microRenewables HANDBOOK

SOLAR PV ROOFTOP

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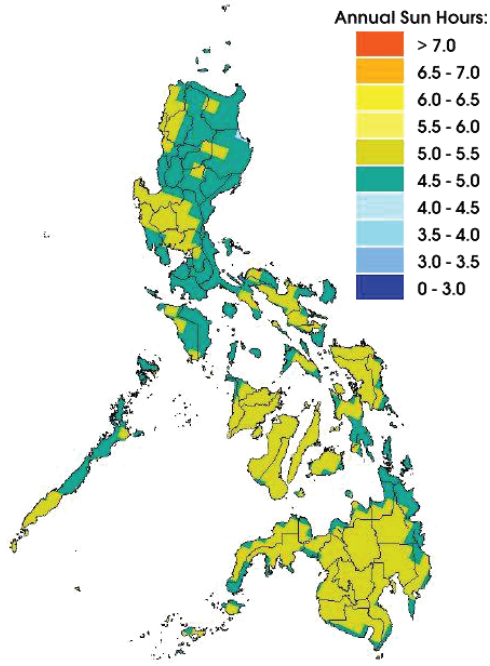
CREST

FRIEDRICH EBERT STIFTUNG

Introduction to Solar Energy



▲ Philippine Solar Map. Photo from NREL.

Solar energy is the radiant light and heat coming from the sun. Solar energy is crucial for plants and trees to generate their food, circulate air, regulate global temperature and make life exist in the planet. Humans have been harnessing energy from the sun for centuries. However, the advent of technology helps us convert solar energy into electricity to be able to power our homes, provide lighting, drive appliances and increase our economic production.

As a tropical country, all areas of the Philippines receive an ample amount of solar radiation, making solar energy a viable and practically unlimited energy source that can be tapped by any community. The Philippines has an average of four (4) sun-hour, or the number of hours in a day when solar radiation reaches its peak value of 1000 watts per meter squared or 1kW/m^2. In Europe, where the use of solar energy for electricity was first popularized, most areas only receive an average of less than 2 sun-hour.

There are different ways to harness solar energy and use it for our day-to-day. This handbook will discuss the use of solar photovoltaic (PV) technology for electricity and power production.

