MMSU | Office of the President
MARIANO MARCOS STATE UNIVERSITY

20 May 2020

ASec. ROBERT B. UY
Assistant Secretary
Department of Energy

Dear Asec Uy:

Greetings from Mariano Marcos State University!

I am writing to pursue our discussion as regards the intent of the Mariano Marcos State University (MMSU) to work with the Department of Energy (DOE) to promote the objectives of "E-Power mo" in general and, in particular, promote the use and development of Renewable Energy in the Ilocos region.

Please kindly recall, that during our meeting in January 2019, I mentioned that MMSU plans to conduct a "Feasibility Study for MMSU to Achieve Net-Zero Energy Buildings (NZEBs)." MMSU hopes to serve as a pilot project site that would showcase how RE technologies can be used to achieve NZEBs. The "Net-Zero study" may also attract investors to partner with MMSU on this regional endeavor.

I have attached a Project Brief that explains the objectives and proposed activities under this study.

MMSU is willing to assign a Focal Person and a Team of Experts from the University to work with the DOE in finalizing the attached Project Concept Paper and the Terms of Reference of an Energy Specialist that will be contracted to lead in the preparation of the study.

I look forward to an energy-filled partnership with the Department.

Very truly yours,

SHIRLEY C. AGRUPIS
President

PROJECT BRIEF

"Feasibility Study for MMSU to Achieve Net-Zero Energy Buildings (NZEBs)."
Mariano Marcos State University -Department of Energy

Stakeholders of the Project

The project will be jointly implemented by the Department of Energy (DOE) and the Mariano Marcos State University (MMSU).

The Renewable Energy Management Bureau (REMB) will be the implementing unit of this activity on behalf of the DOE. The Development for Renewable Energy Applications Mainstreaming and Market Sustainability (DREAMS) project, a project being led by the REMB, will provide technical and financial support for the conduct of the study.

The Energy Audit Team of MMSU will be the implementing unit of this activity on behalf of the MMSU. MMSU will provide counterpart staff and funds.

Other local stakeholders like the Ilocos Norte Electric Cooperative and RE Generators operating in the area will also be involved as sources of data and resource persons in the study.

A. Objective of the "Net Zero Study"

The "Feasibility Study for MMSU to Achieve Net-Zero Energy Buildings (NZEBs)" will be used to guide MMSU in implementing the activities that will make some, or all, of MMSU's buildings net-zero energy facilities.

The results of the "Net Zero" study also hopes to encourage investors to invest in the development of MMSU as a pilot project site that would showcase how RE technologies can be used to achieve NZEBs.

B. Requirement for Technical Assistance

A Net-Zero Energy Specialist (ES) is needed to create a net-zero energy building (NZEB) feasibility study, including an implementation plan, for Mariano Marcos State University (MMSU) located in Ilocos Norte.

The feasibility study should contain the energy audit, recommendations, and cost and economic viability of retrofitting the existing buildings to make them NZEBs, or cost of constructing a new NZEB if this was decided by MMSU.

The ES is expected to:

a. gather primary and secondary data by conducting site visits, key informant interviews, and focused group discussions (as necessary) with the key stakeholders to be able to formulate a comprehensive study.

b. Together with the other experts at MMSU, lead in the writing of the study and share the findings through a stakeholders' forum to determine the best classification of NZEBs that MMSU would like to achieve. The classifications of NZEBs will be based on the US National Renewable Energy Laboratory's (NREL) definitions of: (1) Net-Zero Site Energy, (2) Net-Zero Source Energy, (3) Net-Zero Energy Costs, and (4) Net-Zero Emissions. After determining which classification of NZEBs best suits MMSU, comprehensive feasibility will be conducted.

The detailed content and outline of the study will be agreed upon by MMSU and DOE.

D. Expected Outputs and Deliverables

The feasibility study should, at the minimum, contain the energy audit, recommendations, and cost of retrofitting the existing buildings to make them NZEBs, or cost of constructing a new NZEB if this was decided by MMSU.

The results of this study will be shared by the ES during a stakeholders' forum, which will be led and implemented by the ES with the help of the DREAMS PMU.

The goal of the stakeholder's forum is for MMSU's leaders to decide which NZEB classification they would pursue, based on the ES's recommendations. MMSU should also decide which facilities would be considered in the comprehensive feasibility study.

E. Institutionnel Arrangement

The over-all delivery of the outputs of the ES will be monitored and coordinated by the DREAMS Project Management Unit which is headed by the Director of the REMB. The ES will however have to work closely with the Focal Person assigned by MMSU in the conduct of the study.

Both MMSU and DOE will, subject to availability of space, provide a working area to the ES during his/her consultations with their concerned units.

The MMSU will facilitate linkage with the officials of MMSU and other local stakeholders. The communication, gathering and consolidation of data for the study, within or outside of DOE and MMSU, shall be the responsibility of the ES.

F. Project Duration of the Work

The results of the study must be completed NLT 30th September 2020. The detailed work plan will be discussed between DOE and MMSU.

G. Duty Station

The ES is preferably based in Ilocos Norte. If based in Manila, several fieldworks are expected to be conducted in Ilocos Norte subject to the approved inception plan. The ES is not required to report daily to DOE or MMSU but shall make himself available within 3 days after receipt of notice.

I. Scope of Price Proposal and Schedule of Payments

Funds for the professional fees and local travel of the ES will be shouldered by the DREAMS project. Local consultations and accommodation of the ES and REMB staff during field visits if any, will be the counterpart of the MMSU.

UNITED NATIONS DEVELOPMENT PROGRAM
DEPARTMENT OF ENERGY
MARIANO MARCOS STATE UNIVERSITY
DREAMS PROJECT

TERMS OF REFERENCE

SOLAR PUMP IRRIGATION SYSTEM OFF-PEAK PRODUCTION UTILIZATION

(2 sets of 4.3kWp & 1 set of 10kWp)

As part of Mariano Marcos State University's quest for Net Zero Energy Buildings and Development for Renewable Energy Applications Mainstreaming and Market Sustainability (DREAMS)

2021

TABLE OF CONTENTS

A. Background

The Development for Renewable Energy Applications Mainstreaming and Market Sustainability (DREAMS) Project is a five-year project being implemented by the Department of Energy (DOE) through its Renewable Energy Management Bureau (REMB) in partnership with the Global Environment Facility (GEF) and the United Nations Development Programme (UNDP).

The objective of the DREAMS Project is to reduce GHG emissions through the promotion and facilitation of the commercialization of renewable energy (RE) markets through the removal of barriers to increase investments in RE-based power generation projects. This will be achieved through (1) enforcement of a supportive policy and regulatory environment for leveraging investment in RE development and applications at the local level, (2) strengthened institutional capacity that leads to increased RE investment at the local level, (3) capitalized RE market to increased share of RE-based power capacity, and (4) RE commercialization to increase confidence of local RE developers that leads to an enhanced uptake of RE projects and successful replication using proven and emerging RE technologies.

The DREAMS project has a Support Fund for RE (SF4RE) that can be accessed by MMSU, ECs, NPC-SPUG, QTPs, NPPs, BAPAs and RE developers to leverage investments for their RE projects that will lead towards an increase in RE based installed capacity. The DREAMS project will provide technical assistance to MMSUs and smaller RE proponents for them to be able to access the SF4RE and other financing instruments.

B. Stakeholders of the Project

The project will be implemented together with Mariano Marcos State University. The DREAMS Project Management Unit (PMU) shall maintain over-all project coordination.

C. Objective

The Solar energy produced by the existing Solar Irrigation system of the Department of Agriculture will be utilize during off season to contribute to the quest of MMSU in attaining Net Zero Energy Buildings or NZEBs. A Solar Engineering Procurement Construction (EPC) is needed to design and install a power cabinet to house the inverters including manual transfer switches, dc and ac circuit breakers, surge protection devices. In addition, this also includes the excavation and concreting of distribution poles, construction of distribution lines going to the nearest MMSU building with three (3) phase 220 volts system.

D. Scope of Work and Methodology of the Required Services

- Supply and install switching system, i.e. grid tie inverters and other protections in an elevated power cabinet on a concrete foundation complete with pipes and wirings
- Excavation and concreting of distribution poles foundation and construction of distribution line based on the shortest route or as provided.
- After completion, the Firm must provide maintenance support and provide warranty on the equipment and workmanship as specified in the Bill of Materials.

The specific scope of work is detailed below:

1. Inception Plan/Preparation of Work Plan

Once the contract is awarded to the firm, the firm is required to create an inception plan/work breakdown in consultation with the MMSU and the DREAMS PMU. At the minimum, the inception plan should contain an estimated timeline of activities and exact scope of work ranging from engineering works.

2. RE Facility Design

The firm is highly encouraged to do a physical site visit on the project site if upon their review additional information and variation is needed.

The design for the system will be based on the installed solar capacity of the irrigation facility which is 2 sets of 4.3 kilowatts and 1 set of 10 kilowatts. Also, the firm must provide electrical single line diagram of the system connection to the existing facility.

3. Supply Equipment

The firm would be responsible for the procurement, supply, and delivery of all the equipment needed for the installation, based on the approved design and material specification. An estimate of the equipment needed is listed in the Bill of Materials.

4. Installation

The Firm is responsible for all aspects installing the system. This includes:

1. Civil works for the distribution poles foundation, mounting system and electrical works i.e. grid tie inverters, cables, electrical protection devices, electrical wiring, and commissioning the system. The Firm must also provide all personal protective equipment (PPE) needed by the installers.
2. Distribution Line: these include the distribution line route, distribution pole height and classification, tapping points, the inverter cabinets, etc.

   Note: These specific work items which would be covered by the Firm or proponent would be agreed upon and be made part of the implementation plan. Additional work required by the Firm but not included in the agreed work plan will be for the cost of the Firm, while cost for additional work required by the proponent will be shouldered by the proponent. The Firm must provide the manpower, all equipment, and tools necessary to complete the installation.

5. Operate and Maintain

The Firm is expected provide technical advice and send support staff as part oversee the maintenance for a minimum period of four months. The General Terms and Conditions of the Maintenance Agreement shall be included in the bid offer and shall be part of the bid evaluation.

6. Skills Training

The Firm should will conduct actual orientation to MMSU tender, designated staff or technical team in the proper switching operations of the facility as part of the commissioning and maintenance agreement. A minimum of one day lecture to discuss the system design, basic installation skills, and system troubleshooting and basic maintenance. The training design will be part of the evaluation of the bid proposal.

E. Expected Outputs and Deliverables

The Firm in close coordination with MMSU, and DREAMS PMU shall create a workplan with a detailed work breakdown structure to execute the following:

1. **System design**

The Firm must submit a detailed system design supported by illustration drawings , mounting system layout, proposed location of the inverter cabinet/box, the line route, and interconnection to the existing DA irrigation pump solar PV's. Also, an electrical line diagram is required as a plan for the electrical wiring.

2. **Equipment delivery**

The Firm is responsible in the procurement of all equipment needed for the installation and should ensure the safe delivery of the items to the project site.

3. **Installation**

The Firm is in-charge of installing the Solar PV system (mounting system, solar PV panels, inverters, cables, and other balance of system) on the identified sites according to the approved final system designs. The electrical connections to the grid and installation of safety protection devices is also the responsibility of the installer.

4. **System Commissioning and Testing**

The Firm is responsible for the system commissioning and testing. Once the commissioned system reaches 5 days of continuous satisfactory performance based on the specified technical capacities, e.g. KW outputs, then the system testing will be considered completed.

5. **Maintenance Period**

The minimum maintenance period is two (2) months after the system is commissioned and tested. The maintenance should comply with the accepted maintenance level agreement. The general terms and conditions of the proposed maintenance service level agreement shall be submitted as part of the Firm's application to this request for proposals.

Deliverables/ Outputs	Estimated days to Complete	Target Due Dates
Approved system design	5	Jan 2022
Equipment Delivery	15	Feb 2022
Installation	120	Mar 2022 – Jun 2022
System Commissioned & working for 5 straight days. Submission of all as-build plans (Solar PV system and electrical wiring), warranty certificates and other pertinent documents.	5	Jun 2022
Maintenance period	60	Jul 2022-August 2022

F. Duration of the Work

The contract period is will be from March 2022 to June 2022.

G. Professional Qualifications of the Successful Firm Contractor and its key personnel

Refer to Part I. "Criteria for Selection of the Best Offer"

H. Scope of Price Proposal and Schedule of Payments

This is a lump-sum approach. The lump sum amount must be "all inclusive" of expenses, e.g. supplies, meals, lodging, and other local travel fares. The contract price is fixed regardless of changes in cost components.

Deliverables	Payment
Approved of Inception Plan, Completed Community Mobilization, Meeting with MMSU, and detailed System Design	10%
Equipment Delivery	40%
Installation (50% finished based on total system capacity)	35%

System Commissioned & working based on approved technical specifications, for 5 straight days. Submission of all as-build plans (Solar PV system and electrical wiring), warranty certificates and other pertinent documents.	10%
Maintenance period (after 2 months or depending on the final offer of the bidder)	5%
Total	100%

I. Criteria for Selection of the Best Offer

The Combined Scoring Method, using a 70%-30% distribution for technical and financial proposals, respectively, will be implemented. The minimum passing score of the technical proposal is 70%. The evaluation of the Technical Proposal will comprise the 3 major criteria as shown in the table below.

Technical Proposal Evaluation Criteria		**Points Obtainable**
1.	Bidder's Qualification, Capacity, and Experience / Expertise of the Firm	300
2.	Proposed Methodology, Approach, and Implementation Plan	400
3.	Management Structure and Key Personnel	300
	Total	**1000**

J. Minimum Technical Qualifications of Firms

Section 1. Bidder's Qualification, Capacity, and Experience		**Points Obtainable**
1.1	**Track Record:** Minimum of 3 years of continuous experience in project integration or Engineering, Procurement and Construction EPC) of residential and commercial solar PV systems (2 kW to 100 kW systems) • minimum score = 70 points; additional 10 points for every additional year maximum of 100 points	100

1.2	**Track Record (value):** Minimum Php 3 Million (worth gross sales or contract price) of completed the engineering, procurement, and construction in the last 3 years (2018-2020).	200
Total Section 1		300

Section 2. Proposed Methodology, Approach and Implementation Plan		**Points obtainable**
2.1	• Training: Number of days for the training of participants is at least 5 days • Minimum = 70 points for 5 days, additional 10 points for every additional day maximum of 100 points	100
2.2	• Operations and Maintenance: Minimum of 4mos for the maint. period • Minimum = 170 points for 4 months, additional 10 points for every additional month maximum of 200 points	200
2.3	• Warranty on workmanship: Minimum of 1 year • Warranty on equipment must meet the specs indicated in Annex B. • Meets the minimum requirements = 70 points, additional 10 points for every additional year on workmanship warranty • If minimum is not met = 0 points	100
Total Section 2		400

A detailed CV of all Team members using Annex 5 template shall be submitted and shall reflect and show evidence of the criteria set below

3. Project Team Composition			**Points obtainable**
3.1	Team Project Manager: minimum a Senior Level Executive or Officer with permanent item/regular employee (Division/Unit Head; Manager or equivalent position) of the firm for a minimum of 3 years • minimum = 70 points • additional 10 points for each additional year of employment, maximum of 100 points • if not senior level and permanent = 0 points regardless of years in service		100
3.2	**Electrical Engineer/ Electrician**		100
	• Educational Background: Minimum AB/BS degree in Electrical or Electronics engineering <u>with license</u> • minimum = 17.5 points; additional 3 points for every additional degree or certificate related to the solar pv installation or RE in general maximum of 25 points	25	
	Experience: • minimum 3 years of experience in designing and doing electrical works in buildings, residential homes and other infrastructure • minimum 17.5 points; additional 2 points for every additional year of experience maximum of 25 points	25	
	• minimum 1 year of actual experience in designing and/or installing electrical systems of solar PV systems	50	

	• minimum 35 points; additional 5 points for every additional year maximum of 50 points		
3.3	**Head Installer/ Foreman**		100
	Education: • Minimum High School graduate • Minimum = 35points; additional 5 points for every additional degree of any course, maximum of 50 points	50	
	Experience: • minimum 2 years of supervising Solar PV systems installations • minimum = 35 points; additional 5 points for every additional year, maximum of 50 points	50	
Total			**300**

K. **Documents required to be submitted:**

1. CV of key personnel (refer to Annex C)
2. Portfolio of at all past Solar PV projects completed in the last 3 years (optional to attach actual pictures; max of 2 pictures per project)
3. Audited Financial Statements in the last two (2) years or FY2019 and FY 2020
4. The Proposed General Terms and Conditions for the Maintenance Level Agreement

L. **Proposed Bill of Materials**

ITEM	UNIT	QTY	WARRANTY PERIOD
MAJOR COMPONENTS + PROTECTION			
Grid Tie Inverter, 5 kilowatts, Input: 80-200 Vdc, Output: 220Vac Single phase 60HZ	pcs	4	2 year

ITEM	UNIT	QTY	WARRANTY PERIOD
DC Breaker, MCB	pcs	4	
DC SPD	pcs	4	
AC Breaker, MCB	pcs	4	
AC SPD	pcs	4	
NEMA 3R panel box	pc	4	
Marshalling box, 10" x 10"	pc	2	
40AT circuit breaker	pc	4	
10 Ways Distribution Box	pcs	8	
6mm² twin solar cable	m	100	
3 ways MC4 connector pair	pcs	50	
MC4 connector pair	pcs	40	
Metal clamp ½" Diameter	pcs	200	
MOUNTING & WIRES			
Poles + hardware	pcs	160	
Fuse Cut-out with fuse link	set	1	
Lightning Arrester	set	1	
Inverter cabinet with ventilation, stainless water proof	pcs	4	
Spool insulator with bracket	pcs	160	
Secondary Bracket	pcs	50	
Entrance cap 1"	pcs	4	
GI Pipe 1" dia.	pcs	4	
1" metal clamp	pcs	40	
1" Male coupling	pcs	20	
1" elbow GI	pcs	40	
PVC ½" Diameter	pcs	50	

ITEM	UNIT	QTY	WARRANTY PERIOD
Elbow, PVC ½" Diameter	pcs	100	
#3.5mm² THHN copper wire	m	100	
#8 mm² THHN copper wire	m	30	
#14 mm² THHN copper wire	m	800	
#22 mm² THHN copper wire	m	800	
2" x 2" x 3/16" angle bar	pc	40	
S1 gravel and sand	load	5	
Holcim Cement	pcs	200	
LABOR AND INSTALLATION			
Installation Labor + mobilization	lot	1	

OTHER MATERIALS AND CONSUMABLES	UNIT	QTY
Drill bit masonry 3/16"	pcs	5
Drill bit metal 1/8"	pcs	2
Metal Primer, gray, 1 lit	pcs	100
Black, QDE, 1 lit	pcs	200
¾ marine plywood	pcs	50
Pencil Torch	pc	1
Blind rivet	box	32
Concrete Nail, 2"	kg	16
Plastic Cable Ties 12", pack of 100	pack	2
Elastomeric Sealant	sachet	6
Rubber tape, big	pcs	20
Electrical tape	pcs	30

SOLAR PUMP IRRIGATION SYSTEM OFF-PEAK PRODUCTION UTILIZATION
(2 sets of 4.3kWp & 1 set of 10kWp)

- Cost Estimate (Php 3, 600,617.18)

PARTICULARS	ESTIMATED COST
Major Components and Protection	306,656.00
Mounting and Wires	2,179,184.00
Other Materials and Consumables	200,462.08
Hauling + Transportation Expenses	80,000.00
Insurance Cost	134,315.10
Installation Cost	600,000.00
Training Cost	30,000.00
Others (Contingency)	70,000.00
OVERALL TOTAL	**Php 3,600,617.18**

UNITED NATIONS DEVELOPMENT PROGRAM
DEPARTMENT OF ENERGY
MARIANO MARCOS STATE UNIVERSITY
DREAMS PROJECT

FEASIBILITY STUDY

MARIANO MARCOS STATE UNIVERSITY – NET ZERO ENERGY BUILDINGS

As part of Mariano Marcos State University's quest for Net Zero Energy Buildings and Development for Renewable Energy Applications Mainstreaming and Market Sustainability (DREAMS)

2021

Mariano Marcos State University NZEB Study

1. INTRODUCTION & RATIONALE

The concept of Net Zero Energy Building (NZEB) is to make the building carbon footprint zero. Generally, this is achieved by first reducing the energy demand of the building through energy efficiency technologies and energy conservation then supplying the demand by on-site or off-site renewable energy sources. The NZEB quest of the Mariano Marcos State University (MMSU) is a noble pursuit towards energy neutral campus is attainable.

