy to Grid (MWH)	9,914.00	9,860.00	9,801.00	9,737.00	9,667.00	9,587.00	9,500.00	9,411.00	9,321.00	9,232.00
Solar Percentage on the whole PELCO I Demand	2.54	2.31	2.15	2.04	1.95	1.86	1.77	1.70	1.63	1.56

Figure: 2.1.7 2021 10-Year PELCO I Demand vs. Proposed 5MW Solar EG Plant MWH Output

CONCEPTUAL DESIGN

3.1 Engineering Design of the Project

The Proposed Project will be located at Brgy. Escaler, Magalang, Pampanga. The total land area of approximately sixty-three thousand five hundred nineteen sq. m (63, 519 sq. m.) includes the driveway, control house, and the power substation.

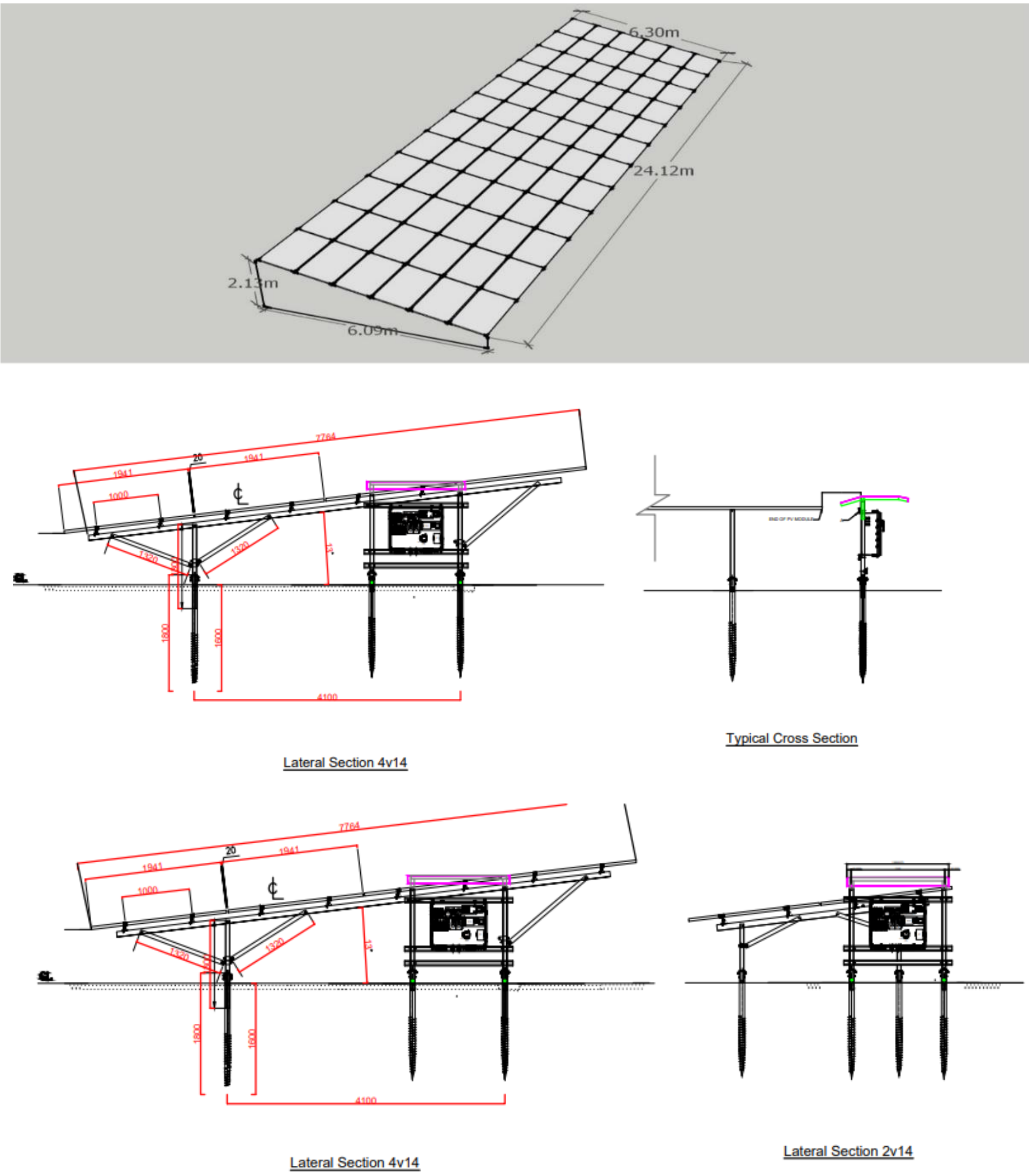


Figure 3.1.1 Actual Dimension of each Array and the dimension of the Rack

This figure shows the size of an array simulated and drawn using SketchUp Software. The longitude and latitude of the project location were considered for the design of the racks to determine the tilt angle. This is vital to maximize the yield and output of the Solar EG Plant.

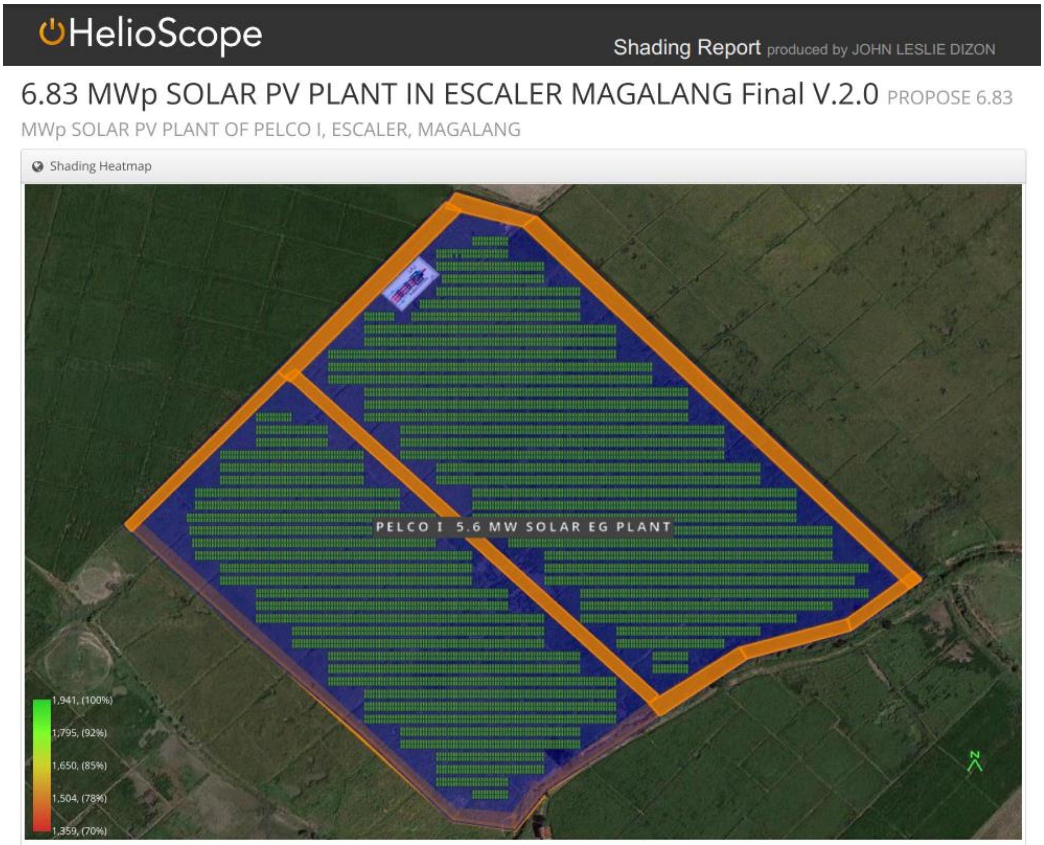


Figure 3.1.1 Proposed Location and Design of the 5 MW Solar EG Plant created using HelioScope Online PV Plant Design Software

3.2 Infrastructure Component

3.2.1 Basic Design Codes

This report's reference standards and codes as a basis for design are the Philippine Distribution Code (PDC), IEEE, and IEC.

The following code provisions and standards were mainly used:

- IEEE std. 1547-2003, "IEEE Standards for Interconnecting Distributed Resources with Electric Power Systems."
- Section 3.2.2 of the Philippine Distribution Code, "Frequency Variations."
- Section 3.2.3 of the Philippine Distribution Code, "Voltage Variations."
- Section 5.3.3 of the Philippine Distribution Code, "Distribution Impact Studies."
- NEA Engineering Bulletin DX1120 December 1992, "Voltage Levels on Rural Distribution System."
- NEA Engineering Bulletin DX1320_" Specifications and Drawings for Distribution Line Construction, 13.2 kV and 24kV"
- IEC 61724 "Photovoltaic System Performance."
- Article II, Section 2.9.4 of the Distribution Services and Open Access Rules (DSOAR).

3.2.2 System Requirements

Since the rated output power of the Proposed PELCO I-Owned Solar Power Plant is around 6.828 MW based on the HelioScope and PVsyst simulation, said power output must be exported to the facilities owned by Distribution Utility (PELCO I), wherein the maximum aggregate capacity is ≤ 10MW (Distribution Voltage).