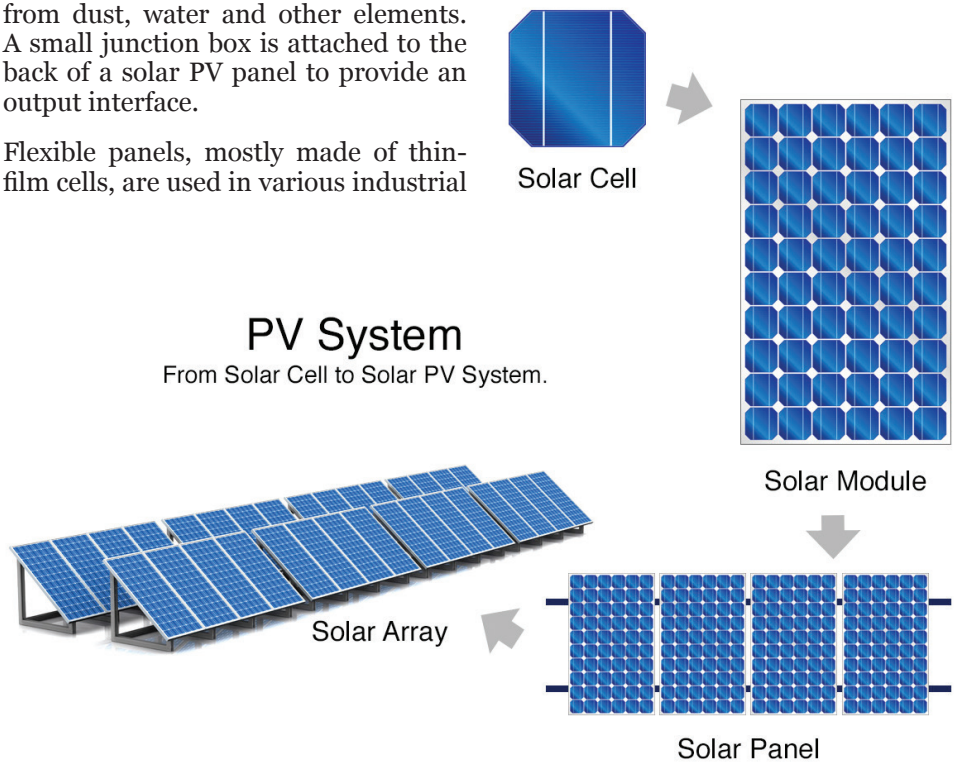
Solar Cells

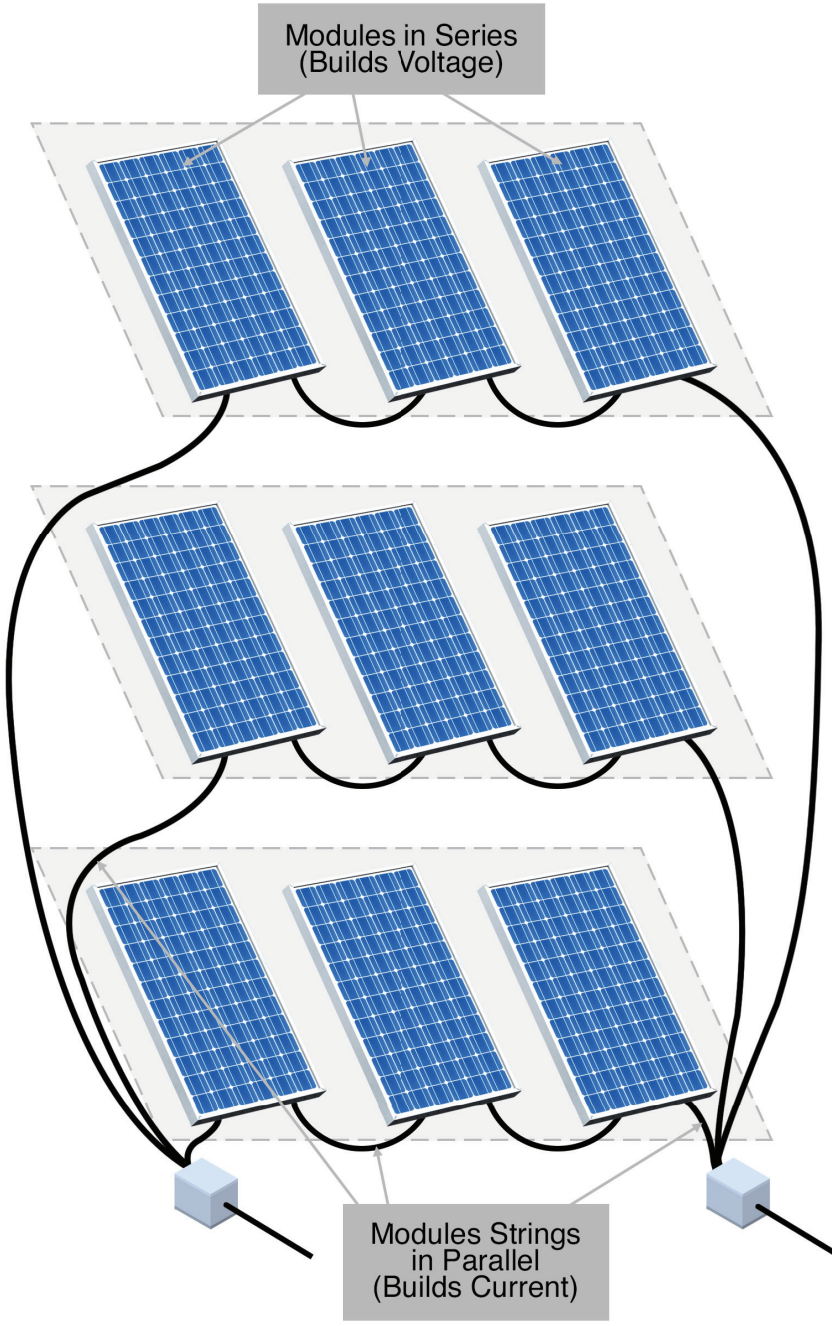
Solar photovoltaic technology utilizes the photovoltaic effect or converts light (photons) to electricity. This process happens through the use of photovoltaic cells or “solar cells”. When solar light hits the cell, it causes an electric flow. The greater the solar intensity, the greater the flow of electricity. If it’s cloudy or rainy, electricity production is very low. No electricity is produced at night due to the absence of solar radiation.