MMSU has been proactive and very supportive in the government goal of reducing the CO_2 emission of the country as early as 2005. This is manifested by MMSU's effort to reduce its energy consumption by more than 10% as mandated by the DOE since 2007 until today. This efforts of MMSU was resulted into a Five Star Award (97% compliance) on the "Energy Conservation Measures in the Government" in 2009 and the "Don Emillo Abello Energy Efficiency Award" in 2017.

MMSU has an active Energy Management Team that formulates policies and ensures its implementation towards Energy Efficiency and Conservation (EEC). Several EEC programs has been implemented already at MMSU like (1) Lighting Retrofitting Program; (2) All new ACU installations must be Inverter Type; (3) Setting of ACU thermostat to 25°C and 6 hours operation only; and many more. Above all, the President of the university is very supportive and the prime mover of the Energy Self-Sufficiency Program of the University.

At present, there are already existing and on-going solar installations at MMSU. These are:

A. Existing
1. Two sets of 10kWp Hybrid Grid-Tied system to power 2 sets of 150L capacity Reflux distiller
2. 4kWp OFF GRID for experimental purpose
3. 3 sets of 1kWp Solar Pump Irrigation System
4. 15 units of Solar Street lights

B. On-going
1. 2 sets of 4.3kWp Solar Pump Irrigation System funded by the Department of Agriculture
2. 1 set of 10kWp Solar Pump Irrigation System funded by the Department of Agriculture
3. 4 sets of 1kW Solar Pump Irrigation System

Generally, MMSU is doing a lot of effort already towards reducing its carbon footprint, hence, the quest for NZEB is not an impossible dream. In fact with the vast resources of MMSU, MMSU can pursue a NZEB PLUS status.

NZEB Plus is an NZEB that produces more energy *On-site* than its annual energy consumption and sells the excess energy generated to the grid or to interested Green Energy Option Program (GEOP) *End-user*. NZEB Plus is a sure NZEB, which qualifies for NZE Site, *Source, Cost and Emission.* NZEB Plus status can be achieved by maximizing the solar potential of MMSU both rooftop and ground and participate to GEOP not only as End-user but as well as RE Source. The inclusion of a Biomass power generation will ensure the reliability of power during power interruption from the local electric cooperative.

The question to answer is how much investment is needed to achieve the NZEB Plus Status and when will be the payback period? This is the purpose of the study to look into the feasibility of MMSU NZEB Plus quest.

Definition of Terms

EM Team - Energy Management Team

GEOP - Green Energy Option Program

NZE Site - Net Zero Site Energy is a site NZEB produces at least as much RE as it uses in a year, when accounted for at the site.

NZE Source - Net Zero Source Energy is a source NZEB produces (or purchases) at least as much RE as it uses in a year, when accounted for at the source. Source energy refers to the primary energy used to extract, process, generate, and deliver the energy to the site. To calculate a building's total source energy, imported and exported energy is multiplied by the appropriate site-to-source conversion multipliers based on the utility's source energy type.

NZE Cost - Net Zero Cost Energy in a cost NZEB. The amount of money the utility pays the building owner for the RE the building exports to the grid is at least equal to the amount the owner pays the utility for the energy services and energy used over the year.

NZE Emission - Net Zero Emission Energy is a net-zero emissions building produces (or purchases) enough emissions-free RE to offset emissions from all energy used in the building annually. Carbon, nitrogen oxides, and sulfur oxides are common emissions that NZEBs offset. To calculate a building's total emissions, imported and exported energy is multiplied by the appropriate emission multipliers based on the utility's emissions and on-site generation emissions (if there are any).

NZEB - Net Zero Energy Building. Net zero energy buildings are highly efficient buildings with extremely low energy demand, which is met by renewable energy sources. Such buildings produce as much energy as they consume, accounted for annually. In order to achieve net zero energy goals, NZEBs must first sharply reduce energy demand using energy efficient technologies, and then utilize renewable energy sources to meet the residual demand.

RE- Renewable Energy

2. TECHNICAL AND FINANCIAL DETAILS

This section presents the general concept of RE sources like Solar & Biomass, site locations for each installation and Financial and Technical Performances of each RE source covered in this report.

2.1. Site Location

The Mariano Marcos State University Batac Campus has a land area of 264.95 ha which houses several National Research Institutes like the Philippine Rice Institute, National tobacco Administration, Philippine Carabao Center and Department of Agriculture. Majority of this land area is for agricultural use, either for research or for production. The vast area for agricultural land has a potential of 5MWp for ground mount solar installations on farm roads (brown colored line) and open irrigation canals (light blue rectangles). The ground mount solar installations do not affect the land utilization because no PV modules will be installed on any planting area.

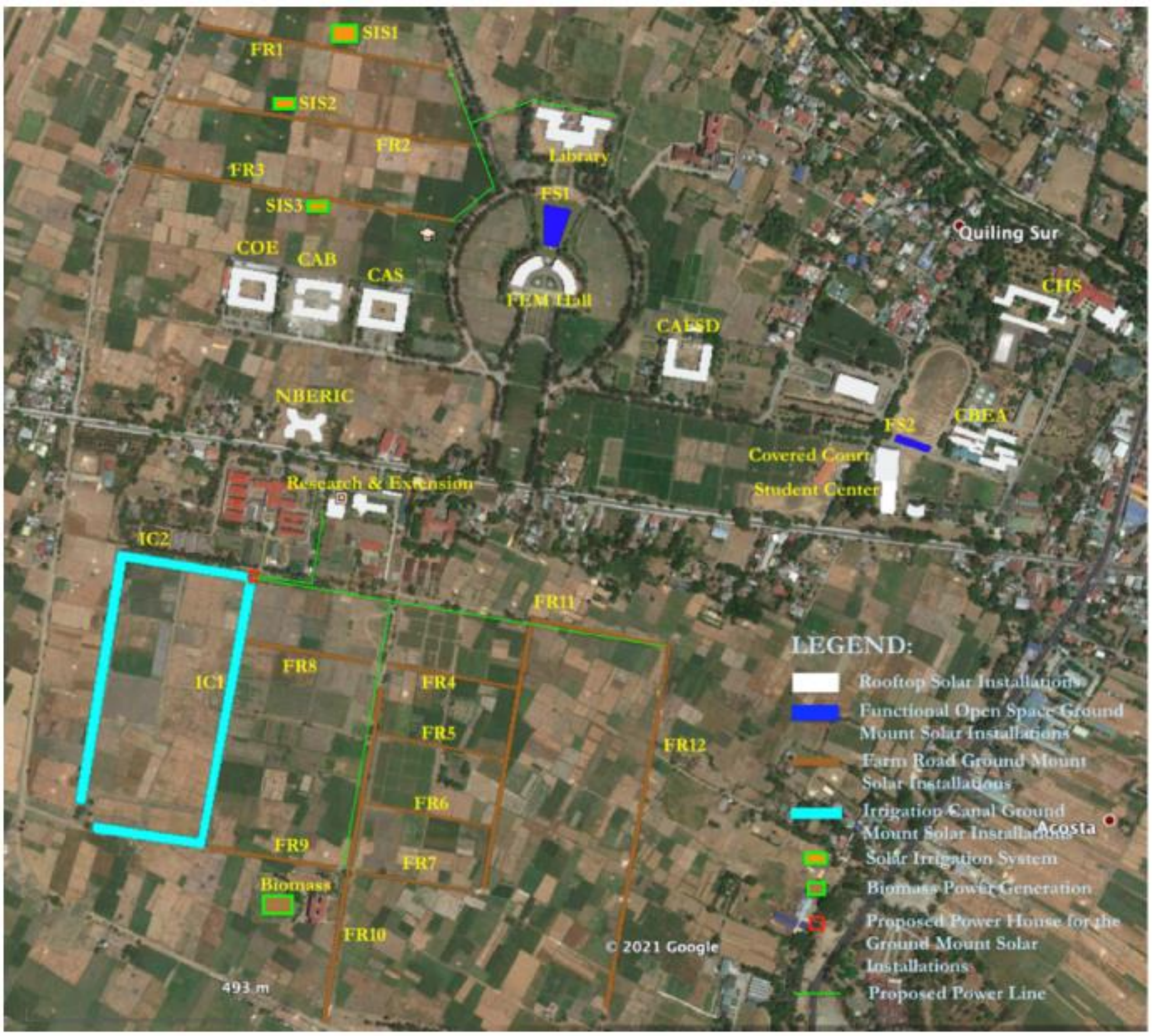


Fig. 2.1. MMSU NZEB site development plan showing the locations of each of the proposed renewable energy sources installations.

Other possible ground mount solar installations will be on functional open spaces (blue polygon) like the sunken garden and southern part of the oval.

The rooftops/roof decks (white polygons) of most of the buildings of MMSU has an accumulated area of more than 33,000 m^2 which has a solar potential of 4MWp.

For the biomass power generation (brown polygon with green outline), the best location is in between the Library and CIMEA due to the accessibility of three phase power line and to the service road.

2.2. Solar PV System

Solar photovoltaics (PV) are semiconductor devices that convert sunlight directly into electricity. They do so without any moving parts and without generating any noise or pollution. They must be mounted in an unshaded location; rooftops, carports and ground-mounted arrays are common mounting locations. Ground mount solar installations can be placed anywhere in a yard or field that sees the sun throughout the day. Ground mounting is similar to pole mounting in that it requires a dedicated space in the field to set the panels, hence it is ideal for agricultural use since there farm roads and irrigation canals. It can benefit the farmers wherein their paths will be shaded decreasing the exposure to UV rays. They can also be protected against sudden downpour of rains.

PV systems work very well in Ilocos Norte, where the average annual solar energy that can be harnessed is 0.7-1.1 kWh/m2/day. An inverter is required to convert the direct current (DC) to alternating current (AC) of the desired voltage compatible with building and utility power systems. The balance of the system consists of conductors/conduit, switches, disconnects and fuses. Grid-connected PV systems feed power into the facility's electrical system and do not include batteries. Figure 2 shows the major components of a grid-connected PV system and illustrates how these components are interconnected in a grid-connected PV system.

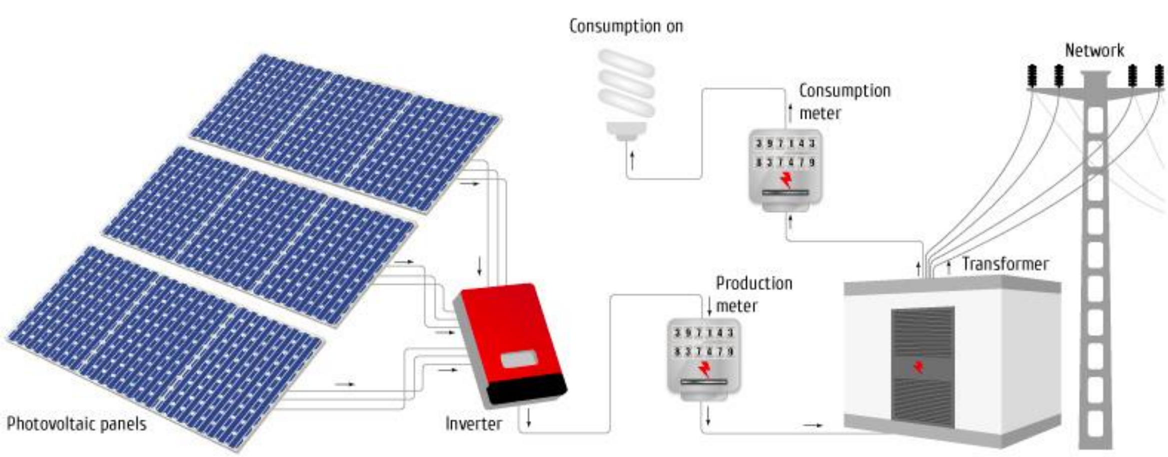


Fig. 2. Major components of grid-connected photovoltaic system.

PV panels are made up of many individual cells that all produce a small amount of current and voltage. These individual cells are connected in series to produce a larger current. PV panels are very sensitive to shading. When shade falls on a panel, the shaded portion of the panel cannot collect the high-energy beam radiation from the sun. If an individual cell were shaded, it would act as a resistance to the whole series circuit, impeding current flow and dissipating power rather than producing it. By determining solar access—the unimpeded ability of sunlight to reach a solar collector—one can determine whether an area is appropriate for solar panels. If a site is found to have good solar access for a PV system, the next step is to determine the size of that system, which highly depends on the average energy use of the on-site facilities. Providing more power than a site would use is generally not advisable due to the economics of net-metering agreements. In the case of the assessed sites, both solar rooftop and ground mount, there will be excess electricity generated at the site and this would be sold to the serving utility, Ilocos Norte Electric Cooperative (INEC) or through the GEOP. For this report, it is assumed INEC or GEOP- End User would purchase any electricity that the site can generate. The systems will be broken down by site so the system size can be adjusted based on what the utility requests.

The primary component of a PV system is the PV array. It converts sunlight to electrical energy; all other components simply condition or control energy use. Most PV arrays consist of interconnected PV modules that range in size from 50 Watt-peak (50Wp) to 550Wp. Peak watts are the rated output of PV modules at standard operating conditions of 25°C and insolation of 1,000 Watts/m². Because these standard operating conditions are nearly ideal, the actual output would be less under typical environmental conditions. PV modules are the most reliable components in any PV system. They have been engineered to withstand extreme temperatures, severe winds and impacts. PV modules have a life expectancy of 20–30 years, and manufacturer's warranty them against power degradation for 25 years. The array is usually the most expensive component of a PV system; it accounts for approximately half the cost of a grid-connected system.

PV arrays provide direct current power at a voltage that depends on the configuration of the array. This power is converted to alternating current at the required voltage and number of phases by the inverter. Inverters enable the operation of commonly used equipment such as appliances, computers, office equipment and motors. Current inverter technology provides true sine wave power at a quality often better than that of the serving utility. The locations of both the inverter and the balance of the system equipment are important. Inverters are available that include most or all of the control systems required for operation, including some metering and data-logging capability. Inverters must provide several operational and safety functions for interconnection with the utility system.

2.2.1 Economics and Performance

This portion presents the assumptions, engineering design, supply and demand and financial study in order to analyze the performance of the solar PV System and its economics.

2.2.1.1 Assumptions

Generally, the economics of PV system depend on incentives, the cost of electricity and the solar resource including panel tilt and orientation. It was assumed that the GEOP will incentivized participants both end-user and RE source. End-user can buy at a cost of PhP7.50/kWh and RE source can sell at PhP7.00/kWh. The difference of 50 cents will be for the wheeling charge of INEC. For the purpose of estimating the savings from the annual electricity purchased from INEC before NZEB, the local electricity rate was assumed at PhP 8.50.

For ground mounted and roof deck solar installations, the tilt will be 15° fixed and facing South. While rooftop solar installations will depend on angle of the roof and orientation. The efficiency to be used in the calculations will be variable.

For the solar PV system analysis, an efficiency of 70-80% was assumed and utilization factor of 60-85%. These includes losses in the inverter, wire losses, PV modules losses, losses due to temperature effects specially the City of Batac has longer dry season than rainy season and roof angle & orientation. An average sun-hour of 5 was assumed throughout the calculations.

2.2.2 Engineering Design

This portion presents the engineering design calculations to estimate solar rooftop potential. These includes, kWp potential and annual potential energy production. It presents also single line diagrams & block diagrams that shows how the system will be integrated to the existing grid. Also, it presents the bill of materials of the 30kW and 250kW solar installation. Furthermore, it presents the structural support for the ground mounted solar installations.