The Electrical System specifications for this design are:

I. 0.600 kV solidly grounded wye primary, 13.2 kV delta secondary, 3 phase, and 60Hz for the Solar PV Plant step up Substation

II. 13.2 / 7.620 kV, Wye, 3 Phase, 4 Wire, and 60 Hz for the Medium Voltage Electrical System

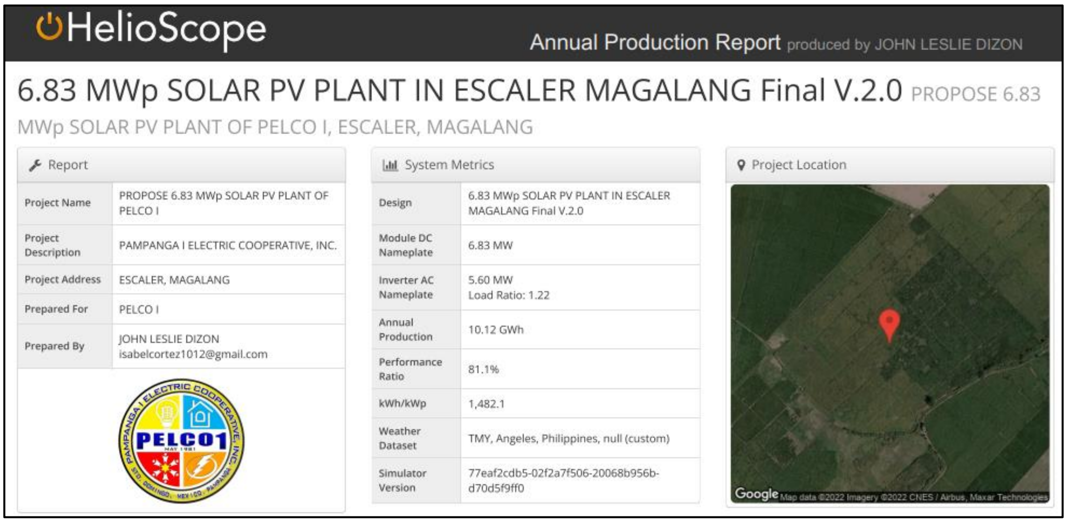


Figure: 3.2.1 System Metrics of the Proposed 6.828 MW EG PV Plant

The proposed solar PV Plant has a Module DC Nameplate of 6.828 MWp with an AC output of 5 MW and a 1.22 DC/AC Load Rato. Simulated annual generated energy reaches about 10 GWh/year, having a performance ratio of 81.1% excluding point of array (POA) irradiance. Weather Data Set being used was TMY, Angeles, Philippines, wherein the parameters were derived from the Office of Energy Efficiency and Renewable Energy and Meteonorm. On the other hand, a similar simulation from the PVsyst Version 7.2.14 licensed software shows a similar simulation result with almost the same design and temperature conditions. It produced 10GWh/year of Energy with a performance ratio of 79.05%, which is nearly the same as the one simulated with the Helioscope.

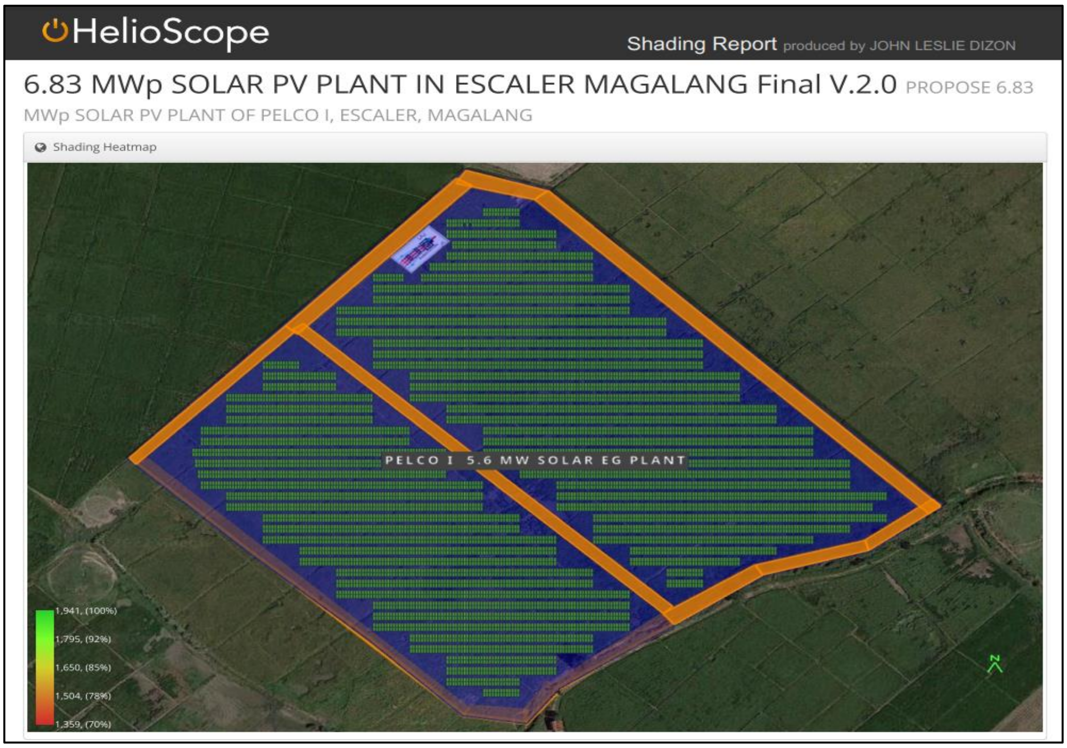


Figure: 3.2.2 Result of Shading Heat map on HelioScope Simulation

The shading heat map from the Helioscope simulation shows that the proposed EG PV Plant can harness around 1,482.1 kWh/m^2 of solar irradiance, having heatmap performance from 93% to 100%, which is a good indication of a suitable location to harness the energy from the sun.

	Unit	Climate data location	Facility location	Source
Latitude		15.2	15.3	
Longitude		120.6	120.7	
Climate zone		0A - Extremely hot - Humid		Ground+NASA
Elevation	m	155	14	Ground – Ground
Heating design temperature	°C	20.2		Ground
Cooling design temperature	°C	34.5		Ground
Earth temperature amplitude	°C	9.1		NASA

Month	Air temperature	Relative humidity	Precipitation	Daily solar radiation - horizontal	Atmospheric pressure	Wind speed	Earth temperature	Heating degree-days 18 °C	Cooling degree-days 10 °C
	°C	%	mm	kWh/m²/d	kPa	m/s	°C	°C-d	°C-d
January	25.2	68.9%	50.87	4.65	99.4	2.4	24.5	0	471
February	25.8	66.6%	47.01	5.21	99.4	2.3	25.9	0	442
March	27.4	64.3%	53.91	5.91	99.3	2.3	27.8	0	539
April	28.8	66.1%	93.46	6.20	99.2	2.1	29.3	0	564
May	28.6	71.9%	283.87	5.51	99.0	1.9	28.4	0	577
June	27.3	79.3%	256.62	5.04	98.9	1.8	27.4	0	519
July	26.7	82.6%	366.94	4.67	98.9	1.8	27.1	0	518
August	26.3	84.9%	370.75	4.08	98.9	1.8	26.8	0	505
September	26.6	81.9%	300.48	4.41	99.0	1.7	26.7	0	498
October	26.7	77.9%	227.47	4.58	99.0	1.9	26.2	0	518
November	26.5	73.8%	165.23	4.45	99.2	2.0	25.2	0	495
December	25.4	70.4%	136.86	4.31	99.4	2.3	24.3	0	477
Annual	**26.8**	**74.1%**	**2,353.48**	**4.91**	**99.1**	**2.0**	**26.6**	**0**	**6,124**
Source	Ground	Ground	NASA	NASA	NASA	Ground	NASA	Ground	Ground
Measured at					m	10	0		

Solar Irradiance Level

Figure: 3.2.3 Result of Solar Irradiance Level simulated on the RetScreen Expert Software

As per National Electrification Administration (NEA) during the Seminar-Workshop on the Simplified Planning Tool and Photovoltaic last May 23, 2018, the qualified value for the solar irradiance level of a proposed location for the Solar EG PV Plant was ≥4 kWh/m2/d. In connection with this, our generated SIL for PELCO I proposed location was 4.91 kWh/m2/d. Thus, based on the result, the SIL of the proposed location for the proposed 6.828 MWp PELCO I Solar EG PV Plant was above the standard limit.

Figure: 3.2.4 Monthly Production of Energy of the 6.828 MWp Solar EG Plant

The **HelioScope** simulation shows that the highest production going to the grid is in March, while the lowest is in August. Meanwhile, PVsyst provided a simulation of the 25-year having 0.55%/year of degradation of the proposed plant.