Solar cells are then arranged in a group to form a solar PV module or simply, a solar panel. Glass protects the cells from dust, water and other elements. A small junction box is attached to the back of a solar PV panel to provide an output interface.

Flexible panels, mostly made of thin-film cells, are used in various industrial applications. However, rigid solar panels, especially the monocrystalline type, has higher efficiency than thin-film solar panels.

Solar panels produce a unidirectional flow of electric charge or what’s commonly called as Direct Current (DC). Solar panels have a negative (-) terminal and a positive (+) terminal. Panels are arranged either in a series to achieve a desired output voltage (V, volt) or in parallel to achieve a desired current output (A, ampere).




Modules in Series
(Builds Voltage)
Modules Strings
in Parallel
(Builds Current)

Benefits of Solar PV Rooftop

There's an increasing trend in installing solar PV systems due to high electricity costs, declining prices of solar PV devices, and growing environmental consciousness among citizens. For urban centers where space is limited, rooftops provide an adequate area to place solar panels and harvest the energy from the sun.

The sun is a clean and free source of energy. Solar PV systems do not require fossil fuels to operate; therefore, it has no emissions and do not emit toxic pollutants into the environment. Solar PV offsets the demand for electricity coming from coal and other dirty sources, hence it reduces greenhouse gas emission into the atmosphere. Depending on the capacity, solar PV can be installed in a rooftop between 1-5 days.

Users of solar PV rooftops become "prodsumers": they enjoy the benefit of producing their own power while still maintaining the services of their respective private distribution utility or electric cooperatives (DUs/ECs).

Electricity produced by a solar PV rooftop is the cheapest among all energy sources, as shown by an analysis called Levelized Cost of Electricity (LCOE). Based on CREST's computation, the LCOE for solar PV rooftop is at 5.01 pesos per kiloWatt per hour (CREST, 2019). This amount is significantly lower compared to the retail electricity price from an electric distribution utility, e.g. Meralco's October 2020 electricity rate was 8.56 pesos per kWh.

Solar PV systems can be used to provide power even in far-flung islands or communities. It can also be used in a wide range of application such as agriculture production, irrigation, emergency and disaster response, transport and others.

▲ Solar Evacuation Center in Barangay Meysulao, Calumpit, Bulacan.