2.2.2.1 Solar Rooftop Installation

To estimate the solar rooftop/roofdeck potential and annual potential solar energy production of MMSU Batac Campus, area method was used through the formula below;

$$kWp_R = A*n*UF$$

where:

kWp_R = solar rooftop potential in kW
A = roof area in m^2
n = mono crystalline solar panel efficiency = 18%
UF = roof utility factor

and;

$$kWh_A = kWp*d*Sh*n_s$$

where:

kWh_A = solar annual energy production in kWh
Sh = sun-hour = 5 hours
n_s = system efficiency =0.7
d = no. of days

Sample calculation1: the NBERIC building has a roof deck area of 1500 m^2, its solar rooftop potential is;

$$kWp_R = 1500*0.18*0.80 = 243kW$$

and it's annual energy production is;

$$kWh_A = 243*365*5*0.8 = 354{,}780\ kWh$$

The table below shows the solar rooftop potential of some of the buildings at MMSU Batac Campus.

Table1. MMSU selected building solar rooftop potential and annual potential energy.

Building	Roof Area (m^2)	Solar Rooftop Potential (kWp)	Annual Potential Solar Energy Production (kWhr)
NBERIC	1,500	243	354,780
FEM Hall	2,164	273	398,098
CAB	3,006	379	552,969
Covered Court & Student Center	3,650	460	671,514
Research & Extension	1,825	263	383,618
Library	3,494	440	642,671
CAS	3,696	466	679,971
COE	3,743	472	688,527
CAFSD	2,230	281	410,149
CBEA	3,885	489	714,647
CHS	5,391	679	991,725
Total	***34,583***	***4,444***	***6,488,671***

Based from table 1, the recommended kWp rooftop solar installations per building will be computed considering a 30kWp per solar array. The several solar arrays will compose the recommended kWp solar installation per building.

Sample calculation2: the NBERIC building has a solar rooftop potential of 243kWp, assuming a 6 solar arrays at 30kWp will be installed, the recommended solar rooftop installation will be;

$$\mathbf{kWp = 6*30 = 180kW}$$

The projected annual solar energy production is;

$$\mathbf{kWh_A = 180*365*5*0.8 = 262{,}800\ kWh}$$

Table2. Recommended Grid-tied solar rooftop installation and projected annual energy production of the selected buildings at MMSU Batac Campus.

Building	Recommended Solar Rooftop Installation (kWp)	Projected Annual Solar Energy Production (kWhr)
NBERIC	180	262,800
FEM Hall	180	262,800
CAB	360	525,600
Covered Court & Student Center	360	525,600
Research & Extension	180	262,800
Library	270	394,200
CAS	270	394,200
COE	270	394,200
CAFSD	180	262,800
CBEA	270	394,200
CHS	180	262,800
Total	***2,700***	***3,942,000***

The recommended solar rooftop installations shown in table 2 should not exceed the solar rooftop potential shown in table 1. The 2.7MWp solar rooftop capacity will be for the Grid-tied System only. Table 3 next page shows the recommended buildings to be installed with On-Grid Hybrid System. The idea of a hybrid system is to ensure reliability of power. There are some loads which requires uninterruptible power. A combination of a Grid-tied to cover the 90% load and a Hybrid Grid-tied to cover the 10% emergency load is recommended.

Table3. Recommended On-Grid Hybrid solar rooftop installation.

Building	Recommended Solar Rooftop Installation (kWp)	Projected Annual Solar Energy Production (kWhr)
NBERIC	45	65,700.00
FEM Hall	45	65,700.00
CAB	45	65,700.00
Library	75	109,500.00
Research & Extension	45	65,700.00
CHS	45	65,700.00
Total	***300***	***438,000***

The figure below shows the single line diagram for the grid-tied system to produce a three-phase system since the existing system in each building is 230Vac 3-phase. Several PV arrays rated at 30kWp each are connected in parallel. There must be exactly 3 pairs or parallel PV arrays. Note that the recommended solar capacity shown in table 2 in each building is a multiple of 3 and 30 to ensure that there will be exactly 3 pairs of equal kWp. Each parallel PV arrays are then connected in delta as shown in figure 3 to make a 3-phase system.

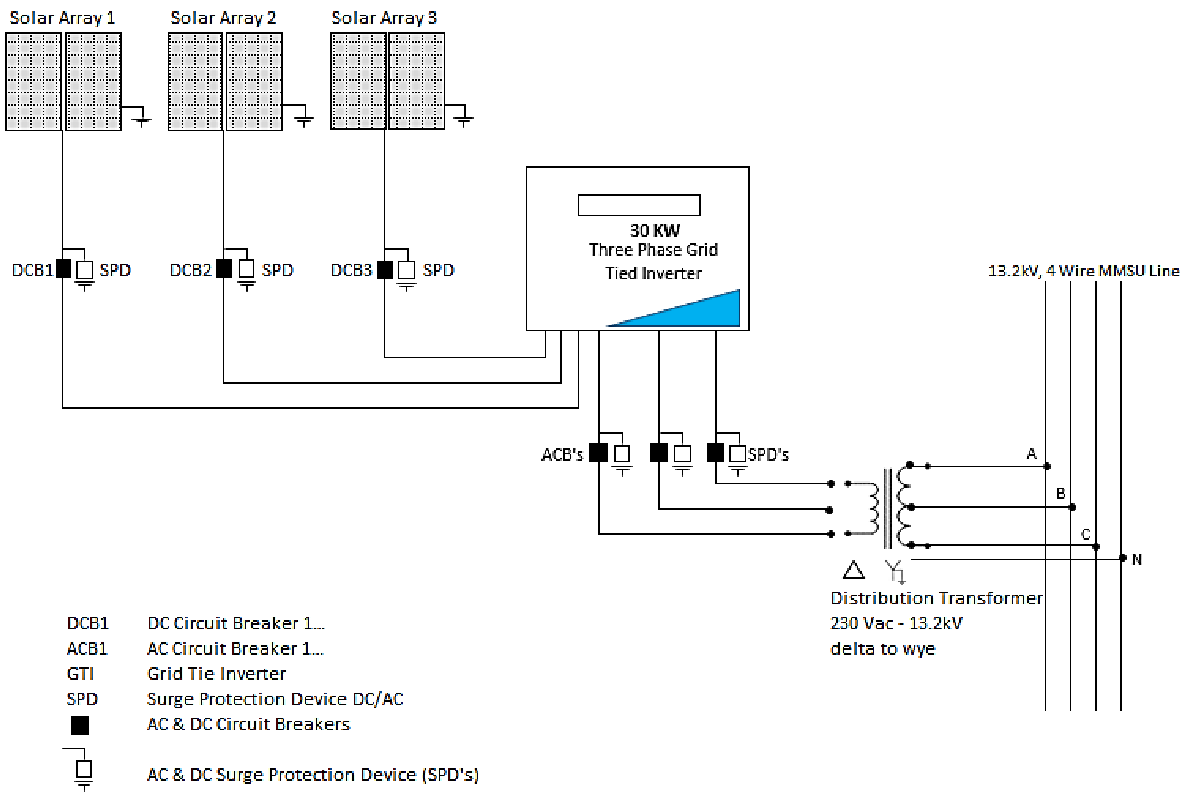


Fig. 3. Single line diagram for the Grid-tied system

For the Hybrid System, the single line diagram is shown in figure 4. To produce a 5kW three phase system, three pairs of exactly the same kWp PV arrays are connected in delta. A 5kW On-grid hybrid inverter is chosen since the recommended solar rooftop installations for each of the selected buildings with hybrid is a multiple of 5. From table 3, three pairs of 3 sets of 5kW are to be installed in each buildings except for the library to make the 45kW capacity. For the Library which has a 75kW capacity, 3 pairs of 5 sets of 5kW are to be installed.

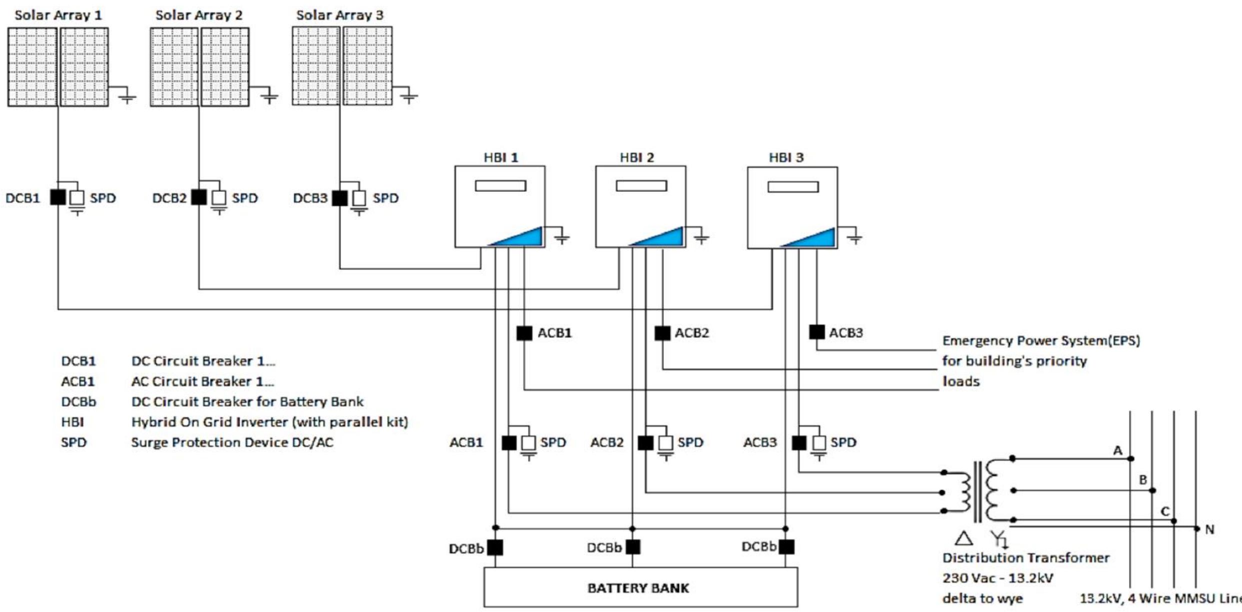


Fig. 4. Single line diagram for the On-grid Hybrid Roof Mounted Solar Installations.

To estimate the total cost of the Grid-tied rooftop solar installations, the bill of materials for a 30kWp installation is presented in table 4 below.

Table 4. Sample detailed material cost for a 30kW Grid Tied Solar Power System.

QTY	UM	DESCRPTION	UNIT COST	TOTAL COST
1	Set	30 Kilowatts 3 phase Grid Tie Inverter	220,000.00	220,000.00
54	Pc	550 Wp solar module, mono	10,500.00	567,000.00
22	Pc	4.2 m aluminum rails	2,500.00	55,000.00
88	Pc	L-Foot, Aluminum	300.00	26,400.00
36	Pc	End Clamp, Aluminum	210.00	7,560.00
130	Pc	Mid-clamp, Aluminum	210.00	27,300.00
5	rolls	6mm² twin solar cable (100m/roll)	18,000.00	90,000.00
22	Pc	Splice Kit	200.00	4,400.00
21	Pc	MC4 connectors	200.00	4,200.00
36	Pc	YMC4 connectors	280.00	10,080.00
6	Pc	AC MCB	1,000.00	6,000.00
6	Pc	DC MCB	1,500.00	9,000.00

6	Pc	DC SPD	1,800.00	10,800.00
3	Pc	AC SPD	1,000.00	3,000.00
6	Pc	12 ways distribution box	2,000.00	12,000.00
50	pc	¾” dia. Pvc pipe	250.00	12,500.00
1	roll	# 8 THHN copper wire, 150m/roll	15,000.00	15,000.00
10	packs	Cable Tie	300.00	3,000.00
16	pcs	Cable Tray 2" and 3"	1,500.00	24,000.00
1	box	Marshalling kiosk	2,500.00	2,500.00
1	pc	ladder	25,000.00	25,000.00
1	lot	Shipment and Delivery to Site	40,000.00	40,000.00
1	lot	Mobilization and Installation	450,000.00	450,000.00
		TOTAL		***1,624,740.00***

Based from the total cost and capacity, the estimated cost per kW is PhP 54,158.

For the On-grid Hybrid Solar rooftop installations, the bill of materials for a 5kW system is shown in table5.

Table 5. Sample detailed material cost for a 5kW Hybrid Solar Power System.

QTY	UM	DESCRPTION	UNIT COST	TOTAL COST
1	Pc	5 Kilowatts 3 phase Grid Tie Inverter	120,000.00	120,000.00
10	Pc	550 Wp solar module, mono	10,500.00	105,000.00
2	Pc	3.3kWhr Lithium Battery	125,000.00	250,000.00
1	lot	Mounting Rail system	15,000.00	26,400.00
30	m	$16mm^2$ twin solar cable	150.00	7,560.00
1	set	Protection Kit	5,900.00	27,300.00
1	lot	Connectors and Clamps	5,500.00	90,000.00
1	lot	Piping System	5,000.00	4,400.00
1	Pc	Manual Transfer Switch	2,500.00	4,200.00
1	lot	Mobilization and Installation	80,000.00	10,080.00
		TOTAL		***593,400.00***

Based from the total cost and capacity, the estimated cost of installing a rooftop On-grid Hybrid System per kW is PhP 118,680.

2.2.2.2 Ground Mounted Solar Installation

To estimate the ground mount solar potential and annual potential solar energy production of MMSU Batac Campus, the length and the width of the farm roads and irrigation canals as well as the length and with of a 550Wp solar panel were considered.

The formula below was used to estimate the kWp potential of ground mount solar installations;

$$\mathbf{kWp_{GP} = L_R * PV_{kWp} * N / W_P}$$

where:

kWp_{GP} = potential of ground mount solar installations in kWp
L_R = length of farm road in m
PV_{kWp} = kWp of recommended solar panel = 0.55Wp
N = number of panels that can be placed along the width of the farm road = 3
W_p = width of the recommended solar panel = 1.133m

Sample calculation3: the farm road 1 has a length of 420m, it's solar rooftop potential is;

$$\mathbf{kWp_{GP} = 420*0.55*3/1.133 = 612kW}$$

and it's potential annual energy production is;

$$\mathbf{kWh_A = 612*365*5*0.8 = 893{,}010\ kWh}$$

Doing the same calculations for farm roads 2-12 and irrigation canals 1-2, the summary is listed in table 6 next page. Estimated vales on this table will be used as a basis in determining the exact number of panels to be used for a 250kW 3-phase inverter. The choice of 250kW capacity was based on what is most recommended available inverter in the market and the farm road with the lowest solar potential which is 291kW. This is to maximize the ground mount solar potential capacity.

Table 6. Ground mount solar potential and potential annual solar energy production.

Location	Length (m)	Ground Mount Solar Potential (kWp)	Annual Solar Rooftop Potential (kWhr)
Farm Road 1 (FR 1)	420	612	893,010
Farm Road 2 (FR 2)	500	728	1,063,107
Farm Road 3 (FR 3)	500	728	1,063,107
Farm Road 4 (FR 4)	200	291	425,243
Farm Road 5 (FR 5)	200	291	425,243
Farm Road 6 (FR 6)	200	291	425,243
Farm Road 7 (FR 7)	200	291	425,243
Farm Road 8 (FR 8)	200	291	425,243
Farm Road 9 (FR 9)	200	291	425,243
Farm Road 10 (FR 10)	600	874	1,275,728
Farm Road 11 (FR 11)	680	990	1,445,825
Farm Road 12 (FR 12)	650	947	1,382,039
Irrigation Canal 1 (IC 1)	600	874	1,275,728
Irrigation Canal 2 (IC 2)	650	947	1,382,039
	Total	***8,447***	***12,332,039***

Since the farm roads and irrigation canals are located in different areas and separated by at least 200 m, it was suggested to group it into three clusters namely:

CLUSTER 1 composed of farm roads 1-3
CLUSTER 2 composed of farm roads 4-12
CLUSTER 3 composed of irrigation canals 1-2

To compute for the recommended ground mount solar installations in each location and cluster, the formula below was used;

$$\mathbf{kWp_{GR} = SP_{kW} * N_{pP} * N_G}$$

where:

kW_{GR} = recommended ground mount solar installations in kW
SP_{kW} = solar panel kW rating = 0.55kWp
N_{pP} = number of solar panel per location <=540^x pcs
N_P = number of group

Note: ^{x} The 540 pcs of 550Wp solar panel makes 297kWp. This is the optimized number of 550W panels for a 250kW inverter according to its specifications shown in figure 5 next page which can handle an input power up to 300kW. The 540 panels are divided into 20 pcs connected in series to make 27 parallel strings. The 20 pcs panel in series at 49.65Voc (fig. 6 next page) produces 993V open circuit voltage which is still below the allowable 1000V dc input voltage. The 27-parallel combination at 13.42A (fig. 6) makes 362.34A input current which is below the 600A maximum input dc current.

Type designation	PVS800-57-0100kW-A	PVS800-57-0250kW-A
	100 kW	250 kW
Input (DC)		
Recommended max input power (P_{PV}) [1]	120 kWp	300 kWp
DC voltage range, mpp (U_{DC})	450 to 750 V (- 825 V*)	450 to 750 V (- 825 V*)
Maximum DC voltage ($U_{max\,(DC)}$)	900 V (1000 V*)	900 V (1000 V*)
Maximum DC current ($I_{max\,(DC)}$)	245 A	600 A
Voltage ripple	< 3%	< 3%
Number of protected DC inputs (parallel)	1 (+/-) / 4 [2]	2 (+/-) / 8 [2]

Fig. 5. Specifications of the recommended 250kW Inverter.