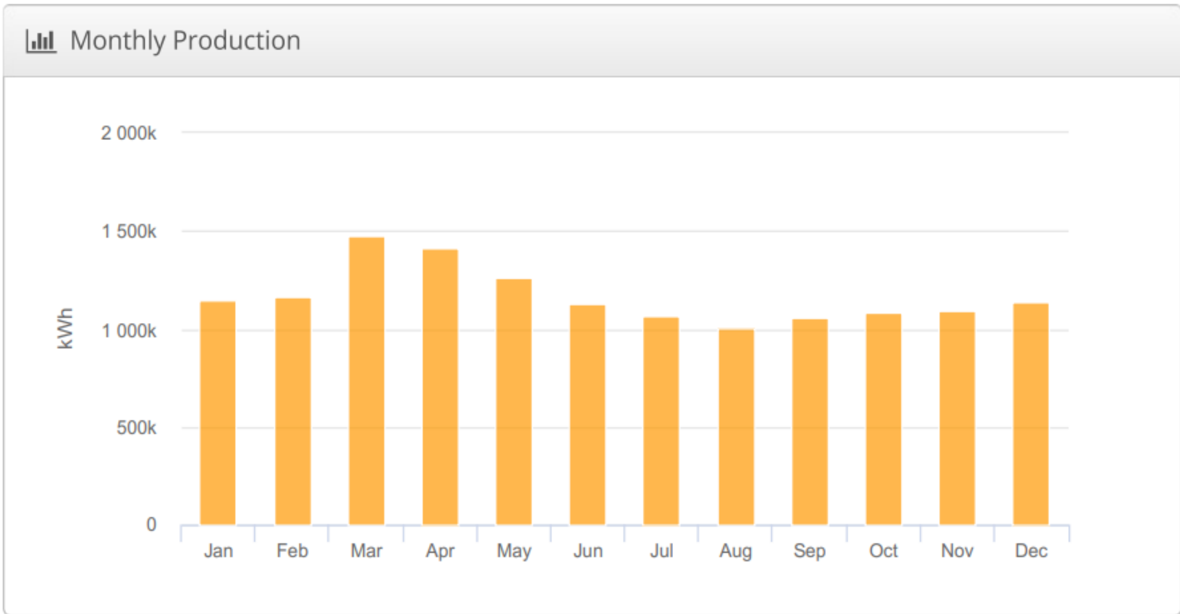


Figure: 3.2.4 Monthly Production of Energy of the 6.828 MWp Solar EG Plant

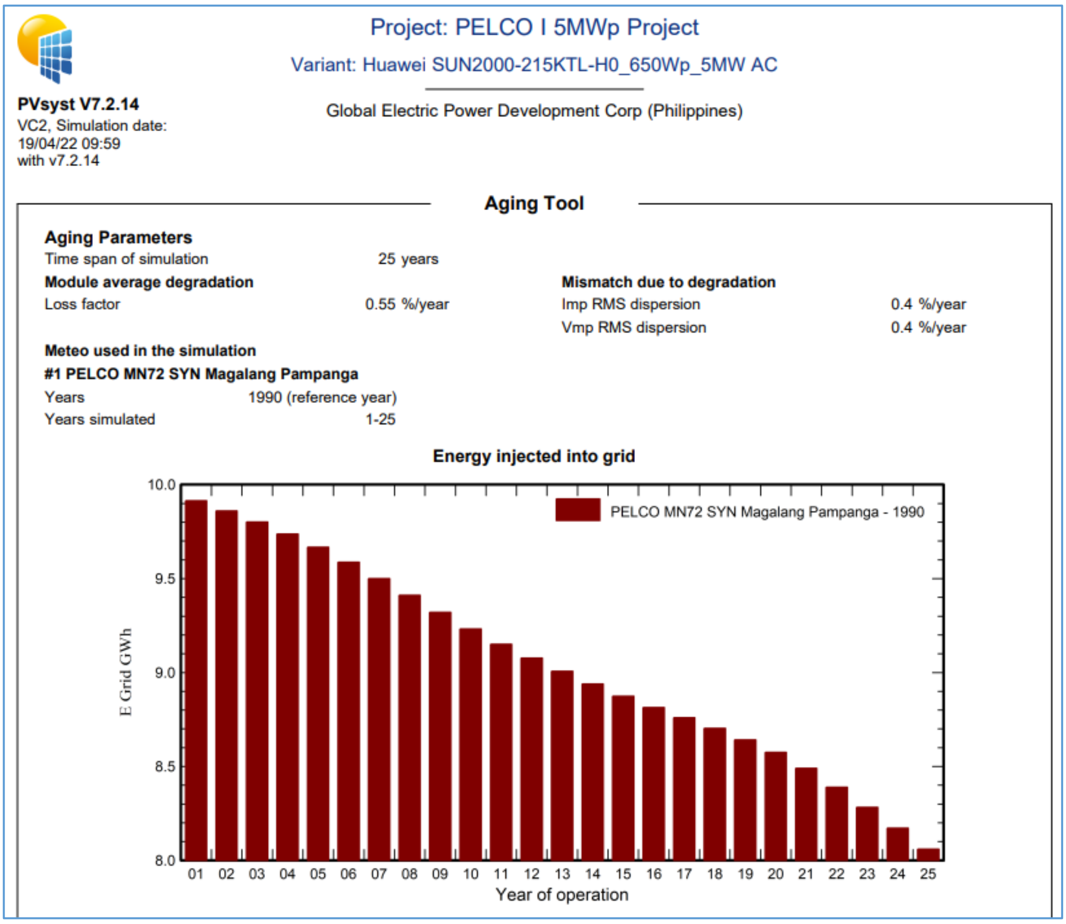


Figure: 3.2.4.1. 25-Year Generation Production simulated on PVSyst

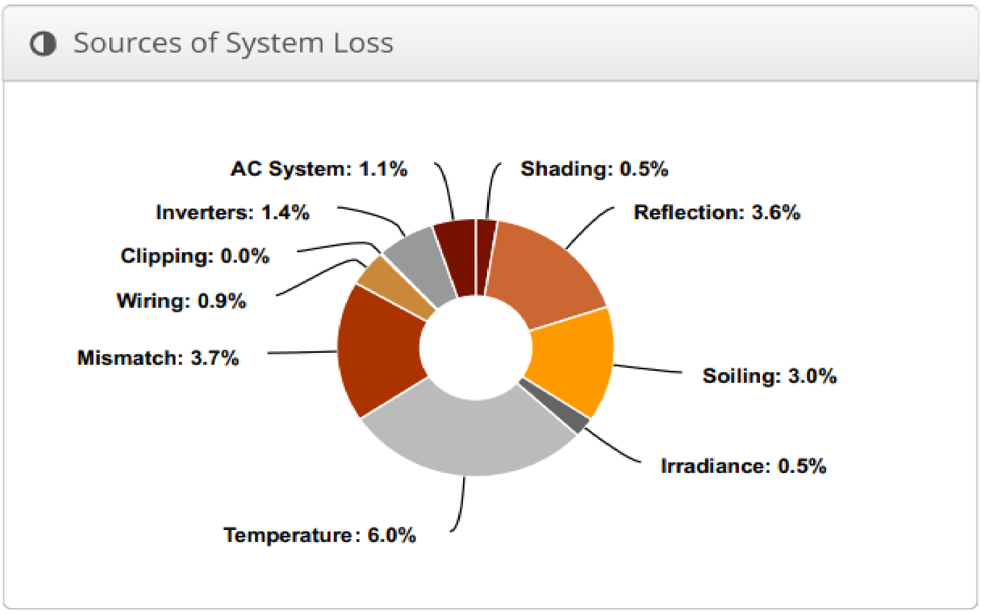


Figure: 3.2.5 Typical Loss Factor of the whole Proposed PV Plant

This figure shows the breakdown of the losses within the system's design. HelioScope defines all the parameters, normal ranges, and notes as follows:

Parameters	"Normal Range"	Notes
POA Irradiance	1% to 20%	A positive value means an increase. A negative value means modules are pointed away from the equator.
Shaded Irradiance	0 to -10%	Depends on shading.
Reflection	1% to 5%	Based on the reflection of light from shallow angles.

Soiling	1% to 5%	Default is a 2% loss.
Output at Irradiance	1% to 5%	For non-linear behavior of module curve under low light.
Output at Temperature	3% to 7% for fixed-tilt 6% to 15% for flush mount	All arrays will have temperature-related losses.
Output at Mismatch	0 to 7%	Default is approx. 2%
Optimal DC Output	0 to 2%	DC wiring losses between modules and inverters
Constrained DC output	0 to 3%	Accounts for clipping losses
Inverter Output	2% to 7%	Accounts for efficiency of the inverter
Energy to Grid	0.5% to 3%	Accounts for AC losses between inverter and grid connection.
Total Performance Ratio	68% to 88%	Composite of all of the factors above (excluding POA irradiance).

Table: 3.2.6 Typical Loss Factor

Based on this table, all of the results of “source systems loss” from Figure 3.2.5 are within limits set by HelioScope, as seen in Table 3.2.1. Therefore, the design of the proposed PV EG Plant had met all the standards set by Folsom Labs, the creator of HelioScope.

Condition Set

Description	Condition Set 1
Weather Dataset	TMY, Angeles, Philippines, null (custom)
Solar Angle Location	Meteo Lat/Lng
Transposition Model	Perez Model
Temperature Model	Diffusion Model
Irradiation Variance	5%
Cell Temperature Spread	4° C
Module Binning Range	-2.5% to 2.5%
AC System Derate	0.55%

Temperature Model Parameters

Rack Type	U_{const}	U_{wind}
Fixed Tilt	29	0
Flush Mount	15	0
East-West	29	0
Carport	29	0

Soiling (%)

J	F	M	A	M	J	J	A	S	O	N	D
3	3	3	3	3	3	3	3	3	3	3	3

Module Characterizations

Module	Uploaded By	Characterization
TSM-DE21 650 (Trina Solar)	Folsom Labs	Spec Sheet Characterization, PAN

Component Characterizations

Device	Uploaded By	Characterization

Figure 3.2.7 Temperature Condition Set from Helioscope

Annual Production

	Description	Output	% Delta
Irradiance (kWh/m²)	Annual Global Horizontal Irradiance	1,879.9	
	POA Irradiance	1,828.6	-2.7%
	Shaded Irradiance	1,818.9	-0.5%
	Irradiance after Reflection	1,753.7	-3.6%
	Irradiance after Soiling	1,701.1	-3.0%
	Total Collector Irradiance	**1,701.1**	**0.0%**
Energy (kWh)	Nameplate	11,621,429.5	
	Output at Irradiance Levels	11,561,370.8	-0.5%
	Output at Cell Temperature Derate	10,872,506.7	-6.0%
	Output After Mismatch	10,474,960.6	-3.7%
	Optimal DC Output	10,376,363.4	-0.9%
	Constrained DC Output	10,372,716.1	0.0%
	Inverter Output	10,227,449.0	-1.4%
	Energy to Grid	**10,118,944.0**	**-1.1%**
Temperature Metrics			
	Avg. Operating Ambient Temp		26.9 °C
	Avg. Operating Cell Temp		35.6 °C
Simulation Metrics			
		Operating Hours	4765
		Solved Hours	4765

Figure: 3.2.8 Breakdown of Annual Generated energy from Helioscope

Components

Component	Name	Count
Inverters	SUN2000-215KTL-H0 (Huawei)	28 (5.60 MW)
Transformer	Primary Side: Medium Voltage (13.2kV), Secondary: 800V	1
AC Home Runs	185 mm2 (Aluminum)	28 (21,987.8 m)
Home Runs	16 mm2 (Aluminum)	56 (3,664.1 m)
Combiners	4 input Combiner	4
Combiners	6 input Combiner	24
Combiners	7 input Combiner	24
Combiners	8 input Combiner	4
Strings	25 mm2 (Copper)	360 (34,173.8 m)
Module	Trina Solar, TSM-DE21 650 (650W)	10,504 (6.83 MW)

Wiring Zones

Description	Combiner Poles	String Size	Stringing Strategy
PELCO I 5.6 MW SOLAR EG PLANT	9	14-32	Along Racking

Field Segments

Description	Racking	Orientation	Tilt	Azimuth	Intrarow Spacing	Frame Size	Frames	Modules	Power
PELCO I 5.6 MW SOLAR EG PLANT	Fixed Tilt	Portrait (Vertical)	8°	0°	1.6 m	2x13	407	10,504	6.83 MW

Figure 3.2.5 Components and Hardware of the Solar PV Plant, Wiring Zone, and Field Segments from Helioscope

In the field segments, the racking was fixed tilt with a tilt angle of 8 degrees in a landscape (horizontal) orientation. For the azimuth angle, it will be set to 0 degrees. The maximum spacing is 1.6m between arrays and 1m from the fence. It will also show the number of modules to be used, inverters, AC and DC Panels, sizes, and length of wires needed for the project. In addition, the technical specifications of all hardware were also shown.

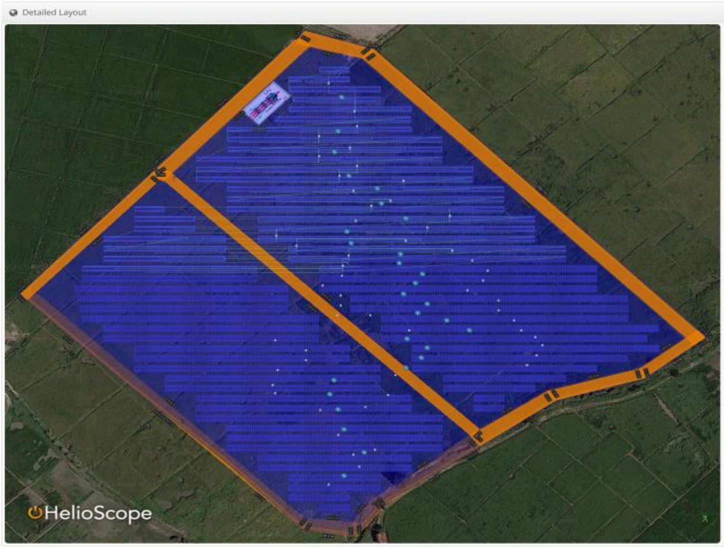


Figure 3.2.6 Detailed Layout showing the wire schedule, inverters, combiner box, power substation, and control house.

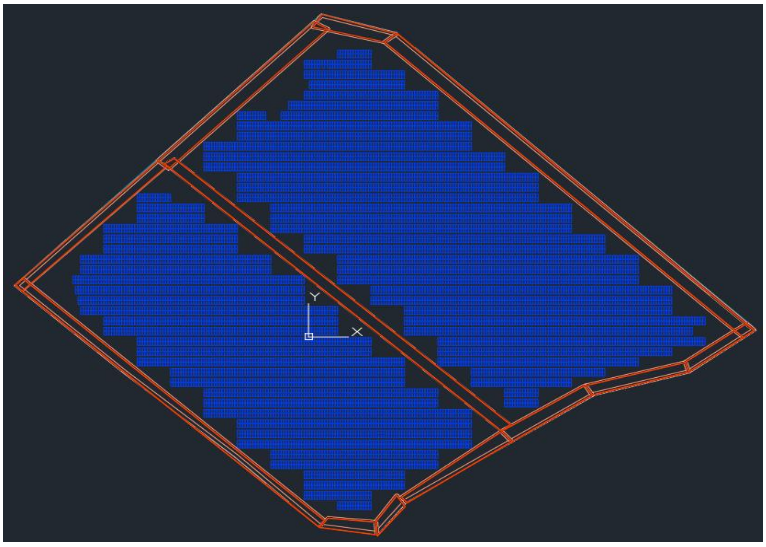


Figure 3.2.7 Detailed Layout showing the arrays and panels generated from the Helioscope in CAD Format.

3.3 Distribution Impact Study (DIS)

Technical Criteria

The technical criteria used in evaluating the results of the simulations are based on the Philippine Distribution Code. Any violations currently inherent to the PELCO I system and not directly due to the project’s connection will not be considered as degradation to the distribution system.

A. Power Flow Criteria

RE integration can change current flows in the distribution network, leading to the overloading of feeders and transformers, especially during maximum generation and minimum loading conditions.

- Distribution Level Criteria

All distribution lines and equipment loading levels should not exceed 70% of the maximum continuous ratings of phase conductors and transformers.

- Sub transmission Level Criteria

Sub transmission line loading should not exceed 90% of the conductor’s thermal rating, while delivery point power transformer(s) should not exceed 100% of their rated capacity during N-1 conditions.

B. Voltage Criteria

Renewable Energy integration may also result in changes in voltage profile along a feeder and may exceed the statutory voltage limits.

- Distribution Utility Criteria

The voltage present at any Connection Point shall be within 5% of nominal voltage during normal conditions and within 10% during N-1 conditions.

C. Power Quality

Four aspects of power quality issues that must be observed:

Flicker Severity: impression of unsteadiness of visual sensation induced by a light stimulus whose luminance or spectral distribution fluctuates with time.

- DU Criteria: Flicker Severity at any point shall not exceed 1.0 for the short term and 0.8 for the long term.

Harmonics: are sinusoidal voltages and currents having frequencies that are integral multiples of the fundamental frequency.

- DU Criteria: Total Harmonic Distortion (THD) of the voltage and the current's Total Demand Distortion (TDD) shall not exceed 5% during normal operating conditions.

Frequency Variation: the nominal frequency shall be 60 Hz.

- DU Criteria: The DU shall design and operate its system to assist the System Operator in maintaining the fundamental frequency within the limits of 59.7 Hz and 60.3 Hz during normal conditions.

D. Fault Current Criteria

Installation of a new RE EG Plant in the distribution networks will potentially increase fault levels in the network. Fault contribution from EG might trip the feeder breaker and recloser. The impact of EG fault’s current contributions on system protection coordination must be considered.

DU Criteria: The maximum short circuit current should not exceed 90% of the interrupting capability of protective equipment and should not significantly affect the existing protection scheme.

E. Control and Safety Issues

The Distributed Generation interconnection system shall detect an islanded condition during the operation of automatic sectionalizing equipment and shall cease to energize the system within two seconds (2 sec) after forming an island. The adverse impact of unintentional islanded operations is as follows: (a) unstable network (significant frequency or voltage variations will occur when the DG unit tries to supply the load on the island). (b) Power quality and reliability (potential damage to equipment) is worsening. (c) Safety problems to utility crews.

The Distribution Code defines the following technical scope of Distribution Impact Studies (DIS):

3.3.1 Short Circuit Analysis

Fault current simulation aims to determine the resulting fault level upon connection of the Project to the distribution system of PELCO I, specifically in the proposed connection point and nearby substations. In the case of solar power plants, solar PV panels are decoupled from the distribution system by a power converter/inverter; hence, the impact on the fault current is negligible. However, these values should be compared with the actual breaker ratings to ensure that the fault current ratings are not exceeded. The resulting fault levels at the monitored substations prior to and upon entry of the Project are shown in Table 3.3.1.1.

Table: 3.3.1.1 Short Circuit Analysis

Status	Section ID	Voltage Level	Short Circuit RMS Symmetrical (Amperes)			
			LG	LL	LLG	3PH
W/out Project	DXF62S6C3000155	13.2 kV	9530	8229	9516	9503
W/ Project	DXF62S6C3000155	13.2 kV	9530	8229	9516	9503
W/out Project	DXF62S6A1014513	13.2 kV	1819	2162	2276	2496
W/ Project	DXF62S6A1014513	13.2 kV	1819	2162	2276	2496

In the table above, the resulting fault levels are the same, even with integrating the proposed PELCO I 5MW Solar EG Plant. Thus, upgrading the power circuit breaker is not required.