Module Type		PW-72M530HM		PW-72M535HM		PW-72M540HM		PW-72M545HM		PW-72M550HM	
Test Environment		STC	NOCT	STC	NOCT	STC	NOCT	STC	NOCT	STC	NOCT
Maximum Power	P_{MAX}(W)	530	394.44	535	398.16	540	401.88	545	405.61	550	409.33
Maximum Power Voltage	V_{MPP}(V)	40.47	37.65	40.6	37.77	40.73	37.89	40.86	38.02	40.99	38.14
Maximum Power Current	I_{MPP}(A)	13.1	10.48	13.18	10.54	13.26	10.6	13.34	10.67	13.42	10.73
Open Circuit Voltage	V_{OC}(V)	49.02	46.27	49.18	46.43	49.34	46.58	49.5	46.73	49.65	46.87
Short Circuit Current	I_{SC}(A)	13.79	11.14	13.87	11.2	13.96	11.27	14.04	11.34	14.13	11.41
Tolerance	(W)	0 - +5		0 - +5		0 - +5		0 - +5		0 - +5	
Module Efficiency	(%)	20.5		20.7		20.9		21.1		21.3	

STC:Irradiance 1000 W/m²,Cell Temperature 25°C,Air Mass AM1.5 according to EN 60904-3.
Average efficiency reduction of 4.5% at 200W/m² according to EN 60904-1
NOCT: Irradiance at 800 W/m²,Ambient Temperature 20°C,Wind Speed 1m/s.

Fig. 6. Specifications of the recommended 550Wp solar panel.

Sample calculation 4: for farm road 1, the recommended ground mount solar installations is;

$$kWp_{GR} = 0.55 * 540 * 2 = 594\ kW$$

The computed value of 594kW falls below the potential value which is 612kW, this is acceptable.
The same computation was done for FR2 to FR3 and IC1 & IC2. Results of the computations are shown in tables 7, 8 & 9 next two pages.

Table 7. Cluster 1 recommended solar installation capacity and projected annual solar energy production.

Location	Ground Mount Solar Potential (kWp)	Number of Group (250kW)	Number of Solar Panel per Group	Number of Solar Panel per Location	Recommended Installation (kWp)	Projected Annual Energy Production (kWhr)
Farm Road 1 (FR 1)	612	2	540	1,080	594	867,240
Farm Road 2 (FR 2)	728	2	540	1,080	594	867,240
Farm Road 3 (FR 3)	728	2	540	1,080	594	867,240
Total	***2,068***	***6***	-	***3,240***	***1,782***	***2,601,720***

CLUSTER 1 has a potential capacity of 2MW as shown above in table 5. Maximizing the 300kW input capacity of the 250kW inverter and considering the lowest potential of 612kWp for this cluster, a total of six 250kW inverters are required to generate 1.782MW of power. A total of 3,240 panels rated at 550Wp are required to generate the recommended power of 1.782 megawatts.

Table 8. Cluster 2 recommended solar installation capacity and projected annual solar energy production.

Location	Ground Mount Solar Potential (kWp)	Number of Group (250kW)	Number of Solar Panel per Group	Number of Solar Panel per Location	Recommended Installation (kWp)	Projected Annual Energy Production (kWhr)
Farm Road 4 (FR 4)	291	1	540	540	297	433,620
Farm Road 5 (FR 5)	291	1	540	540	297	433,620
Farm Road 6 (FR 6)	291	1	540	540	297	433,620
Farm Road 7 (FR 7)	291	1	540	540	297	433,620
Farm Road 8 (FR 8)	291	1	540	540	297	433,620
Farm Road 9 (FR 9)	291	1	540	540	297	433,620
Farm Road 10 (FR 10)	874	3	540	1,620	891	1,300,860
Farm Road 11 (FR 11)	990	3	540	1,620	891	1,300,860
Farm Road 12 (FR 12)	947	3	540	1,620	891	1,300,860
Total	***4,558***	***15***	-	***8,100***	***4,455***	***6,504,300***

CLUSTER 2 has a potential capacity of 4.55MW shown in table 6 previous page. A total of fifteen 250kW inverters are required to generate 4.45MW of power. A total of 8,100 panels rated at 550Wp are required to generate the recommended power of 4.455 megawatts.

For CLUSTER 3, it has a potential capacity of 1.82MW presented in table 7 below. A total of six 250kW inverters are required to generate 41.78MW of power. A total of 3,240 panels rated at 550Wp are required to generate the recommended power of 1.782 megawatts.

Table 9. Cluster 3 recommended solar installation capacity and projected annual solar energy production.

Location	Ground Mount Solar Potential (kWp)	Number of Group (250kW)	Number of Solar Panel per Group	Number of Solar Panel per Location	Recommended Installation (kWp)	Projected Annual Energy Production (kWhr)
Irrigation Canal 1 (IC 1)	874	3	540	1,620	891	1,300,860
Irrigation Canal 2 (IC 2)	947	3	540	1,620	891	1,300,860
Total	***1,820***	***6***	-	***3,240***	***1,782***	***2,601,720***

Generally, the farm roads and irrigation canals electrical system are all identical. The same 250kW capacity inverter is recommended for all groups. Each group has the same number of solar panels and the same configuration at 20x27 to make a 297kW solar installation capacity. This is to maximize the capability of the chosen inverter to handle up to 300kW input power. The figure below is the single line diagram showing the connections of the major components of the 250kW capacity solar installation.

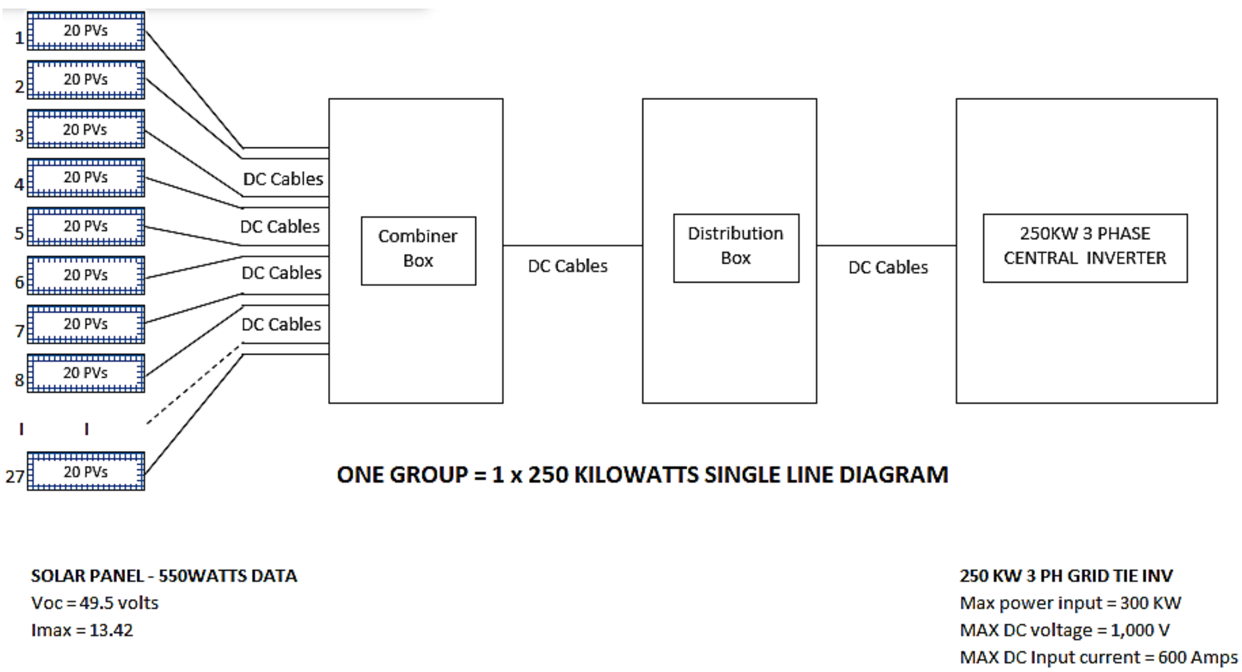
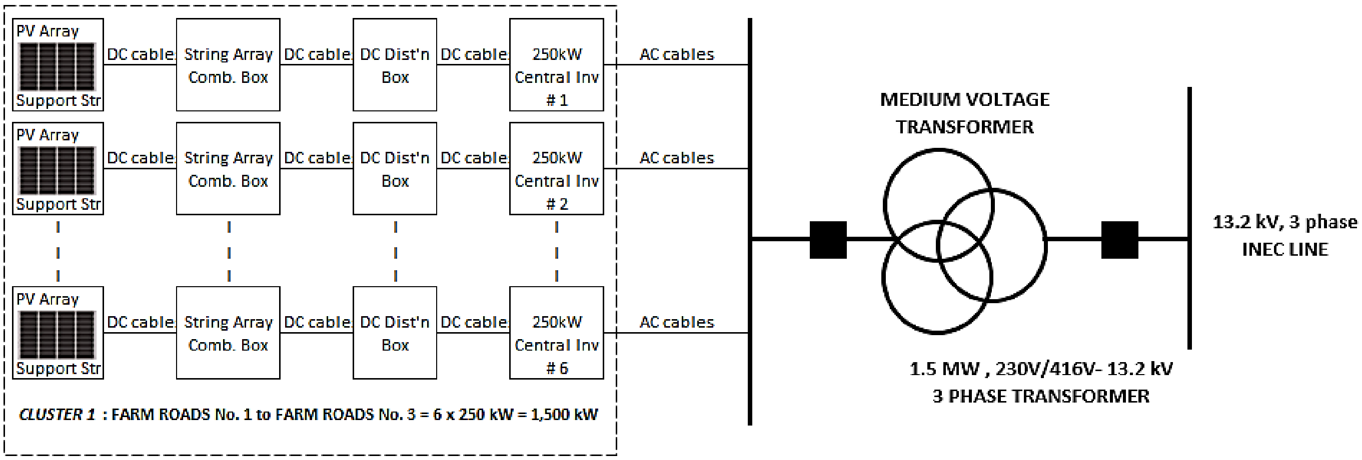
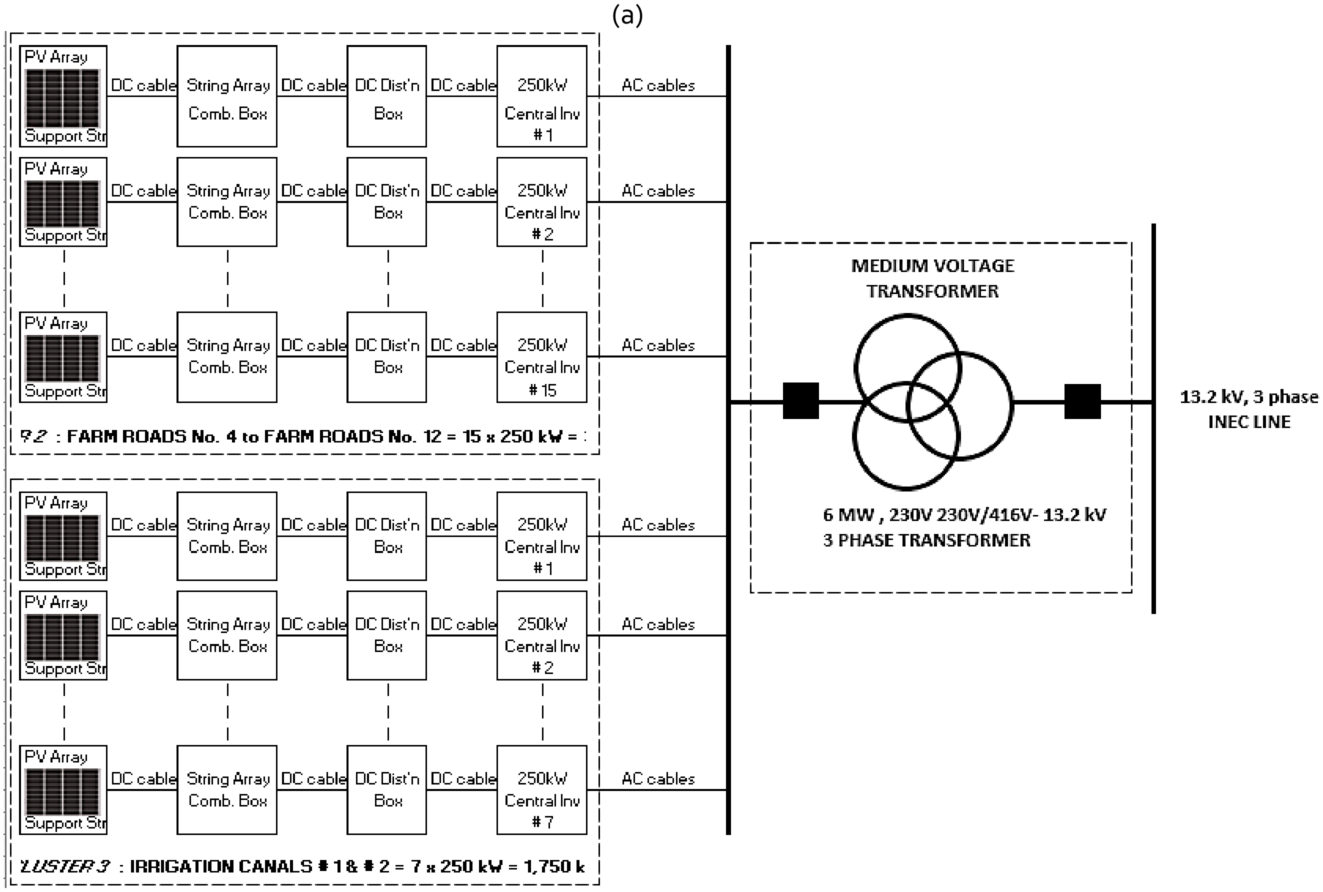


Fig. 7. Single line diagram of a 250kW capacity ground mounted solar installation.

Figure 8 below is the single diagram of the ground mount solar installations showing how several groups are interconnected and then connected to the 13.2kV distribution line.



(a)



(b)

Fig. 8. Single line diagram of several 250kW inverters interconnection and connection to the 13.2kV distribution line. (a) Cluster 1 (b) Cluster 2 and Cluster 3.

To estimate the cost of the Grid-tied ground mount solar installations, the bill of materials for a 250kWp installation is presented in table 10 below and tables 11 & 12 in succeeding pages.

Table10. Sample detailed material cost for a 250kW Grid-tied without the central inverter for the ground mount solar installation.

QTY	UM	DESCRPTION	UNIT COST	TOTAL COST
540	Pc	550 Wp solar module, mono	10,500.00	5,670,000.00
198	Pc	4.2 m aluminum rails	2,500.00	495,000.00
792	Pc	L-Foot, Aluminum	300.00	237,600.00
108	Pc	End Clamp, Aluminum	210.00	22,680.00
1,170	Pc	Mid-clamp, Aluminum	210.00	245,700.00
27	rolls	$6mm^2$ twin solar cable (100m/roll)	20,000.00	540,000.00
189	Pc	Splice Kit	200.00	37,800.00
189	Pc	MC4 connectors	200.00	37,800.00
54	Pc	YMC4 connectors	280.00	15,120.00
54	Pc	AC MCB	1,000.00	54,000.00
27	Pc	DC MCB	1,500.00	40,500.00
27	Pc	DC SPD	1,800.00	48,600.00
27	Pc	AC SPD	1,000.00	27,000.00
27	Pc	12 ways distribution box	2,000.00	54,000.00
270	pc	¾" dia. Pvc pipe	250.00	67,500.00
9	roll	# 8 THHN copper wire, 150m/roll	15,000.00	135,000.00
90	packs	Cable Tie	300.00	27,000.00
9	box	Marshalling kiosk	2,500.00	22,500.00
9	lot	Shipment and Delivery to Site	40,000.00	360,000.00
9	lot	Mobilization and Installation	350,000.00	3,150,000.00
		TOTAL		***11,287,800.00***

Figures 9-11 shows the structural design for the farm roads ground mount solar installations. It is a sample drawing for a twenty two meters long by six meters wide that will hold the sixty solar modules rated 550 watts to make a 33kWp installations. The 60 panels will be arranged 20x3. For a 297kW installation, nine 22m structure along each farm roads is needed.

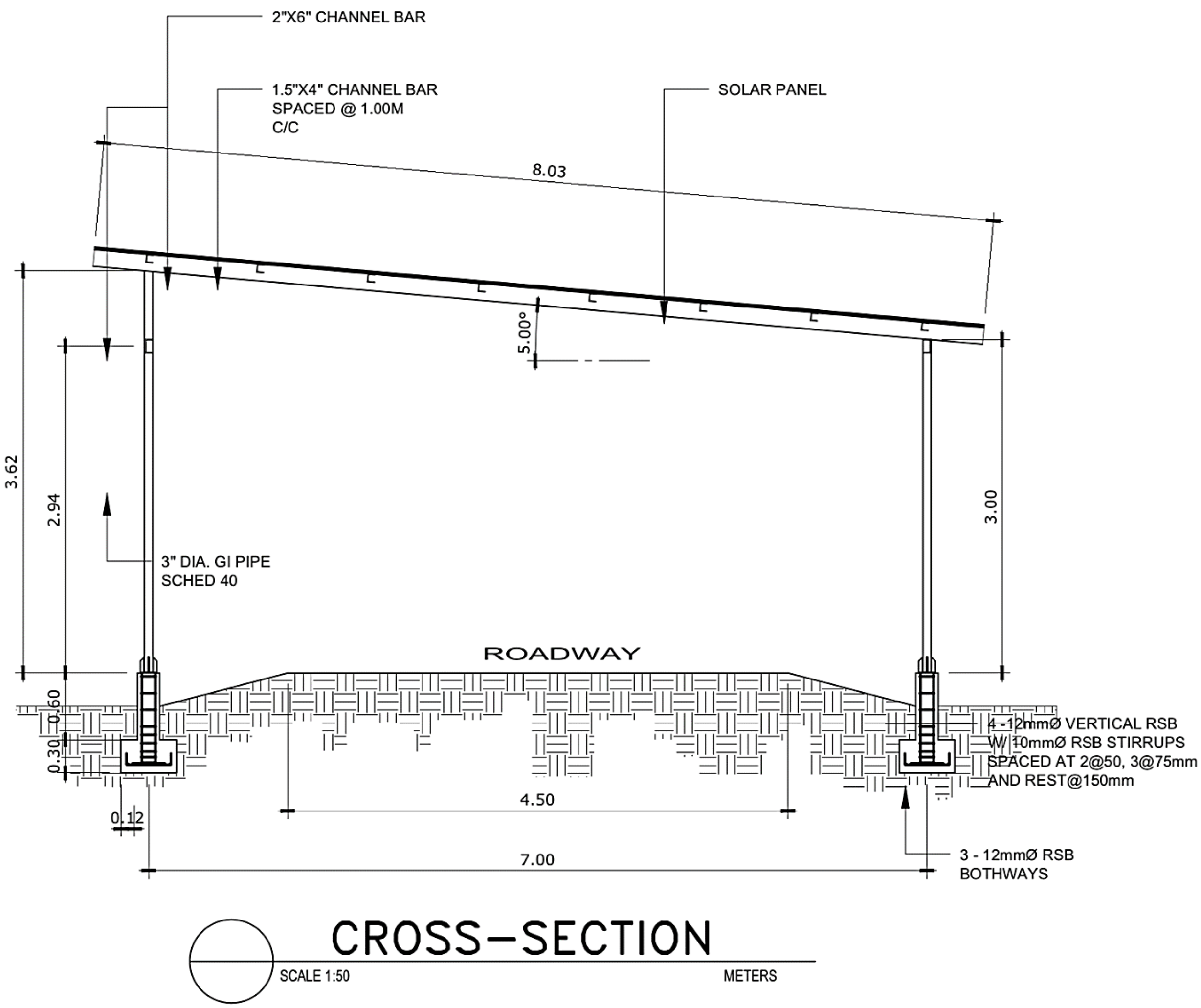


Fig. 9. Cross section of the structure support for the ground mount solar installations.

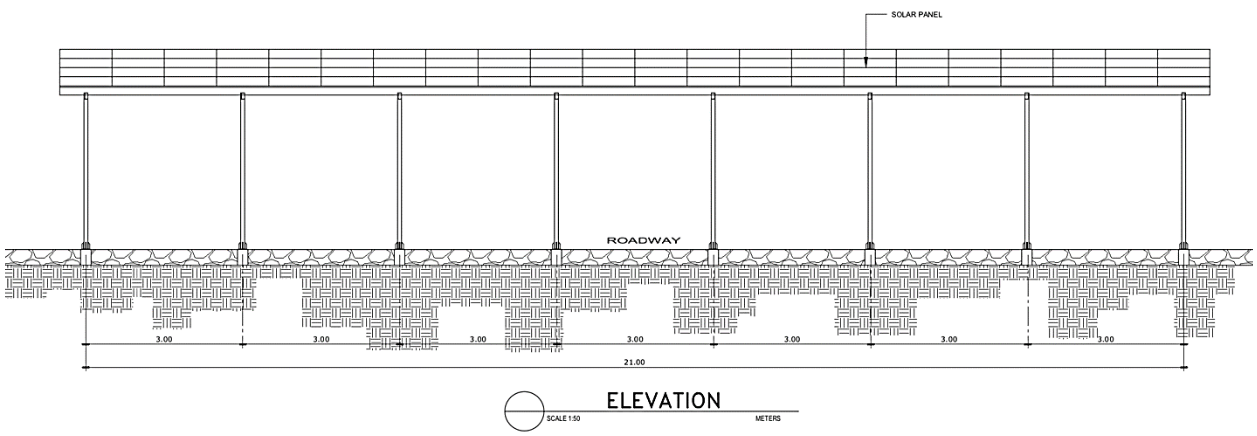


Fig. 10. Elevation of the structure support for the ground mount solar installations.

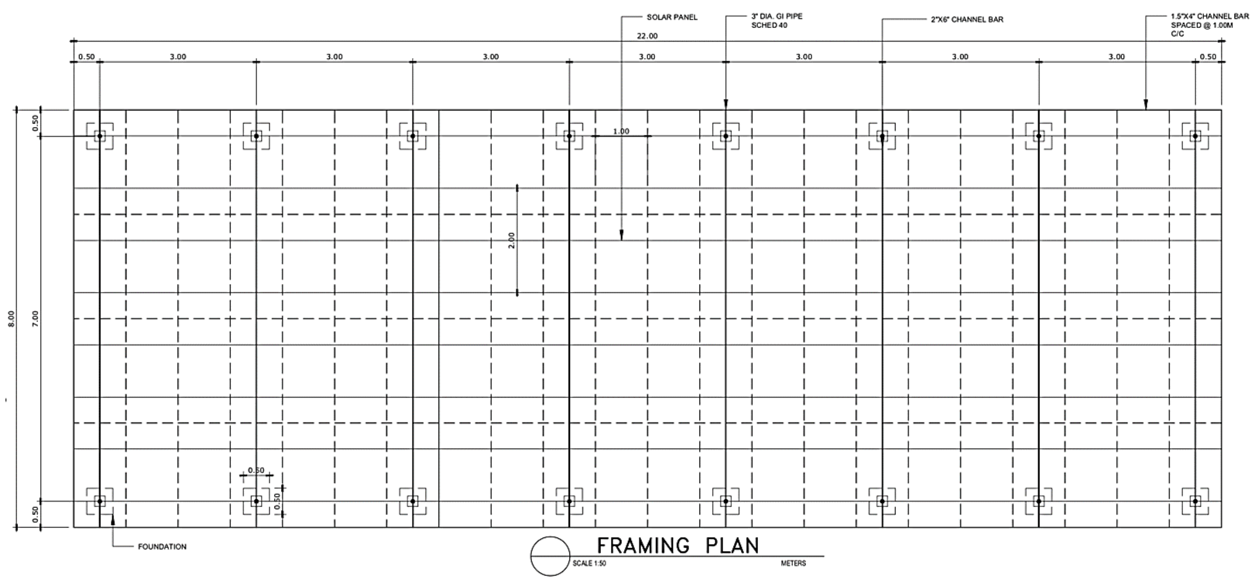


Fig. 11. Framing plan of the structure support for the ground mount solar installations.

Generally, following the standard structural design will result into the bill of materials listed in table 11 below.

Table11. Bill of materials for the 22m span structure for the ground mount solar installations.

DESCRIPTION OF MATERIALS		QTY	UNIT	UNIT COST (PhP)	TOTAL COST (PhP)
I. CONCRETE WORKS					
1	PORTLAND CEMENT	15.00	bags	240.00	3,600.00
2	FINE AGGREGATES	1.00	cu.m	400.00	400.00
3	COARSE AGGREGATES	2.00	cu.m	400.00	800.00
II. REINFORCING STEEL					
1	12MM DIAMETER RSB	16.00	pcs	202.00	3,232.00
2	10MM DIAMETER RSB	16.00	pcs	142.00	2,272.00
3	TIE WIRE #16	5.00	kgs	90.00	450.00
III. STRUCTURAL STEEL					
1	3" DIAMETER GI PIPE SCHEDULE 40	10.00	pcs	2,808.25	28,082.50
2	3" X 6" CHANNEL BAR	17.00	pcs	7,056.00	119,952.00
3	2" X 3" CHANNEL BAR	30.00	pcs	3,000.00	90,000.00
4	GI SHEET PLAIN GAUGE 1/4	1.00	pc	2,000.00	2,000.00
5	WELDING ROD	40.00	kgs	90.00	3,600.00
6	ANCHOR BOLT W/ WASHER NUTS	100.00	kgs	41.23	4,123.00
7	WELDING ROD	40.00	kgs	90.00	3,600.00

SUMMARY		
I. CONCRETE WORKS		*₱ 4,800.00*
II. REINFORCING STEEL		*₱ 5,954.00*
III. STRUCTURAL STEEL		*₱ 251,357.50*
X. LABOR		*₱ 78,633.45*
	Sub-total	**₱ 340,744.95**

Since nine structures are needed for the 250 kW capacity per group, the total cost for the structure is Php 3,066,704.55

Following all standards of distribution lines and substation handbook design and applying rule of thumb, table 12 below shows the bill of quantities and specifications of materials for the plurality of central inverters and the substation needed for the ground mount solar installations. Estimated cost in table 12 is for Clusters 1-3.

Table12. Bill of materials for the central inverter and substation needed for the ground mount solar installation.

		Item Description	Qty	Unit	Unit Price	Amount
Electrical Works						
I	**CENTRAL INVERTER**					
		250KW, LV transformer+RMU with the following accessories AC, DC DS, Protection Relay, UPS, Fire Extinguisher	28	set	560,000.00	15,680,000.00
	I.2	INSTALLATION WORKS				
		Installation Works	1	lot	2,500,000.00	2,500,000.00
		Shop Supplies and Equipment	1	lot	350,000.00	350,000.00
					Total Materials Cost	15,680,000.00
					Imported	15,680,000.00
					Installation Works	2,850,000.00
					I. Sub-Total (Php)	**18,530,000.00**
II	**ELECTRICAL CABLING, COMBINER BOX AND ACCESSORIES**					
	II.1	CABLE & ACCESSORIES				
		<u>Inverter to Switchgear</u>				
		50mm2, 13.8kV, XLPE,Al	2,000	mtrs	274.03	548,069.76
		Termination Kit (for 70sqmm) outdoor type 3M, cold shrink	6	pcs	17,500.00	105,000.00
		Lug, Terminal for 70mm mmsq. Power cable, 2holes	6	pcs	250.00	1,500.00
		<u>DC combiner box to Inverter</u>				
		Power Cable 240mm2, 1.5kV, XLPE,Al	7,200	mtrs	334.70	2,409,859.46
		Lug, Terminal for 240mm mmsq. Power cable, 2holes	80	pcs	300.00	24,000.00
		Rubber Tape and Vinyl Tape	80	pcs	2,000.00	160,000.00
		Cable 6mm2, 1.5kV, SOLAR CABLE	30,900	mtrs	45.00	1,390,500.00
		Control Cable, Secondary Wiring	1	lot	100,000.00	100,000.00
	II. 2	COMBINER BOX AND ACCESSORIES				
		DC Combiner, 1500VDC,300A,20 branches	28	pcs	58,024.40	1,624,683.20
		Support DC Combiner	28	pcs	2,000.00	56,000.00
		MC 4 connector set	412	pcs	32.01	13,186.11

	II.2	Electrical conduit PVC 0.75 inch x 10ft	1,236	mtrs	150.00	185,400.00
		Conduit Accessories	1,236	mtrs	25.00	30,900.00
	II. 3	GROUNDING				
		Rod, grounding, 3/4"x 10', copper bonded/ copper clad Note: Grounding rod for every 50 meters	88	pcs	1,250.00	110,000.00
		Wire, copper, # 10 AWG, insulated (green with yellow stripe), panel to ground grid	4,380	mtrs	40.00	175,200.00
		Wire, copper, # 2/0AWG, soft drawn, insulated green with yellow stripe, structure to ground grid	500	mtrs	350.00	175,000.00
		Connector and lugs,	103	pcs	250.00	25,750.00
		Exothermic weld powder	103	sets	900.00	92,700.00
	II. 4	LIGHTNING PROTECTION				
		Early Strimmer Device	10	pcs	50,000.00	500,000.00
		Rod, grounding, 3/4"x 10', copper bonded/ copper clad	10	pcs	1,250.00	12,500.00
		Wire, copper, # 4/0AWG, 5kv	200	mtrs	290.00	58,000.00
		Connector and lugs,	20	pcs	250.00	5,000.00
	II. 5	UNDERGROUND SYSTEM				
		Cable Conduit,PVC, 3inch	2,400	mtrs	200.00	480,000.00
		Accessories, (warning tape, spacers)	2,400	mtrs	100.00	240,000.00
		Manholes Trenches	1	lot	200,000.00	200,000.00
	II. 6	INSTALLATION WORKS				
		Direct Labor Works	1	lot	3,500,000.00	3,500,000.00
		Shop Supplies and Equipment	1	lot	300,000.00	300,000.00
					Total Materials Cost	8,723,248.53
					Imported	1,624,683.20
					Local	7,098,565.33
					Installation Works	3,800,000.00
					II. Sub-Total (Php)	**12,523,248.53**

III	**CONTROL HOUSE & PERIMETER LIGHTING**					
		Panel boards, transformer, generator service entrance	1	lot	1,080,060.85	1,080,060.85
		conduit and fittings	1	lot	177,250.00	177,250.00
		Wires and Cables	1	lot	187,160.00	187,160.00
		Switches and Outlets	1	lot	10,123.25	10,123.25
		Lighting Fixture	1	lot	311,133.62	311,133.62
		Utility Boxex, J.B	1	lot	3,340.00	3,340.00
		Perimeter Lighting	1	lot	593,440.00	593,440.00
		Grounding	1	lot	187,500.00	187,500.00
		Hydrogen/temperature sensor	1	lot	320,000.00	320,000.00
		Data/communication	1	lot	24,570.00	24,570.00
		Fire Detection	1	lot	21,212,798.00	21,212,798.00
		INSTALLATION WORKS				
		Labor	1	lot	688,408.11	688,408.11
		Shop Supplies and Equipment	1	lot	50,000.00	50,000.00
					Total Materials Cost	24,107,375.72
					Imported	
					Local	24,107,375.72
					Installation Works	738,408.11
					V. Sub-Total (Php)	**24,845,783.83**
IV	**SUBSTATION**					
	IV. 1	SUBSTATION EQUIPMENT				
		Transformers				
		6 MW Power Transformer, Power, Three phase, 230V/416V/13.8kV	1	unit	5,100,000.00	5,100,000.00
		1.5 MW Power Transformer, Power, Three phase, 230V/416V/13.8kV	1	unit	1,275,000.00	1,275,000.00
		Station Service, 150kVA, 230V/380V/13.8kV	2	unit	402,580.00	805,160.00
		13.8kV				
		Transformer, Potential	6	units	179,758.30	1,078,549.83
		Transformer, Current	6	units	120,000.00	720,000.00
		Disconnect Switches	4	set	570,249.74	2,280,998.95
		Lightning Surge Arresters	6	units	85,000.00	510,000.00
		Switchgear	6	set	2,839,178.00	17,035,068.00
		Post Insulator	12	units	5,000.00	60,000.00
	IV. 2	TAKE OFF STRUCTURE				
		Take off Aframe/Hframe, hot dipped galvinized, fabricated	2	lot	1,500,000.00	3,000,000.00

		Galvanized structure for CT ,LA,DS,PT fabricated by contractor, Ibar, or round bar	6	set	40,000.00	240,000.00
		Galvanized Structure for PCB fabricated and supplied by supplier	6	set	50,000.00	300,000.00
		Steel Pole, 55ft	3	assy	105,026.43	315,079.30
	IV. 3	LINE HARDWARE				
		Cross Arm, 4" x 5" x 3/16" x 20'	4	pcs	8,000.00	32,000.00
		Cross Arm, 4" x 5" x 3/16" x 14'	6	pcs	8,000.00	48,000.00
		Insulator, Suspension, 13.8kV, ball and socket typE	24	sets	3,903.24	93,677.71
		Strain Clamp with socket connector, 4/0 ACSR	3	sets	2,500.00	7,500.00
		Fuse cut out	3	pcs.	4,696.77	14,090.31
	IV. 4	BOLTS & CONNECTORS				
		Machine Bolts 5/8" x L" with nut and washers	2	lot	5,000.00	10,000.00
		Oval eye Bolts 5/8" x L" with nut and washers	2	lot	5,000.00	10,000.00
		Oval eye nuts, 5/8"	2	lot	3,000.00	6,000.00
		Connector, "Wedge Type", for 4/0 ACSR Wire	24	pcs.	1,000.00	24,000.00
	IV. 5	CABLES				
		Power Cable 150mm2, 15kV, XLPE	100	mtrs	2,992.48	299,248.25
	IV. 6	TERMINATION KITS				
		Termination Kit (for 240sqmm) outdoor type 3M, cold shrink	6	pcs.	16,671.78	100,030.65
		Termination Kit (for 240sqmm) indoor type 3M, cold shrink	6	pcs.	8,669.32	52,015.94
		Scotch Seal 5313 3M	4	pcs.	464.67	1,858.68
		Scotch 13 tape 3M	4	pcs.	1,277.85	5,111.38
		Scotch PVC tape 3M	4	pcs.	464.67	1,858.68
		Scotch 70 Silicon Tape 3M	4	pcs.	3,485.03	13,940.14
		Silicon Grease 3M	4	pcs.	1,510.18	6,040.73
		Cable support, plastic type U-bolt	2	lot	3,000.00	6,000.00
		Cable Glands for Power cable, control cables and etc	2	lot	20,000.00	40,000.00
	IV. 7	LV CABLES				
		Control Cables (for transformer Wire, 3WIRE, #18) SHIELDED RTD'S	200	mtrs	260.00	52,000.00
		Control Cables (for transformers, Disconnect Switches, Power Circuit Breakers), #16AWG-1.5mm2, 16 CORES	200	mtrs	455.38	91,076.21

		Wire, Multiconductor,4cores, 6.0mm2 for CT, stranded, outdoor type	200	mtrs	390.32	78,064.76
		Wire, Multiconductor,4cores, #12-4.0mm2 for PT, stranded, outdoor type	200	mtrs	261.30	52,260.00
		Wire, Multiconductor,3cores, 4.0mm2 for AC supply for motor, heaters, lighting and etc for DS, PCB, xfmr	200	mtrs	273.00	54,600.00
		Wire, Multiconductor,3cores, 4mm2 for DC supply for DS, PCB	200	mtrs	273.00	54,600.00
	IV. 8	GROUNDING				
		Grounding Inspection Pit	2	sets	3,000.00	6,000.00
		Rod, grounding, 3/4"x 10', copper bonded/ copper clad	35	pcs	1,250.00	43,750.00
		Connector, bonding lug to structure see details	2	lot	2,500.00	5,000.00
		Welding Powder	10	bottles	650.00	6,500.00
		Wire, copper, # 4/0 AWG, soft drawn, bare	100	mtrs	900.00	90,000.00
		Wire, copper, # 4/0 AWG, insulated	50	mtrs	1,100.00	55,000.00
		Grounding Braid (jumper) for D.S, fence	2	lot	1,100.00	2,200.00
		Lightning rod with expansion rack	6	pcs.	8,000.00	48,000.00
		Bolt and Nuts, (for clamping, bolting, grounding and etc)	2	lot	3,000.00	6,000.00
	IV. 9	CABLE TRAY				
		Cable Tray, Ladder Type, 300mm, hot dipped G.I, heavy duty	30	mtrs	4,995.22	149,856.46
		Cable Tray, Cover 1000mm, hot dipped G.I	50	mtrs	6,837.15	341,857.32
		Cable Tray, Cover 600mm, hot dipped G.I	40	mtrs	4,786.00	191,440.10
		Cable Ladder supports, bolts and accessories, in every one meter for 600mm and 1000 mm	2	lot	50,000.00	100,000.00
		Cable Tray Fittings (elbows, nut &bolts, splice plate, supports, Tee and others.) for 600 mm and 1000 mm	2	lot	50,000.00	100,000.00
		Barrier Strip , hot dippedG.I.	40	mtrs	3,717.37	148,694.78
	IV. 10	CONDUITS				
		Electrical conduit RSC, PVC of different sizes	2	lot	30,000.00	60,000.00