3.3.2 Voltage Drop Calculation

Table: 3.3.2.1 Voltage Drop Calculation without Project

Section ID	Voltage Level	Voltage Profile without Project		
		A	B	C
DXF62S6C3000155	13.2kV	1.0138	1.0119	1.0128
DXF62S6A1014513	13.2kV	0.9899	0.9777	1.0049

Table: 3.3.2.2 Voltage Drop Calculation with Project

Section ID	Voltage Level	Voltage Profile with Project		
		A	B	C
DXF62S6C3000155	13.2kV	1.0208	1.0188	1.0197
DXF62S6A1014513	13.2kV	1.0486	1.0351	1.0431

As seen in tables 3.3.2.1 and 3.3.2.2, voltage simulation results show that during normal conditions, before and upon entry of the project, the voltage performance of the monitored substation remains within the standard nominal voltage. Thus, installing power-compensating devices such as capacitor banks is not needed. However, the entry of the proposed EG Plant slightly improved the voltage profile in the area. Nevertheless, the project did not cause degradation to the system.

3.3.3 Substation Loading and Losses Analysis

Table: 3.3.3.1 Substation Loading and Losses Analysis of San Pablo S/S

Status	Transformer Loss (Cu. & Core Loss) in kW	kVAR	San Pablo Substation Loading in %	Proposed 5 MW Solar EG Plant Loading
Without Project	65	413	75%	0%
With Project	22	134	43%	50%
Difference	43	279	36%	

In this table, the San Pablo substation meter registered 65kW of transformer loss with a reactive power of 413 in 75% of substation loading, as the proposed PV Plant was not commissioned. On the other hand, during the commission of the project, a decrease in transformer loss, kVAR, and Substation Loading was seen from the San Pablo S/S. The simulation was done using SYNERGEE Electric.

3.3.4 Thermal Loading

Thermal simulation results show that during normal conditions and before the project's entry, the highest loading of the monitored distribution facilities is at 75%, which is already beyond thermal capacity. Favorably, the entry of the project reduced almost half of the transformer loading of the San Pablo Substation from 75% to 43%. However, a substation expansion plan should be considered a long-term solution.

3.3.5 Control and Safety

The installation of a protection scheme or system to automatically disconnect the proposed EG Plant in the event of a fault in the generation side due to weather conditions or other unusual conditions that may cause disturbances in the distribution must be considered. In support of this, PELCO I will be using a smart inverter that may automatically isolate the EG Plant during islanding conditions. Moreover, the integration and installation of a Supervisory Control and Data Acquisition and Weather Station will be prioritized.

Status	Transformer Loss (Cu. & Core Loss) in kW	kVAR	San Pablo Substation Loading in %	Proposed 5 MW Solar EG Plant Loading
Without Project	65	413	75%	0%
With Project	22	134	43%	50%
Difference	43	279	36%	

Data Acquisition and Weather Station will be prioritized.

3.3.6 POWER FLOW SIMULATION

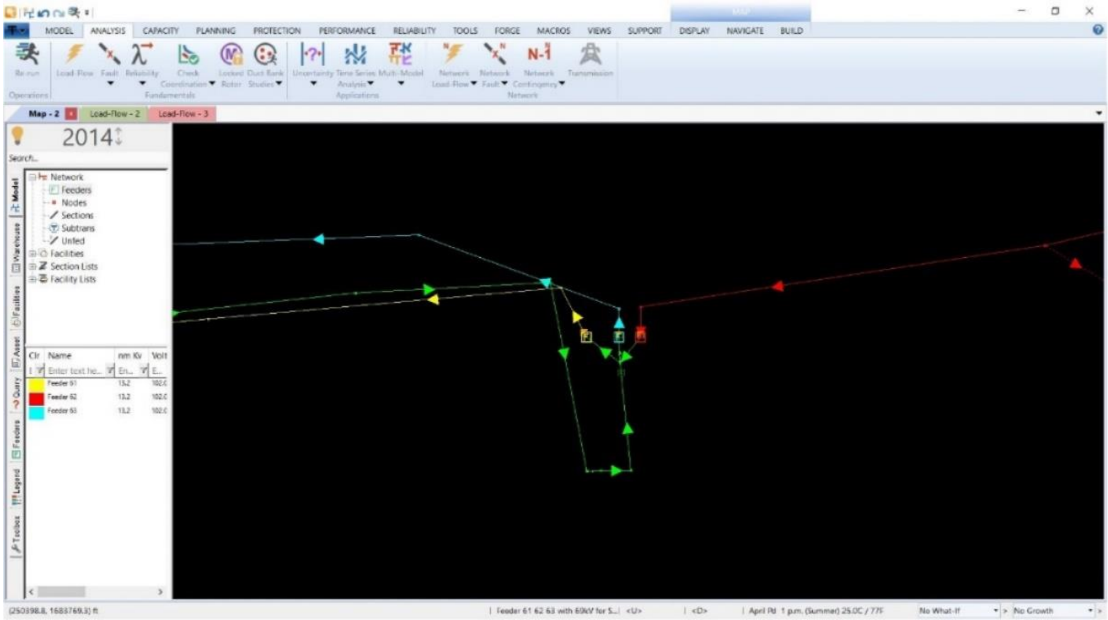


Figure 3.3.6.1. Power Flow as simulated on Synergi showed the 69KV Clark Line 1 of NGCP and the San Pablo S/S of PELCO I during the proposed 5MV Solar Power Plant entry.

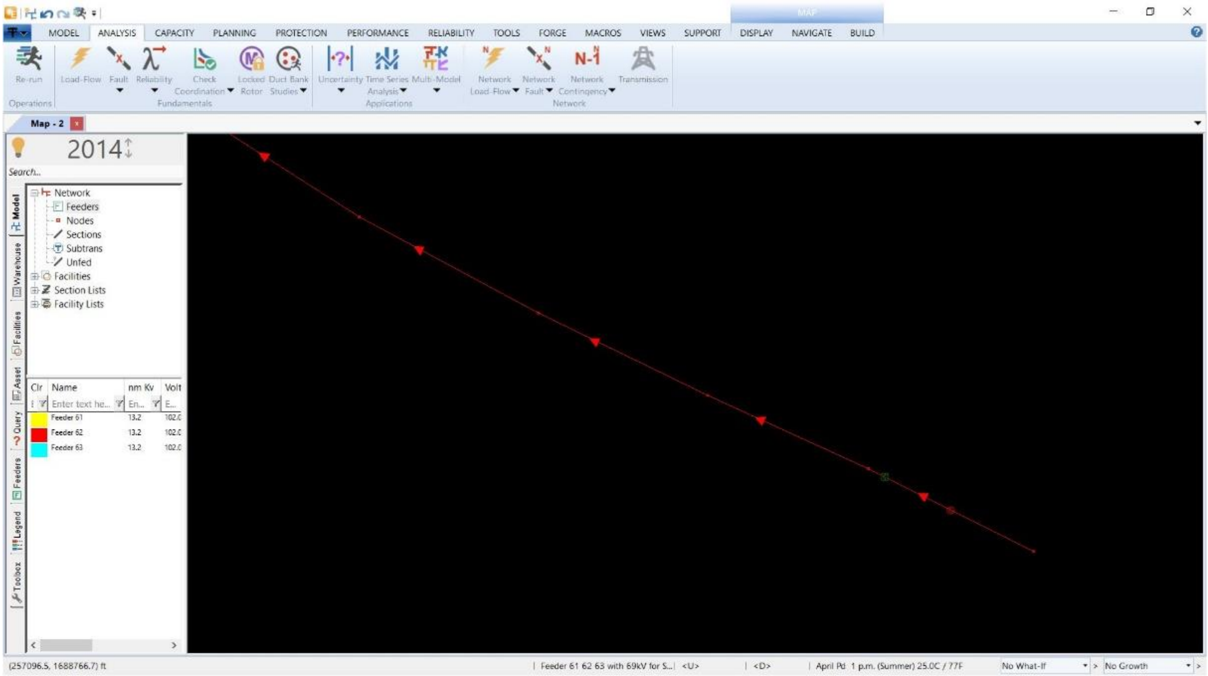


Figure 3.3.6.2. Power Flow as simulated on Synergi during the entry of the proposed 5 MW PELCO I-Owned Embedded Escaler Solar Power Plant

Based on the above illustration, the proposed 5MW PELCO I-Owned Embedded Solar Power Plant production does not create a reverse power flow since the energy produced has been consumed by the customer load demand of the San Pablo Substation. Thus, reverse power flow does not affect the power reliability of the system.

3.3.7 ELECTRICAL ANALYSIS

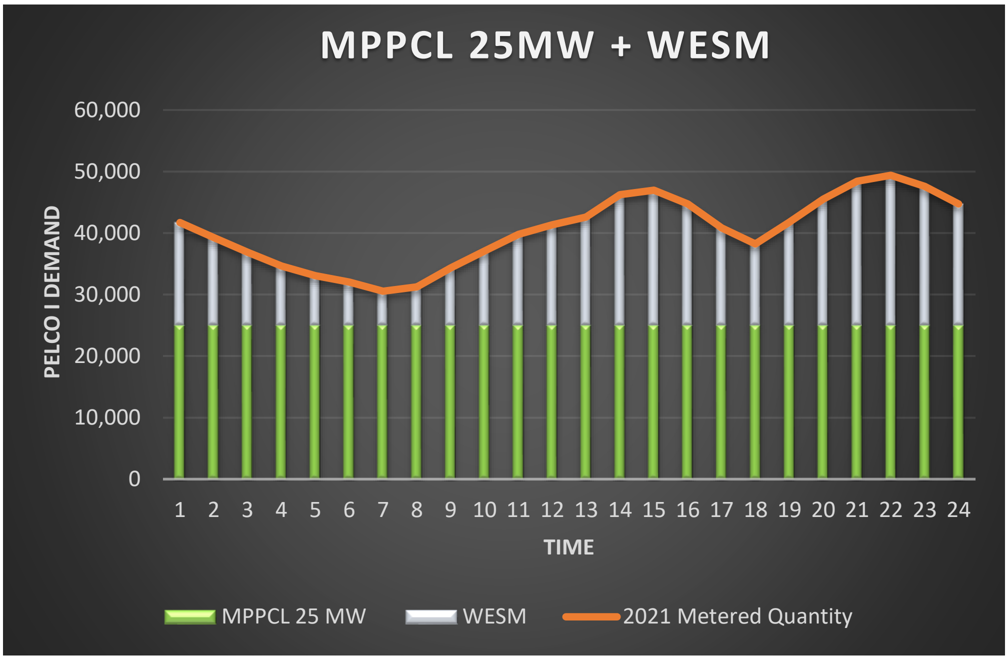


Figure 3.3.6.1 Typical Daily Load Curve of PELCO I without Solar Integration

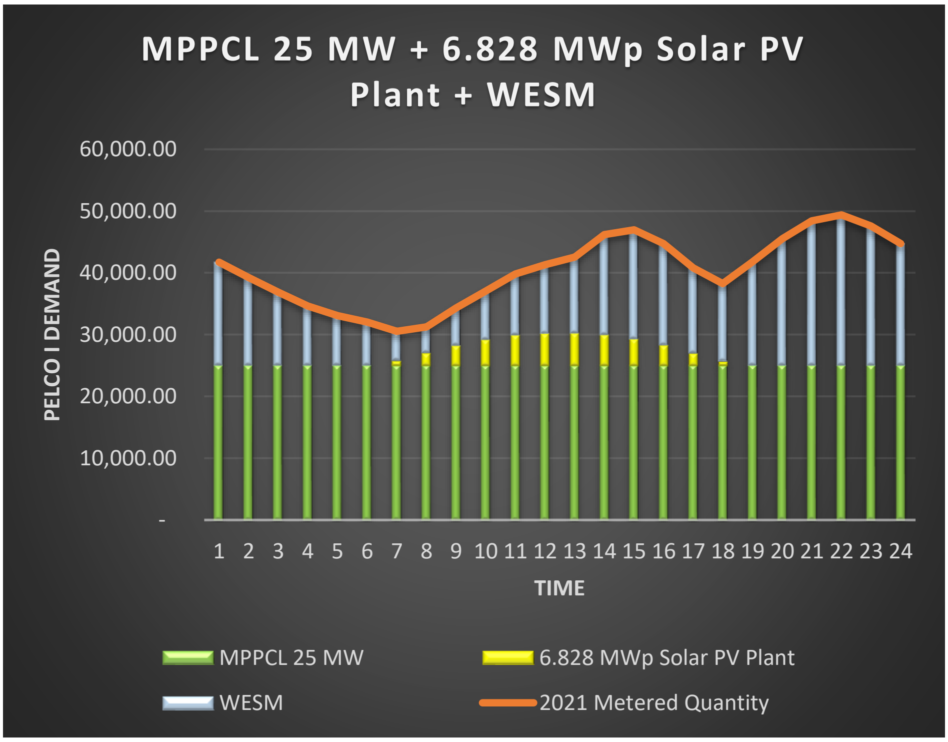


Figure 3.3.6.2 Typical Daily Load Curve of PELCO I with Solar Integration

3.4 Distribution Asset Study (DAS)

3.4.1 Thermal Loading

The project's interconnection will be on the Feeder 62, 13.2kV Backbone 3 Phase Primary Line of PELCO I. However, the only line available on the site is a 7.620kV single-phase primary line. There is a need to rehabilitate and extend a 3 Phase, 4/0 Treewire Backbone Primary Line to cater to the energy delivered to the distribution grid. The asset study also includes the rehabilitation and replacement of 1.99km of backbone line from 2/0 into 4/0 Treewire in Kabayung Sarul Maragul, Escaler, Magalang. In addition, an extension of 0.280km of 3 Phase Primary Line to complete the line for the distribution of generated energy from the proposed 5MW Solar EG Plant of PELCO I. The rehabilitation and distribution line extension cost will be included in Chapter 5 under the construction cost estimate.

Figure 3.4.1.1 Interconnection Map of the PELCO I 5 MW EG Plant

3.4.2 Control and Safety

Installation of SCADA, telecommunication protection equipment, and communication links for status, monitoring, and control of the 5MW Solar EG Plant was included in the cost proposal.

PAMPANGA I ELECTRIC COOPERATIVE, INC.
Sto. Domingo, Mexico, Pampanga
Tel Nos.: 966-0604 * 875-0552 Fax No.: 966-0270
Email Add.: pelco1_mexico72@yahoo.com

AS-PLAN BILL OF MATERIALS

Date: 04/18/2022

A. Name of Project : EXTENSION AND REHABILITATION OF 3 PHASE PRIMARY LINE (FOR 5MW SOLAR EG PLANT)
B. Location: ESCALER, MAGALANG

DESCRIPTION	UNIT COST (PESOS)	PROJECT REQ'MNTS.	EXTENDED COST
Bolt, Carriage 3/8" X 4-1/2"	11.57	28	324.00
Bolt, Double Arming, 5/8" X 20"	101.79	42	4,275.00
Bolt, Oval Eye, 5/8" X 12"	96.43	9	867.86
Bolt, Thimble Eye, 5/8" X 10"	93.60	12	1,123.20
Bolt, Machine, 1/2" X 6"	24.64	43	1,059.64
Bolt, Machine, 1/2" X 12"	36.43	7	255.00
Bolt, Machine, 5/8" X 12"	53.57	41	2,196.43
Bolt, Machine, 5/8" X 14"	58.93	29	1,708.93
Bolt, Single Upset, 5/8" X 12"	93.21	29	2,703.21
Brace, Crossarm, 28" Steel	99.64	28	2,790.00
Brace, Alley arm, Diagonal, 7 Ft.	814.29	43	35,014.29
Bracket, Clevis Deadend W/O Spool	77.14	5	385.71
Clamp, Loop Deadend #6 To #2/0 ACSR	51.43	14	720.00
Clamp, Deadend Strain, #1/0 - #2/0 ACSR	310.71	33	10,253.57
Clevis, Secondary Swinging W/O Spool	81.43	11	895.71
Conductor, Bare, ACSR, #1/0, AWG. 6/1 (MTS.)	33.00	2,872	94,776.00
Conductor, Treewire, ACSR, #4/0, AWG. 6/1 (MTS.)	160.20	9,072	1,453,334.40
Connector, Ampact, #4/0 ACSR	385.71	6	2,314.29
Connector, Compression, #6-#1/0 ACSR Run to #6-#2	37.50	39	1,462.50
Connector, Compression, #1/0-#2/0 ACSR Run to #1/0-#2/0	80.36	10	803.57
Insulator, Pin Type, HDPE, ANSI Class 55-4	450.00	129	58,050.00
Insulator, Spool, 1-3/4", ANSI Class 53 - 2	21.43	29	621.43
Insulator, Spool, 3" ANSI Class 53 - 4	48.21	16	771.43
Insulator, Suspension, Polymer, 4 sheds	460.71	33	15,203.57
Guy grip	120.00	24	2,880.00
Nut, Eye, 5/8" Conventional	51.43	35	1,800.00
Pin, Crossarm, Long Shank, 1" Thread Diameter	294.64	129	38,008.93
Rod, Anchor, Threaded, Single Eye, 5/8" X 7'	321.43	12	3,857.14
Rod, Anchor, Bonding, Single Eye, 5/16" x 2.5", HDG	32.14	12	385.71
Washer, Square, Flat 2-1/4" X 2-1/4" X 3/16"	13.93	325	4,526.79
Washer, Square, Flat 4" X 4" X 1/2" W/ 7/8" Dia. Hole	96.43	12	1,157.14
Wire, Tie, Aluminum, Alloy, Soft, #4 AWG (Ft.)	5.57	840	4,680.00
Wire, Grounding, Galvanized, 5/16" (Ft.)	6.80	675	4,592.41
Wire, Guy, Steel, 3/8", 7 Strand (Ft.)	10.71	600	6,428.57
Pole, Steel, 6ft.,	3,642.86	24	87,428.57
Pole, Concrete, 40 ft. CL 5	15,660.00	15	234,900.00
Anchor Concrete Block	750.00	12	9,000.00
Crossarm, Steel, 3" X 4" X 8'	1,782.24	57	101,587.44
	Total Material Cost		2,193,142.45
	Labor Cost		657,942.73
	12% VAT on Material & Labor		342,130.22
	Total Project Cost		**3,193,215.40**

3.4.3. Construction Cost Estimate of the proposed PELCO I 6.828MWp Solar EG Plant Distribution Line Extension and Rehabilitation