		Conduit Accessories (flange coupler, bends, coupler,saddles,locknuts, etc.) 50mm RSC	2	lot	20,000.00	40,000.00
	IV. 11	LUGS, TERMINALS				
		Lug, Terminal, for 150mmsq power cable, 2holes, copper	2	lot	10,000.00	20,000.00
		Lug, Terminal, for 120mmsq power cable, 2holes, copper	2	lot	10,000.00	20,000.00
		Lug, Terminal for 35mm mmsq. Power cable, 2holes	2	lot	10,000.00	20,000.00
	IV. 12	TUBULAR BUS				
		Tube, 2.5 inch, 6063 T6-SCH 80 , aluminum	12	pcs	52,261.57	627,138.84
		Connector, Bus support, aluminum, slip free, bolted type	12	pcs	22,766.57	273,198.79
		Connector, tube to flat, aluminum, bolted, T	12	pcs	20,780.10	249,361.15
		Connector, tube to flat, aluminum, bolted, Straight	12	pcs	20,780.10	249,361.15
		Connector, expansion, tube equipment pads, aluminum bolted	12	pcs	5,000.00	60,000.00
		Contact Sealant	10	bottles	5,000.00	50,000.00
	IV. 13	ACCESSORIES				
		Wire Markers (Machine printed)	2	lot	5,000.00	10,000.00
		Cable Tie	2	lot	4,201.79	8,403.58
		Paint, Gray	2	lot	10,000.00	20,000.00
	IV. 14	SIGNAGES				
		1. Warning: High Voltage Keep Out with shock picture	8	pcs	1,500.00	12,000.00
		2. Caution: PPE required with picture	8	pcs	1,500.00	12,000.00
		3. Warning: Do not enter authorized person only	8	pcs	1,500.00	12,000.00
	IV. 15	PROTECTION RELAYS				
		PAC 4200 Metering (for Feeders)	2	pcs	90,000.00	180,000.00
		SEL 2523 ANNUNCIATOR	2.00	pcs	208,000.00	416,000.00
		SEL 311L DISTANCE	1.00	pcs	760,000.00	760,000.00
		SEL-735 POWER METER (siemens)	2.00	pcs	186,432.92	372,865.84
		SEL-787 XFMR DIFFERENTIAL	2.00	pcs	397,499.90	794,999.81
		SEL 751A 50/51 FEEDER RELAY	1.00	pcs	189,947.51	189,947.51

		Metal Enclosure(indoor) with Relay mounting, control wiring, DC supply, CBCS, pilot lamps, annunciator with tripping and warning lamps, reset push button, alarm, auxiliary relays and terminal lugs	2.00	set	1,500,000.00	3,000,000.00
		Battery, industrial type,125 volts, 2 volts per cell, 150 AH capacity, complete with Automatic Charger, Battery solution, battery rack, and terminals.	2.00	lot	1,292,947.61	2,585,895.23
	IV. 16	INSTALLATION WORKS				
		Direct Labor Works	1	lot	5,000,000.00	5,000,000.00
		Equipment and Tools	1	lot	1,500,000.00	1,500,000.00
	IV. 17	HAULING WORKS				
		ITR, DS	1	truck	95,000.00	95,000.00
		PCB	1	truck	95,000.00	95,000.00
		Power Transformer	1	truck	1,250,000.00	1,250,000.00
		Escort	2	pick up	50,000.00	100,000.00
		Unloading small item	2	lot	30,000.00	60,000.00
		Unloading Power Transformer	1	lot	110,000.00	110,000.00
					Total Materials Cost	45,211,300.09
					Installation Works	6,500,000.00
					Hauling Works	1,710,000.00
					VI. Sub-Total (Php)	53,421,300.09

Table 13 shows that the cost of installing an 8MWp ground mount solar power system is about PhP 464.12M. This means that the cost per MWp ground mount solar installation is about PhP57.88M.

Table13. Summary of costing for the ground mount solar installation.

Component		Cost per 250kW	Total
Solar panels and peripherals		11,287,800.00	304,770,600.00
Structure support of solar panel		340,744.95	7,837,133.85
Substation			
	Central Inverter		18,530,000
	Electrical cabling and accessories		12,523,248.53
	Control house		24,845,783.83
	Substation		53,421,300.09
Contingency @ 10%			42,192,806.63
		Total	***464,120,872.93***

2.2.2.3 Solar Irrigation System Utilization

Currently, the Department of Agriculture funded three sets of Solar Pump Irrigation System (SPIS) with the following capacity:

1. 2 sets of 4.3kWp
2. 1 set of 10kWp

Note: As per distribution utility, the cost per kilometer of distribution line is Php 800,000.00

Table14. Cost of secondary lines and converters/inverters for the utilization of the existing DA SPIS projects.

Site	Potential (kWp)	Length (m)	Annual Energy (kWh)	Secondary Line Cost (PhP)	Conversion Cost (PhP)	Total Cost (PhP)
DA1	4.3	350	3139	280,000	100,000	380,000
DA2	4.3	800	3139	640,000	100,000	740,000
DA3	10	2000	7300	1,600,000	300,000	1,900,000
					Total	***3,020,000***

2.3. Supply and Demand Analysis

This part presents the analyses of the energy requirement of MMSU Batac Campus and projected generation from the recommended solar installations. Analysis of GEOP participation as end-user and RE source were also presented here.

2.3.1 MMSU Energy Demand

Table 15 shows the annual energy consumption of MMSU Batac Campus. From 2015-2019, this is the actual energy consumption while data on years 2020-2025 are projected consumption based on the average increase rate of 67,227kWh. The actual energy consumption of 2020 was not considered in the computation due to a drop in the consumption because of the lockdown. The last column is the kilowatt peak capacity of a Solar Farm to supply the annual energy requirement. At present the INEC has 2MWp installed solar farm, and other RE Sources in the locality. Hence, on the first year of the implementation of this NZEB Quest Project, MMSU is NZEB:D status.

Table 15. Annual energy consumption of MMSU Batac Campus and kWp of solar installations to meet the load requirement.

Year	Annual Energy Consumption (kWh)	Solar kWp Requirement
2015	1,415,821	
2016	1,507,949	
2017	1,590,999	
2018	1,639,559	
2019	1,684,729	
2020	1,455,568	
2021	1,819,183	1,246
2022	1,886,410	1,292
2023	1,953,637	1,338
2024	2,020,864	1,384
2025	2,088,091	1,430

2.3.2 MMSU Projected Energy Supply from Solar Installations

Tables 16 & 17 shows the schedule of rooftop and ground mount solar installations respectively from 2022 to 2025. The kilowatt capacity combines the grid-tie and on-grid hybrid capacities. The installation schedule for each building is not random. The capacity and activities in each building were considered particularly for the first year of installation. This is to ensure by 2024, MMSU NZEB status will change from NZEB:D to NZEB:A.

Table 16. Recommended yearly solar rooftop installations with projected annual energy production.

Year	Building	Capacity (kWp)	Projected Annual Energy Production (kWh)
2022	FEM Hall	225	328,500
	CAB	405	591,300
	Library	345	503,700
	Sub-total	***975***	***1,423,500***
2023	NBERIC	225	328,500
	Research & Extension	225	328,500
	Covered Court & Student Center	360	525,600
	Sub-total	***810***	***1,182,600***
	CAS	270	394,200
	COE	270	394,200
	CHS	225	328,500
	Sub-total	***765***	***1,116,900***
2025	CBEA	270	394,200
	CAFSD	180	262,800
	Sub-total	***450***	***657,000***
	Total	***3,000***	***4,380,000***

Table 17. Recommended yearly ground mount solar installations with projected annual energy production.

Year	Cluster	Capacity (kWp)	Projected Annual Energy Production (kWh)
2023	Cluster 1 (Farm Roads 1-3)	1,782	2,601,720
2024	Cluster 2 (Farm Roads 4-12)	4,455	6,504,300
2025	Cluster 3 (Irrigation Canals 1-2)	1,782	2,601,720
	Total	***8,019***	***11,707,740***

2.3.3 GEOP Supply and Demand Analysis

The fastest route to NZEB status is through participation to the GEOP as end-user. As early as the last quarter of 2021, MMSU can signify its interest to INEC and facilitate all needed requirements so that by 2022, MMSU attain an NZEB:D status. From table 14, the energy demand by 2022 is projected at 1,886.41 MWh and the kilowatt peak requirement of a solar farm is only 1,292 MWp (table 15). This demand can be easily supplied by the 2MWp solar farm of INEC. Right now, INEC is selling the harnessed energy from its solar farm to WESM at PhP 4-5 per kWh. With the GEOP, INEC can sell it to MMSU at PhP 7.50/kWh. Without the participation to GEOP MMSU is buying electricity at an average rate of PhP 8.50/kWh. This means an estimated savings of PhP 1/kWh. In one year time, the savings of MMSU is estimated at PhP 1.89M by participating to GEOP as end-user.

Table 18. Annual energy supply from solar installations and annual energy demand from 2022-2029.

Year	Supply		Demand (kWh)	Excess (kWh)
	Capacity (kWp)	Projected Annual Energy Production (kWh)		
2022	975	1,423,500	1,886,410	-1,886,410
2023	3,567	5,207,820	1,953,637	-530,137
2024	8,787	12,829,020	2,020,864	3,186,956
2025	11,019	16,087,740	2,088,091	10,740,929
2026	11,019	16,087,740	2,155,318	13,932,422
2027	11,019	16,087,740	2,222,545	13,865,195
2028	11,019	16,087,740	2,289,772	13,797,968
2029	11,019	16,087,740	2,356,999	13,730,741

By the end of 2022, a capacity of almost 1MWp solar installation is done which can produce an annual average energy of about 1.42GWh. Since the demand by 2023 increases to 1.95GWh, there will be a shortage of about 0.5GWh energy which will be sourced out from GEOP via INEC solar farm. Expected savings from the site production is about PhP 12.63M and the savings from GEOP participation is more than PhP 500k. The total expected savings in 2023 is about PhP 1.87M.

By 2024, MMSU status will be changed from NZEB:D to NZEB:A (NZEB Plus) since the projected site production will now be about 5.21GWh of energy. This is more than the energy demand of 2MWh. The excess energy of about 3.19GWh is equivalent to PhP 22.31M when sold at PhP7/kWh through the GEOP. Expected savings from the energy demand is about PhP17.2M. The total savings and sale in 2024 will be about PhP 39.49M. Also, in this year, MMSU participation to GEOP will change from end-user to RE source.

In 2025, the total installed capacity will be 8.79MWp which can generate about 12.83GWh of energy. Expected savings and sales will be about PhP 92.94M. By 2026, the total installed capacity of solar installations both rooftop and ground mount will be about 11MWp which can produce about 16.09GWh of energy yearly this year and there on. Expected savings and sales will be about 115M plus yearly after 2025.

2.4. Financial Study

Table 19. Annual projected gross income and projected accumulated gross income from 2022-2029.

Year	Savings (PhP 1,000)	Sale (PhP 1,000)	Yearly Gross Income (PhP 1,000)	Accumulated Gross Income (PhP 1,000)
2022	1,886		1,886	1,886
2023	530		12,630	2,417
2024	17,177	22,309	39,486	41,903
2025	17,749	75,187	92,935	134,838
2026	18,320	97,527	115,847	250,685
2027	18,892	97,056	115,948	366,633
2028	19,463	96,586	116,049	482,682
2029	20,034	96,115	116,150	598,832
2030	20,606	95,645	116,251	727,182
2031	21,177	95,174	116,351	843,533
2032	21,749	94,703	116,452	959,985

Table 20. Annual operating and maintenance expenses.

Manpower		Salary per mo.	Annual Cost
1	supervisor	90000	1,080,000.00
3	engineer	40,000.00	1,440,000.00
6	technician	20,000.00	1,440,000.00
2	security guard	15,000.00	360,000.00
		Sub-total	***4,320,000.00***
1 lot	supply & materials		680,000.00
		Total	***5,000,000.00***

To analyze the financial feasibility of the NZEB Quest, first we project the annual revenue by computing the (1) expected savings and (2) sales. The savings will come from (a) participating to GEOP as end-user and (b) supplying the energy demand from the site production through the solar installations. The savings and sales are computed as follows:

Sample calculation for 2020 revenue:

$$Revenue_{2020} = Savings_{2020} + Sale_{2020}$$

$$Savings_{2020} = Energy_{DEMAND\ 2022} * (INEC_{RATE} - GEOP_{RATE})$$

where;

$INEC_{RATE}$ =PhP 8.50

$GEOP_{RATE}$ = PhP 7.50

$Savings_{2020} = 1{,}886{,}410 * (8.5\text{-}7.5)$

$Savings_{2020} = PhP\ 1{,}886{,}410$

$Sale_{2020} = 0$

$Revenue_{2020} = 1{,}886{,}410 + 0 = PhP\ 1{,}886{,}410$

Sample calculation for 2024 revenue:

$Savings_{2024} = Energy_{DEMAND\ 2024} * INEC_{RATE}$

$Savings_{2024} = 2{,}020{,}864 * 8.5$

$Savings_{2024} = PhP\ 17{,}177{,}344$

$Sale_{2024} = Energy_{EXCESS\ 2024} * GEOP_{SELLING\ RATE})$

where;

$Energy_{EXCESS\ 2024} = Energy_{PRODUCTION\ 2023} - Energy_{DEMAND\ 2024}$

$Energy_{EXCESS\ 2024} = 5{,}207{,}820 - 2{,}020{,}864$

$Energy_{EXCESS\ 2024} = 3{,}186{,}956$ kWh

$GEOP_{SELLING\ RATE} = PhP\ 7.00$

$Sale_{2024} = 3{,}186{,}956 * 7$

$Sale_{2024} = PhP\ 22{,}308{,}692$

$Revenue_{2024} = Savings_{2024} + Sale_{2024}$

$Revenue_{2024} = PhP\ 17{,}177{,}344 + 22{,}308{,}692$

$Revenue_{2024} = PhP\ 39{,}486{,}036$

Results of all the computation were tabulated in table 15.

Table 21. Annual projected gross income and projected accumulated gross income from 2022-2029.

Year	Savings (PhP 1000)	Sale (PhP 1000)	Revenue (PhP 1000)	Accumulated Revenue (PhP 1000)
2022	1,886		1,886	1,886
2023	530		12,630	2,417
2024	17,177	22,309	39,486	41,903
2025	17,749	75,187	92,935	134,838
2026	18,320	97,527	115,847	250,685
2027	18,892	97,056	115,948	366,633
2028	19,463	96,586	116,049	482,682
2029	20,034	96,115	116,150	598,832
2030	20,606	95,645	116,251	727,182
2031	21,177	95,174	116,351	843,533
2032	21,749	94,703	116,452	959,985

Second, we compute for the annual operating and maintenance expenses. Table 21 shows the recommended manpower to man the smooth operation of the solar power system.

Table 22. Annual operating and maintenance expenses.

Manpower		Salary per mo.	Annual Cost
1	Supervisor	90000	1,080,000.00
3	Engineer	40,000.00	1,440,000.00
6	Technician	20,000.00	1,440,000.00
2	Security guard	15,000.00	360,000.00
		Sub-total	***4,320,000.00***
1 lot	supply & materials		680,000.00
		Total	***5,000,000.00***

Third, compute for the budget requirement of the solar installations. Table 22 shows the recommended yearly budget to install the 3MWp rooftop solar installation and the 8MWp ground mount solar installation.

Table 23. Estimated budget requirement for the solar installations

Year	Estimated Budget
2022	72,386,250
2023	157,687,152
2024	304,616,399
2025	127,509,072
Total	***662,198,873***

Fourth, make a financial statement from 2022 upto the year after the "Loan Payable" becomes zero. The financial statement will be the basis during the negotiation for a Built-Operate-Transfer (BOT) mode of financing the project.

For a solar installation BOT project, usually, investors like the PNOC offers a fifteen lock-up contract. The recipient will pay the investment by paying the 90% of the savings or revenue from the solar installations. The remaining 10% of the revenue becomes the incentive of the recipient. This payment will be done for fifteen years then the whole setup will be transferred to the recipient.

Table 24. Projected financial statement of the rooftop and ground mount solar installations

	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033
Liabilities												
Loan Payable	72,386,250	225,073,402	508,689,801	579,698,873	505,698,873	427,198,873	343,798,873	255,798,873	162,298,873	70,000,000	0	0
Acrued Principal Payment		5,000,000	26,000,000	82,500,000	156,500,000	235,000,000	318,400,000	406,400,000	499,900,000	592,198,873	662,198,873	0
accumulated Interest @ 6% diminishing rate		4,343,175	17,847,579	48,368,967	83,150,900	113,492,832	139,124,764	159,752,697	175,100,629	184,838,561	189,038,561	0
Total Payment		9,343,175	43,847,579	130,868,967	239,650,900	348,492,832	457,524,764	566,152,697	675,000,629	777,037,434	851,237,434	0
Revenue												
Savings	1,886,410	12,629,887	17,177,344	17,748,774	18,320,203	18,891,633	19,463,062	20,034,492	20,605,921	21,177,351	21,748,780	22,320,210
Sale			22,308,692	75,186,503	97,526,954	97,056,365	96,585,776	96,115,187	95,644,598	95,174,009	94,703,420	94,232,831
Total Revenue	1,886,410	12,629,887	39,486,036	92,935,277	115,847,157	115,947,998	116,048,838	116,149,679	116,250,519	116,351,360	116,452,200	116,553,041
Expenses												
Opn & Maint Expenses	1,000,000	2,000,000	3,000,000	4,000,000	5,000,000	5,000,000	5,000,000	5,000,000	5,000,000	5,000,000	5,000,000	5,000,000
Interest Expense		4,343,175	13,504,404	30,521,388	34,781,932	30,341,932	25,631,932	20,627,932	15,347,932	9,737,932	4,200,000	0
Principal Payment		5,000,000	21,000,000	56,500,000	74,000,000	78,500,000	83,400,000	88,000,000	93,500,000	92,298,873	70,000,000	0
Total Expenses	1,000,000	11,343,175	37,504,404	91,021,388	113,781,932	113,841,932	114,031,932	113,627,932	113,847,932	107,036,805	79,200,000	5,000,000
Net Income	886,410	1,286,712	1,981,632	1,913,888	2,065,225	2,106,065	2,016,906	2,521,746	2,402,587	9,314,554	37,252,200	111,553,041

Looking at table 24 above, the 15yrs lock-up period is too long. Considering a diminishing rate of 6% and a flexible principal payment as the revenue increases, at the end of the 11th year, the payable loan has been paid up already. This means that on 12th and the succeeding years MMSU may enjoy a projected net income of more or less PhP 100M annually upto the 25th yr.

2.3. Biomass Power Generation

Biomass can be converted into electric power through several methods. The most common is direct combustion of biomass material, such as agricultural waste or woody materials. Other options include gasification, pyrolysis, and anaerobic digestion. Gasification produces a synthesis gas with usable energy content by heating the biomass with less oxygen than needed for complete combustion. Pyrolysis yields bio-oil by rapidly heating the biomass in the absence of oxygen. Anaerobic digestion produces a renewable natural gas when organic matter is decomposed by bacteria in the absence of oxygen.

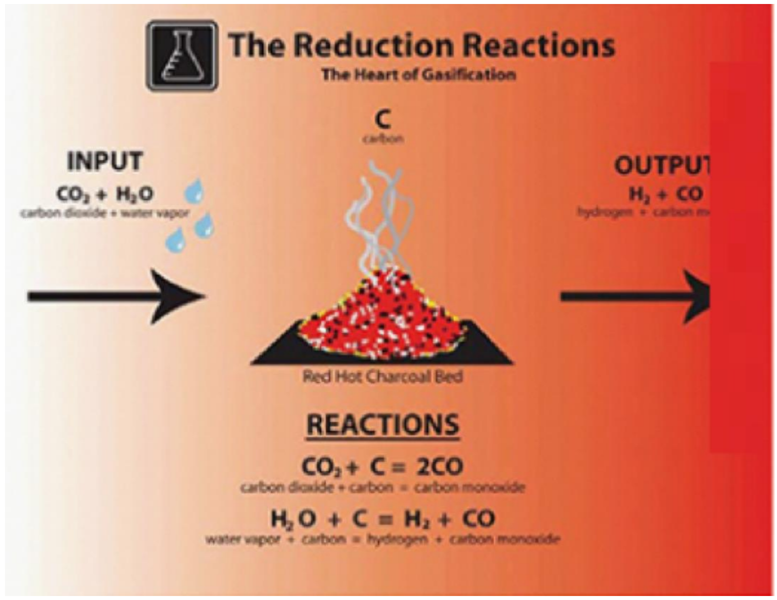


Fig. 13. Biomass reduction reactions

In this study, we will be focusing mainly on the conversion of biomass into electric power through "Gasification"

Gasification is the use of heat to transform solid biomass or other carbonaceous solids into a synthetic "natural gas like" flammable fuel. Thru gasification, we can convert nearly any dry organic matter into a clean burning fuel that can replace fossil fuel in most use situations. Whether starting with wood chips or walnut shells, construction debris or agricultural waste, gasification will transform common "waste" into a flexible gaseous fuel you can use to run your internal combustion engine, cooking stove, furnace or flamethrower. The gasifier is essentially a chemical reactor where various complex, physical and chemical processes take place. Biomass gets dried, heated, pyrolised, partially oxidized and reduce in this reactor as it flows through it.

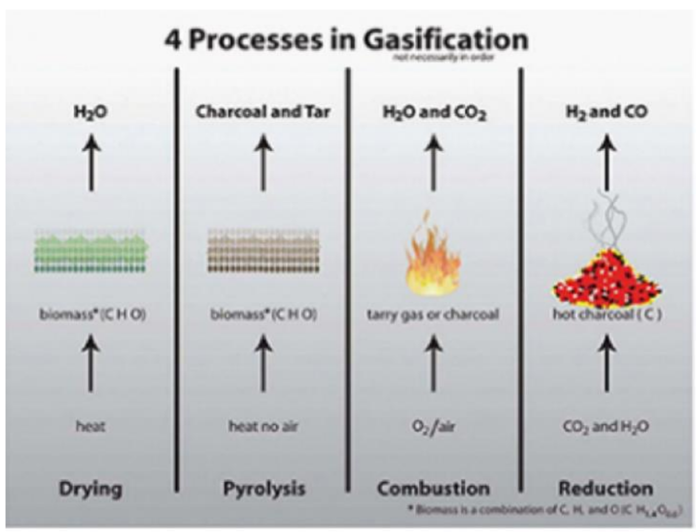


Fig. 14. Four processes of gasification.

Four distinct processes take place in a gasifier: 1) Drying of the fuel 2) Pyrolysis 3) Combustion 4) Reduction.

The major application of gasification is that the produced gas will be directly used for the generation of power (and heat). This can be either in stand-alone combined heat and power (CHP) plants or by co-firing of the produced gas in large-scale power plants.

Fig. 15. Biomass applications.

In view of the decreasing reserves of fossil fuel and also because of aim of the world to reduce the dependency on imported fossil fuels, there is a growing interest in producing syngas from the renewable source biomass,i.e. "biosyngas". Biomass will play an important role in the future global energy infrastructure for the generation of power and heat. The dominant conversion technology will be gasification, as the gases from biomass gasification are intermediates in the high-efficient power production or the synthesis from chemicals and fuel.

The difference between gasification to combustion are best understood comparing the chemical reactions involved in each process.

Combustion is the total oxidation of carbon, hydrogen and other elements, which releases thermal energy. Combustion is generally less thermal efficient than gasification. While gasification is a much cleaner process than combustion (incineration) for converting carbonaceous materials to energy. In gasification, the fuel or converted to chemicals such as ammonia for industrial or agricultural use. The difference between gasification and combustion are best understood by comparing the chemical reactions involved in each process. As can be seen by comparing the typical combustion and incinerations reactions, the level of Sox and NOx are much reduced by gasifying the fuels prior to combustion of the syngas product.

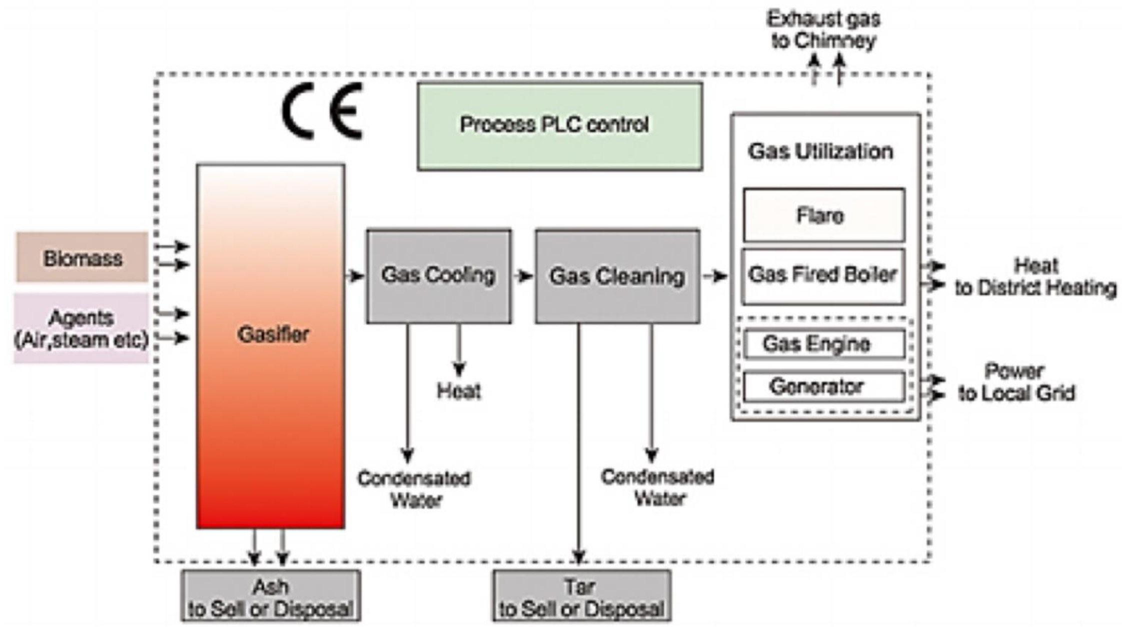
Combustion (Oxidation) Reactions	
$C+O_2 \longleftrightarrow CO_2$	Oxidation of Carbon
$1/2O_2+H_2 \longleftrightarrow H_2O$	Oxidation of Hydrogen
$N+O_2 \longleftrightarrow NO_2(NO_x)$	Oxidation of Nitrogen
$S+O_2 \longleftrightarrow SO_2(SO_x)$	Oxidation of Sulfur
Gasification Reactions	
$C+1/2O_2 \longleftrightarrow CO$	Gasification with Oxygen
$C+CO_2 \longleftrightarrow 2CO$	Gasification with Carbon Dioxide
$C+H_2O \longleftrightarrow CO+H_2$	Gasification with Steam
$C+2H_2 \longleftrightarrow CH_4$	Gasification with Hydrogen
$CO+H_2O \longleftrightarrow H_2+CO_2$	Water–Gas Shift Reaction

Fig. 16. Gasification combustion reactions.

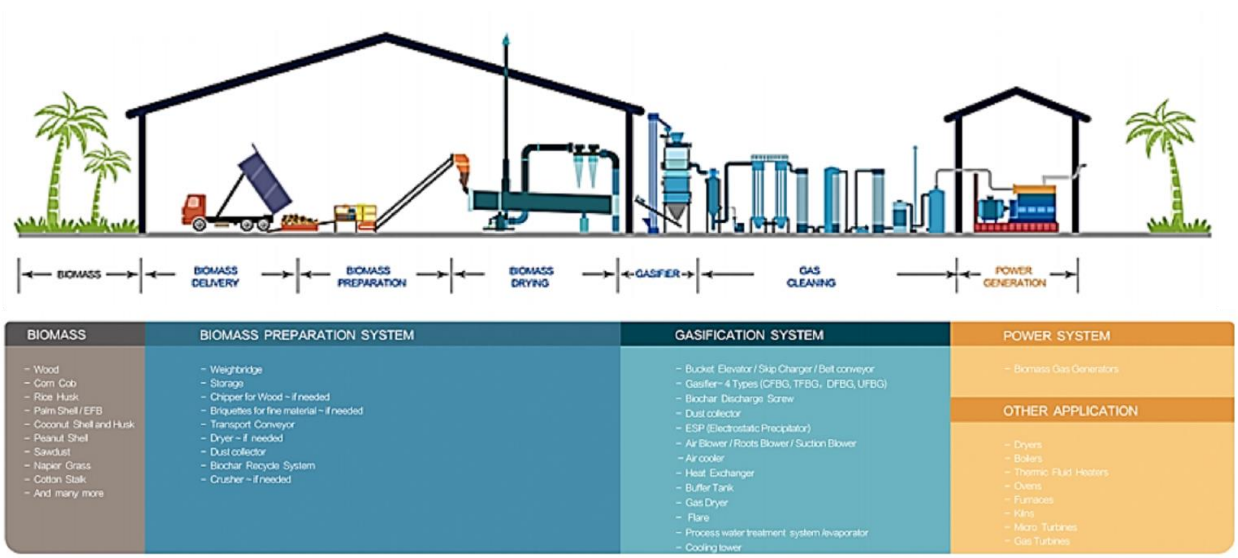
The biomass gasification process includes three (3) steps.

1. The first step is biomass gasification, which convert biomass into syngas.

2. The second step is syngas purification. The producer gas coming from gasifier usually contains contaminants including, dust, coke, tar and etc. The contaminants will be removed by the purification system to ensure normal operation of gas engine.
3. The third step is power generating in gas engine. The high temperature exhaust gas may be reused by waste heat boiler to generate steam or hot water for civil or industrial use. Steam turbine may also be considered to make a gas-steam combines cycle power plant, which will increase the total efficiency.



(a)



(b)

Fig. 2.1. Process flow of converting biomass into electricity. (a) Block diagram (b) Pictorial diagram

2.3.1. Economics and Performance of Biomass Power Generation

This portion presents the assumptions, engineering design, supply and demand and financial study in order to analyze the performance of the Biomass Power Generation System and its economics.

2.3.1.1 Assumptions

The duration of the daily operation of the biomass plays an important role in the computation of its economics. In this study, 8-10 hours of operation time was assumed. All the power generated from the biomass power generation is assumed to be consumed by MMSU, hence for the purpose of this feasibility study, the demand is always 100% of whatever generated. The average electricity rate to be used in the calculation is PhP 8.5/kWh. The overall efficiency is assumed at 23%.

2.3.1.2. Biomass Feedstock Assessment

The basic principle of biomass gasification system is to convert agricultural and forestry products and wood processing remains (including rice husks, wood powder, branches, offcuts, corn straws, wheat straws, cotton straws, fruit shells, coconut shells, palm shells, corn cobs and etc.) into combustible gas.

It is then used as fuel in gas engine to generate electricity. Biomass gasification successfully conquers the disadvantages of biomass, such as low flammability and wide diversity. Biomass gasification system is characteristic of small land requirement and environment friendly. It's one of the most effective way of biomass utilization.

Fig. 18. Biomass feedstock

Also, MMSU has about 130 ha of agricultural farm tenanted by nearby farmers/residents. The 130Ha agricultural land at MMSU is usually planted with rice and corn alternately throughout the year. With these crops, the estimated biomass feedstock every year is about 1305 tonnes. With this, the Biomass Power Potential of agricultural waste for the 130Ha is more than 200kW which can be operated for 16 hours per day.

Furthermore, the MMSU Batac Campus is surrounded by farms on the western and southern part. Hence, agricultural wastes can be sourced-out from farmers to provide them additional income at the same time help in managing agricultural waste in the locality. Therefore, supply of feedstock is not a problem. In fact, these agricultural wastes are not usually utilized but left in the field.

Generally, collection of rice husk and straw will be done on the months of March–May while corn cob and stalk will be on November-December. Since the source of agricultural wastes is just around the Biopower House (furthest distance is about 1km), MMSU farm machineries will be used during the collection. Collected feedstock will be secured and stocked properly to ensure the quality.

2.3.1.2. Engineering Design

A modular Biomass Power Plant consisting of several 100kW capacity is recommended based on the available feedstock potential. At first, a 100kW biomass power plant will be established to provide power when the sun power is not available and during power interruption together with the On-grid Hybrid System. A solar grid-tied system does not produce energy without power from the utility. Thus, to ensure continuous and reliable power supply, the 100kW biomass generator will provide electricity where the solar grid-tied system is to be tied. Also, the biomass generator set will provide power at night to other buildings not installed with On-grid Hybrid System.

Based from studies and considering an electrical effective efficiency of 20%, the biomass fuel input to the power plant is 96kg/hr to produce a 100kW of continuous power for 1 hour. This means, for an operation of 16 hours per day, it requires almost 1.6 tons of feedstock to produce 1,600 kWh of energy per day.

Figure 19 shows the mass and energy balance diagram from the hourly 96kg input corn cob feedstock to the 100kWh output ready for use. The figure below shows also the heat losses, the additional input energy to the feedstock and the usable heat for other agricultural heating or cooling application.

MASS AND ENERGY BALANCE FOR A 100KW BIOMAS GASIFICATION PLANT

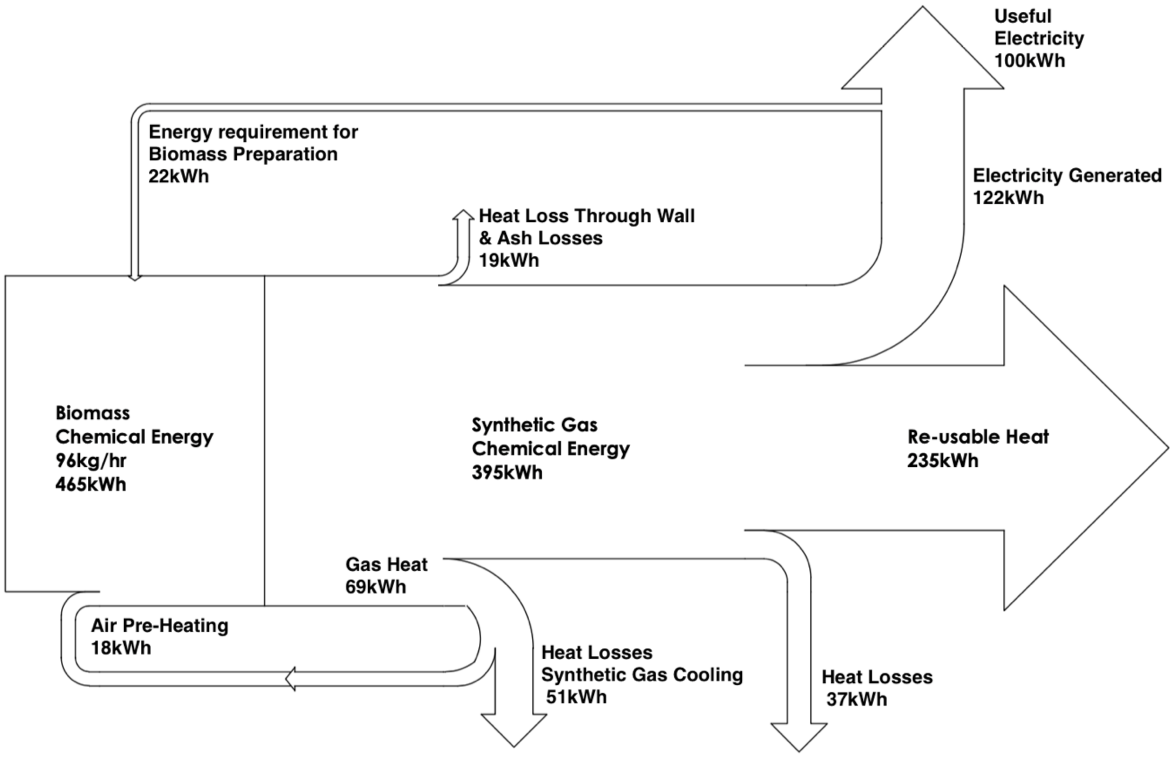


Fig. 19. Detailed hourly mass and energy balance diagram showing the input feedstock, losses and output energy.