HUMAN RESOURCES AND ADMINISTRATIVE REQUIREMENTS

4.1 Institutional Framework of the Project

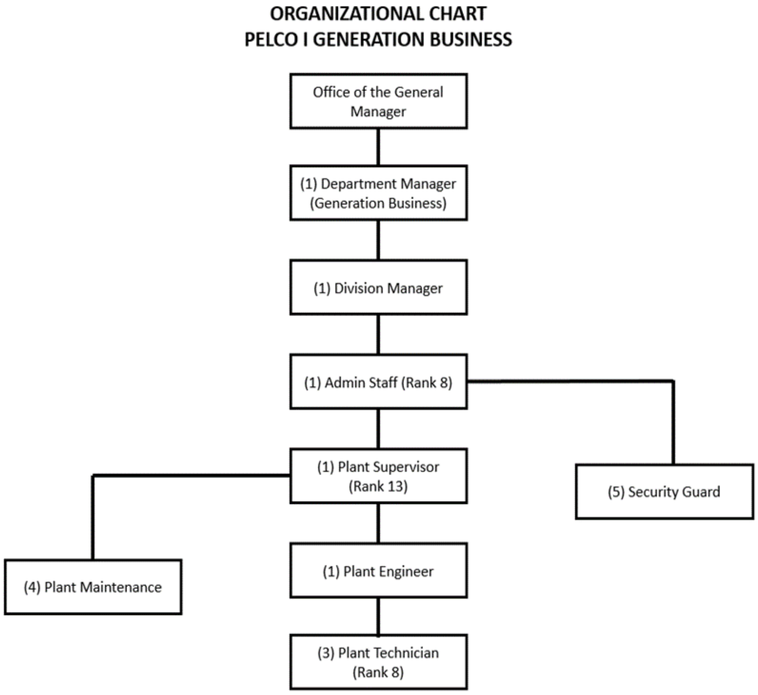


Figure 4.1.1 Institutional Framework of the Proposed PV Plant

Figure 4.1.1, PELCO 1 proposes creating a new department under its generation business. The proposed department will be called the "Generation Department," having eight (8) personnel with seven (7) boards of directors.

4.2 Manpower and Management Requirements

The proposed PV Plant will consist of the following workforce:

4.2.1 (1) Department Manager (Generation Business)

- Must be a Licensed Registered Engineer
- Overall supervision of the operation and maintenance of the plant.
- Morning Shift (8:00 AM –5:00 PM)

4.2.2 (1) Division Manager

- Must be a Licensed Registered Engineer or Certified Public Accountant
- Responsible for the technical and/or financial reporting and monitoring of the solar plant's output.
- Morning Shift (8:00 AM –5:00 PM)

4.2.3 (1) Admin Staff (Rank 8)

- Must be a Four-Year College Course Graduate
- Responsible for supervising all the employees, including the Plant Maintenance crew and Security Guards.
- Morning Shift (8:00 AM –5:00 PM)

4.2.4 (1) Plant Supervisor (Rank 13)

- Must be a Licensed Registered Engineer
- Responsible for supervising the plant engineer, plant technician, and the four (4) plant maintenance crews.
- Morning Shift (8:00 AM –5:00 PM)

4.2.5 (3) Plant Technician (Rank 8)

- Must be a Licensed Registered Master Electrician
- Responsibilities include monitoring and servicing systems, diagnosing problems and troubleshooting equipment, running tests and completing reports, updating and improving existing systems, and repairing or replacing faulty equipment.
- Two shifts: Morning (5:00 AM-2:00 PM) & Afternoon (10:00 AM-7:00 PM)

4.2.6 (4) Plant Maintenance (daily/Pampanga rate)

- Can be high school or college graduate.
- Tasked for the maintenance of the plant, trimming of grasses, and cleanliness of PV Module.
- Morning Shift (8:00 AM –5:00 PM)

4.2.7 (5) Security Guard (daily/Pampanga rate)

- Must be at least a high school graduate.
- Must be physically and mentally fit to work as a security guard. Must have undergone pre-licensing training course/basic security guard course.
- Two shifts Morning & Evening (12 Hours Duty)

4.2 Summary of details of Authorization required and Permits

1. Board resolution stating the interest to develop a RE project
2. Board resolution to joint venture with other stakeholders (in the case with partner/s)
3. Board resolution requesting the availment of a loan and further authorizing the EC general manager and board president to sign a loan agreement and other pertinent documents for this purpose
4. The budget request for a loan
5. Pre-feasibility study
6. Feasibility study and detailed engineering design
7. Renewable Energy Service Contract
8. Corporate Social Responsibility Plan
9. Environmental Compliance Certificate (ECC) or Certificate on Non-Coverage (CNC) from DENR
10. FPIC/Certificate of Pre-Condition/certificate of non-overlap from NCIP
11. LGU endorsements (Barangay to Provincial)
12. Water rights permit from NWRB or NIA (if applicable)
13. Land Conversion Certificate /Permits (if applicable)
14. Other clearances from other concerned agencies
15. 15-year Financial Projection
16. Generation rate mix

FINANCIAL STUDY

5.1. Construction Cost Estimate of the PELCO I-Owned 6.828MWp Solar Power Plant (Electro-Mechanical Portion)

Price of Procurement (Electro-Mech and Civil Works)			
	Lot Description	6.828MWp Escaler, Magalang Solar Power Plant	
		Material	Labor Costs
		Total price	Total price
	Electro- Mechanical		
I.	PV Plant		
A.	Modules, Mounting Structure and Combiner Box	₱128,834,382.34	₱6,275,144.00
B.	Cables and Connectors	₱14,911,176.39	₱4,982,424.90
C.	Inverters and Switchgear	₱29,983,074.39	₱624,750.00
D.	Monitoring, Control and Communications	₱9,979,464.32	₱1,639,669.57
E.	Grid Connection-Related Facilities	₱65,500.00	₱22,925.00
F.	Auxiliaries	₱13,208,401.42	₱3,159,554.69
G	Additional Items:	₱1,081,548.04	
		Material Cost:	₱198,063,527.24
		Labor Cost:	₱16,704,481.33
		VAT on Mat'l and Labor:	₱25,772,161.03
		Insurance During Construction	₱3,000,000.00
		Contingency	₱10,000,000.00
		Total	₱253,540,169.26
	***Nothing follows		

(See Annex D for the detailed Construction Cost Estimate on Electro-Mechanical Works)

5.2. Construction Cost Estimate on Civil Works and Cost of Land

Price of Procurement (Electro-Mech and Civil Works)							
#	Items	6.828MWp Escaler, Magalang Solar Power Plant					
		Unit	Quantity	Material Costs		Labor Costs	
				Unit	Total price	Unit price	Total price
	CIVIL WORKS						
I.	PV Plant						
1	Site clearing (grubbing, removal of vegetation, rocks, etc and disposal)	sqm	**9,600.00**	32.19	**₱309,024.00**		
2	Staking, Levelling, Grading, Embankment, Cut and Fill and Compaction of site area	sqm	9,600.00	64.99	**₱623,904.00**		
3	Access/internal roads within the site (tentatively 4m width, 0.5m shoulders both sides)	sqm	3684.68	846.88	**₱3,120,481.37**		
5	Drainage and Stormwater Collection System	m	1228.23	2,000.00	**₱2,456,460.00**		
6	Sewerage system for the PV plant (control / guard)	Lot	1				
7	Excavation, sand fill, common fill and compaction, crossroad duct banks for cable trenching	Sets	2	253,892.74	**₱507,785.48**		
8	Laydown Area	sqm	1000	210.00	**₱210,000.00**		
	Temporary Fence	90	1,000.00		**₱90,000.00**		
9	Erosion mitigation and control during construction	Lot	1	-			
10	Pile Foundations (if applicable)	Units	-				
11	Perimeter Fence with Guard Posts, Gates, Alarms, and Lighting System	m	1,014.00	3,000.00	**₱3,042,000.00**	₱900.00	₱912,600.00
	Perimter Screw Pile Posts	sets	506.00				
12	Perimeter Fence Foundation with Lightings Only	Units	12	5,000.00	**₱60,000.00**		
13	Inverter station foundations including concrete oil pits and installation	Units	1	435,000.00	**₱435,000.00**		
14	Inverter station platform	Units	1	-			
15	Foundations for Lightning Arrester, CCTV, Perimeter Lighting	Units	12	15,000.00	**₱180,000.00**		
16	Foundations for Weather stations	Assy	1	15,000.00	**₱15,000.00**		
17	Auxiliary Supply Transformer Foundations (3 Units Transformer, Generator, Diesel Tank)	Unit	1	450,000.00	**₱450,000.00**		
II	Land Cost	Lot	1	-			
	Purchase of Land	Lot	63,689.00	200.00	₱12,737,800.00	Cost of Land:	₱12,737,800.00
						Material Cost:	₱11,499,654.85
						Labor Cost:	₱912,600.00
						VAT on Mat'l and Labor:	₱1,489,470.58
						Total:	₱26,639,274.17

5.3. Consolidation of Investment Needs and Determination of Source of Funds

PELCO I, proposes a financial loan from a reputable and registered financial institution to fund the Capital Expenses. These include the Solar Plant Facility cost, Interest During Construction, Value Added Tax, and Contingency. Ninety percent (90%) of the Total Capital Expense will be sourced from the Development Bank of the Philippines. In comparison, PELCO will shoulder the remaining Ten Percent (10%) thru its General Fund. Said loan scheme was part of the loan agreement between DBP and PELCO I.