Converting the 96kg of corn cob into kWh;

Biomass Chemical Energy = 96kg * 17.5MJ/kg * 0.277kWh/MJ
= 465kWh

Assuming 85% conversion from biomass to synthetic gas;

Synthetic Gas Chemical Energy = 465kWh * 85% = 395kWh

Attribute the conversion from biomass to synthetic gas losses to;

Gas Heat = 69kWh (about 15%)
Heat Loss = 19kWh (about 4%)

About 18kWh of the Gas Heat is used for pre-heating to increase the conversion efficiency. The rest about 51kWh is wasted as the synthetic gas cools down.

Energy balance during the biomass conversion to synthetic gas:

Biomass Energy + Air Pre-heating = Synthetic Gas Energy + Gas Heat + Heat Loss

465kWh + 18 kWh = 395 kWh + 69 kWh + 19 kWh
483 kWh = 483 kWh

Assuming 31% conversion of Synthetic Gas into electricity;

Electricity Generated = 395kWh * 0.31 = 122kWh

Assuming 59.5 % conversion of Synthetic Gas into Re-usable Heat;

Re-usable Heat = 395kWh * 0.59 = 235kWh

The remaining 37kWh is the Heat Loss (including other losses) during the conversion.

From the generated 122kWh electricity, about 22kWh is used for the preparation of the feedstock like chipping and pelletizing and other electricity requirement during the plant operation. This leave a 100kWh usable energy.

Energy balance from biomass conversion to electricity generation:

Biomass Energy + Air Pre-heating
= Electricity Generated + Re-usable Heat + Gas Heat + Heat Losses

465kWh + 18kWh = 122kWh + 235kWh + 69 kWh + 19kWh + 38kWh
483 kWh = 483 kWh

Gasification is a thermochemical process which converts biomass materials into gaseous components. Syngas is the product of gasification comprising CO, CH_4, CO_2, H_2 with the balance being N_2 and a carbon-rich ash. A gasification processes can produce three types of by-products: fly ash (including char or unreacted fuel), bottom ash, and tar, which are mostly useless and troublesome to the component of the produced syngas. The major problem of biomass gasification is that the produced gas usually contains unacceptable levels of tar causing process-related problems. Tar from fuel gas condenses at low temperatures, thus blocking, fouling corrosion, erosion and abrasion of process equipment such as engines and turbines.

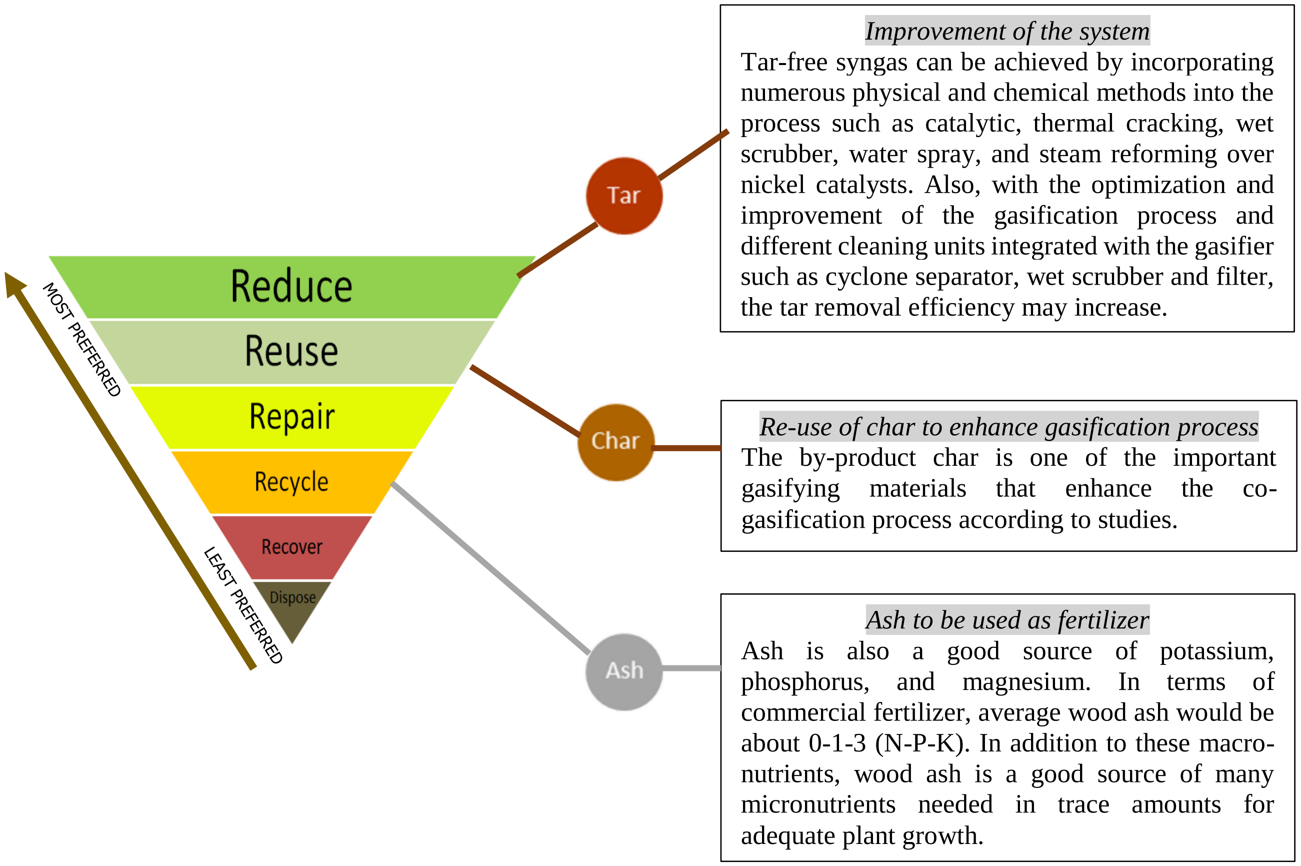


Fig. 20. Waste management plan.

2.3.1.3. Supply and Demand

The biomass generator is assumed to operate form 4pm-8am. This will be done in two shifts. Generally, all the energy of 1,600 kWh generated daily from the 100kW biomass generator will be absorbed by MMSU to provide power at night. For one year, the energy generated is projected at 584,000 kWh.

2.3.1.4. Financial Study

To analyze the financial viability of the biomass power generation, first, the total cost of the project was computed. Table 25 shows the budget for each of the components of a 100kW bio-power facility.

Table 25. Budget requirement for each of the component in establishing a 100kW Bio-power.

Component	Budget
Gasifier FOB China	12,824,010
Custom Tax & delivery	1,200,000
BioPower House	5,000,000
Operation & Maintenance	1,000,000
Contingency @ 10%	2,066,401
Total	**22,090,411**

Table 26 shows the manpower requirement to operate the power plant 16hr a day.

Manpower		Salary per mo	Annual Cost
4	technician	20,000.00	960,000.00
1	security guard	15,000.00	180,000
Sub-total			***1,140,000***
1 lot	supply & materials		300,000
		Total	***1,440,000***

Second, compute for the projected energy generation and savings from operating the plant for 16 hrs a day in one year.

Energy = 100kW * 16hrs * 365 days = 584,000kWh

Savings = 584,000kWh * PhP 8.50/kWh = PhP 4,964,000

Then, make a financial statement (table 27) from year 1 up to the year after the "Loan Payable" becomes zero.

From table 27, considering a 6% diminishing interest rate, the payback period will be sometime in the first quarter of the 12th year.

Table 27. Projected financial statement of biomass power generation facility.

	yr1	yr2	*yr3*	yr4	*yr5*	yr6	*yr7*	*yr8*	yr9	yr10	yr11	yr12	yr13
Liabilities													
Loan Payable	24,796,812	22,960,621	21,014,258	18,951,113	16,764,180	14,446,031	11,988,793	9,384,121	6,623,168	3,696,558	594,351	0	0
Accumulated Principal Payment		1,836,191	3,782,554	-,845,699	8,032,632	10,350,781	12,808,019	15,412,691	18,173,644	21,100,254	24,202,461	24,796,812	
Accumulated Interest @ 6% diminishing rate		1,487,809	2,865,446	4,126,301	-5,263,368	6,269,219	7,135,981	7,855,309	8,418,356	8,815,746	9,037,539	9,073,200	
Total Liabilities		3,324,000	6,648,000	9,972,000	13,296,000	16,620,000	19,944,000	23,268,000	26,592,000	29,916,000	33,240,000	33,870,012	
Revenue													
Savings		4,964,000	4,964,000	4,964,000	4,964,000	4,964,000	4,964,000	4,964,000	4,964,000	4,964,000	4,964,000	4,964,000	4,964,000
Expenses													
Operating & Maintenance Expenses		1,640,000	1,640,000	1,640,000	1,640,000	1,640,000	1,640,000	1,640,000	1,640,000	1,640,000	1,640,000	1,640,000	1,640,000
Interest Expense		1,487,809	1,377,637	1,260,855	1,137,067	1,005,851	866,762	719,328	563,047	397,390	221,793	35,661	0
Principal Payment		1,836,191	1,946,363	2,063,145	2,186,933	2,318,149	2,457,238	2,604,672	2,760,953	2,926,610	3,102,207	594,351	
Total	0	4,964,000	4,964,000	4,964,000	4,964,000	4,964,000	4,964,000	4,964,000	4,964,000	4,964,000	4,964,000	2,270,012	1,640,000
Net Income		0	0	0	0	0	0	0	0	0	0	2,693,988	3,324,000

3. MANAGEMENT OVERVIEW & MONITORING

This section provides a description of how the implementation be managed, monitored and identifies the major tasks and whose responsibility.

3.1. Description of Implementation

The whole project will be divided into seven phases over four years to attain a NZEB Plus status. The table below shows the different phases/activities and its schedule of implementation.

Table 28. Suggested activities to attain NZEB Plus status and year of implementation.

Phase	Activity	Estimated Budget (M PhP)	Date of Implementation	Possible Source of Fund
1	Participation to GEOP as End-user	-	July 2021	-
2	ACU Retrofitting	10	January 2022	MMSU
3	Solar Irrigation System Utilization	10	January 2022	UNDP
4	Solar Rooftop Installations	332	2022-2025	BOT
5	Establishment of Biomass Power Generation Facility	25	January 2023	DOE
6	Participation to GEOP as RE Source	-	2023	-
7	Ground Mount Solar Installations	440	2023-2025	BOT

3.2. Work Plan

Table 29. Workplan for the Participation to GEOP as End-user

		Time Table					
		Jul	Aug	Sep	Oct	Nov	Dec
Submit letter of Intent to INEC	OP						
Confirm eligibility of MMSU as GEOP End-user	INEC						

Settle all outstanding balance	Finance						
Ocular inspection	INEC						
Choose RE Source	EM Team						
Drafting of MOA	INEC						
MOA Signing	MMSU, INEC & DOE						
Installation of metering & equipment	INEC						
Ceremonial Switching	MMSU, INEC & DOE						

Table 30. Workplan for the ACU Retrofitting Project

		Time Table (2022)					
		Mo1	Mo2	Mo3	Mo4	Mo5	Mo6
Ocular inspection of all ACU at MMSU	EM Team						
Prepare procurement plan & PR	EM Team						
Posting & Bidding	BAC						
Replace non-Inverter Type ACU	Contractor						
Commissioning and Inspection	EM Team, BAC, TWG, & UNDP						

Table 31. Workplan for the Solar Irrigation System Utilization

		Time Table (2022)					
		Mo1	Mo2	Mo3	Mo4	Mo5	Mo6
Submit letter of request to DA (assuming approved)	OP						

Submit proposal to UNDP (assuming approved)	EM Team						
Purchase of goods and services	UNDP						
Installation of Switching System	Contractor						
Commissioning and Inspection	EM Team, BAC, TWG, & UNDP						
Ceremonial Switching	MMSU, UNDP & DOE						

Table 32. Workplan for the Solar Rooftop Installations

		Time Table (2022-2025)						
		2022						
		Q1	Q2	Q3	Q4			
Invitation to potential investor	OP							
Drafting of MOA	MMSU & Investor							
Screening and selection of investor	EM Team & OP							
Signing of MOA	MMSU, Investor & DOE							
Installation of Hybrid Grid-Tied System (300kWp)	Investor/contractor							
Installation of Grid-Tied System	Investor/contractor							
Commissioning and Inspection	Investor/contractor, EM Team, BAC, TWG, & UNDP							

Table 33. Workplan for the Biomass Power Generation

			Time Table (2023)			
		2022	Q1	Q2	Q3	Q4
Submit proposal to DOE (assuming approved)	EM Team					
MOA Signing	MMSU & DOE					
Posting, bidding & awarding of contract	MMSU					
Installation of biomass power system	Contractor					
Commissioning and Inspection	EM Team, BAC, TWG, & DOE					
Ceremonial Switching	MMSU & DOE					

Table 34. Workplan for the Participation to GEOP as RE Source

		Time Table (2023)					
		Mo1	Mo2	Mo3	Mo4	Mo5	Mo6
Submit letter of Intent to INEC/DOE	OP						
Confirm eligibility of MMSU as GEOP RE Source	INEC/DOE						
Ocular inspection	INEC/DOE						
Drafting of MOA	MMSU, INEC & DOE						
MOA Signing	MMSU, INEC & DOE						
Installation of metering & equipment	INEC & MMSU						
Ceremonial Switching	MMSU, INEC & DOE						

Table 35. Workplan for the Ground Mount Solar Installations

		Time Table (2023-2025)					
		2023					
		Q1	Q2	Q3	Q4		
Invitation to potential investor	OP						
Drafting of MOA	MMSU & Investor						
Screening and selection of investor	EM Team & OP						
Signing of MOA	MMSU, Investor & DOE						
Installation of Grid-Tied System	Investor/contractor						
Commissioning and Inspection	Investor/contractor, EM Team, BAC, TWG, & UNDP						

3.3. Monitoring

The EM Team of MMSU will be tasked to monitor the implementation of each of the activities mentioned in this Implementation Plan to ensure the success of the NZEB Plus Quest. A monitoring tool will be developed based on the workplan for each activities. Monitoring must be done regularly on a monthly, quarterly and yearly basis. Below is a sample monitoring tool.

Table 3. Sample Monitoring Tool.

Activity 4. Solar Rooftop Installations							
					Remarks		
					Standard	**Timeliness**	**Quality**
Milestone1	Task1						
	Task2						
	Task3						
Milestone2	Task1						

Milestone refers to a significant accomplishment or stage in the development of a particular NZEB activity.

Major Task refers to specific activities under a particular milestone.

Expected Outcome are tangible means of verification to a particular task.

Due Date is the committed date of accomplishing a particular task or milestone.

In-Charge refers to the person responsible of accomplishing a particular task or milestone.

Remarks are to be filled up by the chair of the monitoring team.

Standard refers to compliance to the technical specifications of the contract as well as conformity to local ordinances and existing/applicable codes.

Timeliness refers to the completion of a specific task or milestone as indicated in the workplan.

Quality refers to the overall workmanship and aesthetic of the work done as presented and described in the approved design.

Another monitoring tool will be developed for the maintenance of all the systems to ensure the sustainability of the quest. The monitoring tool must be adaptive and responsive to current challenges of the whole system.

4. IMPLEMENTATION REQUIREMENT & SUPPORT

This section describe the general site specific implementation requirements for (1) Solar Rooftop Installations; (2) Ground Mount Solar Installations; (3) ACU Retrofitting and (4) Establishment of Biomass Power Generation Facility. Also, it presents the support hardware, software, facilities and materials needed for the smooth implementation and sustainability of operation after all the installations.

4.1 IMPLEMENTATION REQUIREMENT

4.1.1 Site Requirement for Solar Rooftop Installations

1. All roof structure and roof decks identified for solar installations must have a structure integrity of holding the installations for a storm signal #4. There must be a separate roof structure and roof deck structure integrity study to ensure that the installation will stay for at least 20 years.
2. There must be a dedicated power room for each building identified to house the inverters, batteries and other peripherals. The power room must be properly ventilated and must be big enough for technician or engineer to do periodic maintenance and troubleshooting.
3. There must be no shading from trees at least from 8am to 5 pm. Trees must be regularly and properly trimmed to ensure that there will be no shading.

4.1.2 Site Requirement for Ground Mount Solar Installations

1. There must be no shading from tress at least from 8am to 5 pm. Trees must be regularly and properly trimmed to ensure that there will be no shading.
2. There must be a separate flood risk assessment conducted before the installations.

4.1.1 Site Requirement for Biomass Power Generation Plant

1. Below are the following requirements for biomass plant
   a. Area ; 70meters x 50meters
   b. Weighbridge
   c. Storage area
   d. Chipper for wood
   e. Briquettes for fine materials
   f. Transport conveyor
   g. Dryer
   h. Dust collector
   i. Biochar recycle system
   j. Crusher

2. Other requirements
   a. Legal issues of gasification-plant operation
   b. Legal issues of construction requirements
   c. Long-term feedstock supply
   d. Storage and transportation/logistics
   e. Financial planning
   f. Communication with local interest groups
   g. Legal and Technical requirements for feeding energy into local grid

4.2 IMPLEMENTATION SUPPORT

1. Forcasting Software
2. Powerful/advanced computer for monitoring and data acquisition