ANNEX D-1

PAMPANGA I ELECTRIC COOPERATIVE, INC.
Sto. Domingo, Mexico, Pampanga

Assumptions/References

Discount Rate	5.75%	DBP offer Sheet
Loan Term	15 years	DBP offer Sheet
Escalation Rate	4%	Average PhCPI
Collection Efficiency	99%	
System Loss	2024 = 6.9%, 2025 = 6.8%, 2026 = 6.7%, 2027 = 6.6%, 2028-2039 = 6.5%	
Forecast	5% increase per annum	
WESM Price	2021 average price	
Transmission Rate	March 2022 Average Rate	
FIT-ALL Rate	March 2022 Average Rate	
UC Rate	March 2022 Average Rate	
DSM Rate	1.39	Average DSM of PELCO I
Project Costing	1MW = 50m (excluding lot and civil works)	project ABC
Real Property Tax	1% of the assessed value	assessed value is 50% of the market value of the property
ER 1-94	Php 0.01 per kwh	
Community Tax	10,500.00	maximum
Allowance for Bad Debts	1%	
Business tax	0.50%	

CAPITAL EXPENSE		
Solar Plant Facility		253,540,169.26
Interest During Construction		6,811,716.77
Value Added Tax		30,424,820.31
Contingency		4,361,650.60
TOTAL CAPITAL		**295,138,356.93**
Solar Panels/Inverters	ABC	250,000,000.00
Land and Land Development		26,639,274.17
Other Assets		4,132,500.00
Extension of 3-Phase Line		3,193,215.40
SOLAR PLANT FACILITY		**283,964,989.57**

Figure 5.4.1. Financial Assumption, References, and Capital Expense

5.4. Computation on the Levelized Cost of Electricity (LCOE) in Php/kWHr

The total project’s LCOE (Php/kWHr) for twenty-five (25) years is **Php. 5.50** based on the simulation. The Php. 2.42 or 44% will be charged for the recovery of the Capital Fund Expenses, while Php. 3.07 or 56% of the Total Project Cost will be charged on the Operation and Maintenance expenses within the life cycle of the Solar Power Plant. (See Annex D-4 for the detailed computation and simulation)

PV Total Project Cost (Php) =	**704,154,509**
PV Total Income (Php) =	**704,154,509**
Net PV (Php) =	**-**
PV Total Generated Energy (kWh) =	**128,068,858**
Levelized Cost of Electricity (Php/kWh) =	**5.50**
Selling Rate (Php/kWh) =	**5.50**
ROI =	**0%**
Start of Payback	**3**

6.1 Rate Impact

Rate Reduction per Year		
Number	25-Years Projection	Rate Reduction for 25-Years in Php/KwHr
0	2023	0.0000
1	2024	0.0123
2	2025	0.0117
3	2026	0.0111
4	2027	0.0106
5	2028	0.0101
6	2029	0.0097
7	2030	0.0093
8	2031	0.0090
9	2032	0.0084
10	2033	0.0078
11	2034	0.0073
12	2035	0.0068
13	2036	0.0064
14	2037	0.0060
15	2038	0.0057
16	2039	0.0054
17	2040	0.0051
18	2041	0.0048
19	2042	0.0046
20	2043	0.0044
21	2044	0.0042
22	2045	0.0040
23	2046	0.0038
24	2047	0.0037
25	2048	0.0016

Figure 6.1.1. The table above shows the 25-Year rate reduction in peso per kilo-watt-hour of the proposed PELCO I-Owned Solar Power Plant during its generation of electricity. (See attached Annex D-7 for the complete computation of the coop's unbundled rate under Rate Impact Analysis).

ENVIRONMENTAL CONCERNS

Solar energy creates clean, renewable power from the sun and benefits the environment. Alternatives to fossil fuels reduce carbon footprint and greenhouse gases around the globe. Solar was known to have a favorable impact on the environment. However, disposal of solar panels after their working life remains a considerable challenge to the renewable industry.

Generating electricity with solar instead of fossil fuels can dramatically reduce greenhouse gas emissions, particularly carbon dioxide (CO_2). Greenhouse gases, produced when fossil fuels are burned, lead to rising global temperatures and climate change. Climate change already contributes to severe environmental and public health issues, including extreme weather events, rising sea levels, and ecosystem changes.

7.1 Impact of the Project on the Environment

By going solar, PELCO I would contribute by helping the environment by reducing global greenhouse gas and carbon footprints.

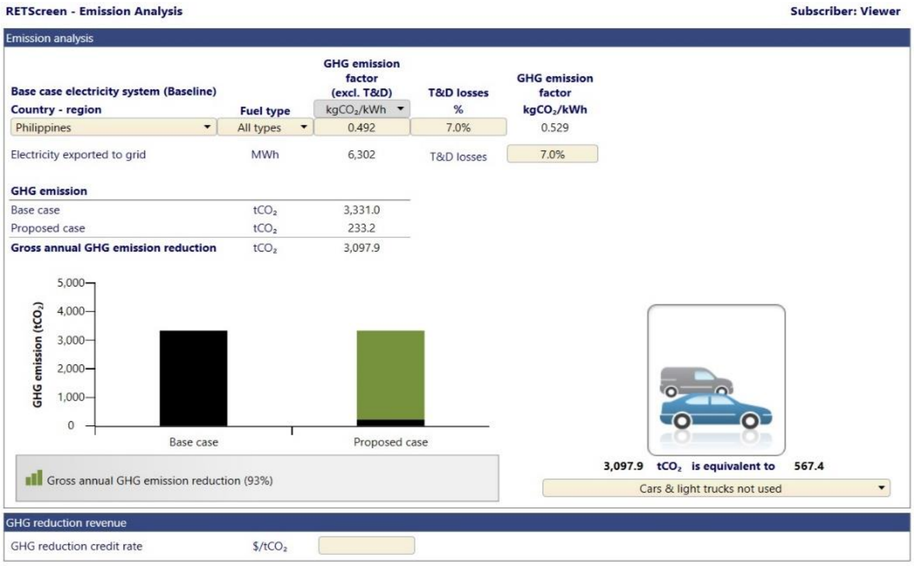


Figure. Simulation of Reduced Carbon footprints from RetScreen

In this figure, the proposed Solar PV Plant will reduce around three thousand ninety-seven (3,097.9 $tCO_{2)}$ carbon dioxide emissions, equivalent to five hundred sixty-seven (567.4) cars and light trucks not used. It can also reduce the gross annual greenhouse gas emission by ninety-three percent (93%).

SOCIAL CONCERNS

The most important social impacts of solar power plants are:

8.1 Acceptance and Awareness of the Public

Promoting the excellent socio and economic impact of the proposed PV Plant was one of the responsibilities of PELCO I. Public acceptance of the Solar PV Plant is often related to landscape. However, the landscape has cultural and environmental aspects: Diverse landscape can maintain more biodiversity and aesthetic and cultural value. Therefore, the landscape should be integrated as one of the socio-ecological impacts or divided into ecological and visual landscapes. With the help of visual landscape planning, cultural heritage and aesthetics can be protected. PV installation usually has a strong negative impact near natural beauty and cultural heritage areas.

8.2 Job Creation

As the proposed PV Project comes into full swing, local employment in the area will be generated. One of the main goals of PELCO I is to make sure that the local community will benefit from the project when it comes to the workforce, from the construction of the PV Plant up to the operation and maintenance phase.

8.3 Health Benefits of Improved Air Quality

Since the proposed PV Plant is clean energy, it will reduce the global emission of greenhouse gas, thus creating an improved air quality that will benefit the people and the next generation.

CONCLUSION AND RECOMMENDATION

This chapter summarizes the proposed project undertaken, the conclusion drawn from analyses and simulations, and the recommendations made as an outgrowth of this proposal.

9.1. Summary of Findings

The salient findings of the proposed project are as follows:

a. The project is technically and financially feasible based on the results of the simulations, computations, and legal considerations.
b. There is no significant degradation in the electrical system of PELCO I, especially in the San Pablo Substation.
c. All asset boundaries were determined.
d. There is a rate reduction of approximately one (1) centavo.

9.2. Recommendations

a. The recommendation is to pursue the construction of the proposed 5MW PELCO I-Owned Escaler Solar Power Plant.
b. The continuation of the further study and construction of the remaining 25 MW Solar Plant Capacity is included in the long-term Philippine Development Plan of PELCO I.
c. Further study on the interconnection of a proposed PELCO I-Owned Embedded Solar Power Plant in its own 69KV Sub transmission line.
d. Considering the inclusion of the study of "Solar-Agrivoltaic."

REFERENCES

1. Philippine Distribution Code 2017 Edition (PDC)
   - Section 3.2.2 of the Philippine Distribution Code, "Frequency Variations."
   - Section 3.2.3 of the Philippine Distribution Code, "Voltage Variations."
   - Section 5.3.3 of the Philippine Distribution Code, "Distribution Impact Studies."
2. National Electrification Administration (NEA), Philippnes
   - NEA Engineering Bulletin DX1120 December 1992, "Voltage Levels on Rural Distribution System."
   - NEA Engineering Bulletin DX1320_" Specifications and Drawings for Distribution Line Construction, 13.2 kV and 24kV"
3. Department of Energy (DOE), Philippines
4. IEEE std. 1547-2003, "IEEE Standards for Interconnecting Distributed Resources with Electric Power Systems."