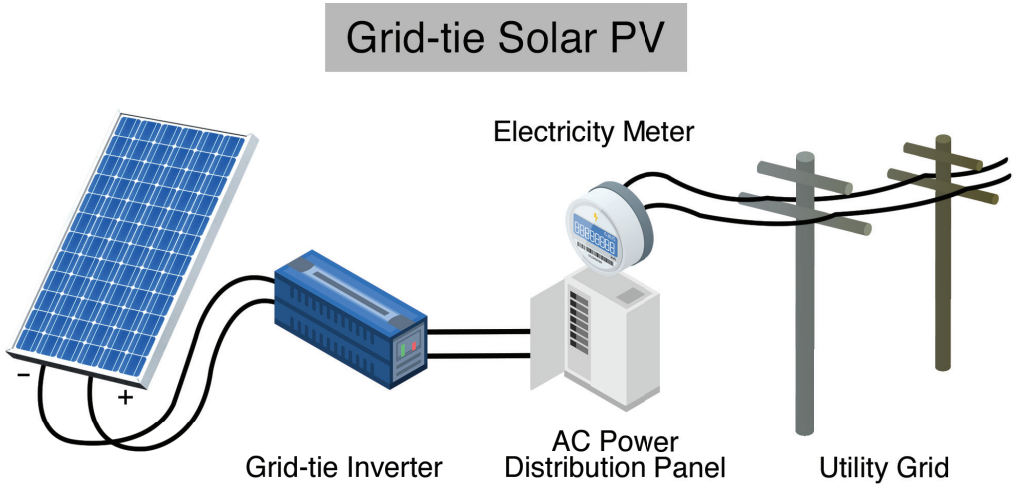
Grid-tie Solar PV

The most popular solar PV rooftop design for Metro Manila and urban centers is the grid-tie solar PV. This system is utility-interactive and the electricity produced by the solar panels blend with the electricity coming from the DUs/Ecs.

This system utilizes only two main devices: solar panels and a grid-tie inverter. A grid-tie system is rated based on the total power of the solar panels in an array. For example, if you have a total of 800W panels, the inverter should be at least 800W or with a higher capacity. An inverter is a device that converts the panel's direct current to non-directional, alternating current (AC), so that the produced electricity can be used by common household appliances. A grid-tie inverter has an anti-islanding protection. It is a safety feature that automatically disables the inverter's PV features if it detects that there is no grid electricity. It means your solar PV rooftop will not work during blackouts.

This type of system offsets the daytime load of the household/ building, thereby cutting electricity demand especially during peak hours. The immediate benefit for the user is savings from reduced electricity consumed. Excess power produced by the user can be passed to the distribution utility to earn "credits" via net-metering. If there is limited solar input or at night, the household automatically gets electricity from the grid.

A grid-tie system is easy to design, operate and maintain. This system also has a lower capital cost. A disadvantage of the system is that it can only be used in areas where there is reliable grid electricity.



Off-grid Solar PV

This is a stand-alone system and can be set-up anywhere. It has a wide-range of application, such as providing electricity in remote areas, street lighting, charging station, water irrigation, transportation, and others.

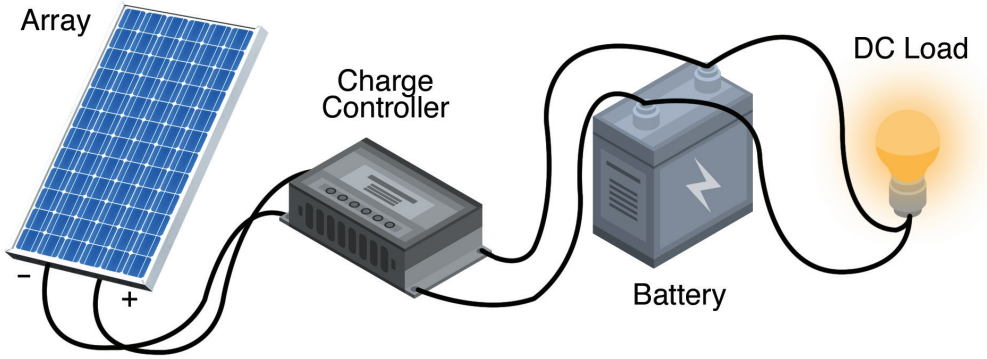
Off-grid solar PV has four main devices: solar panels, an off-grid inverter, a charge controller, and a battery. The electricity from the solar panels flows into the charge controller, then to the battery. The charge controller acts as the electricity regulator to control the charge and discharge of the battery. Similar from the previous design, an off-grid inverter converts direct current to alternating current.

The battery is a device where you store electricity for use especially at night. It is rated in Ampere-hour or Ah. The higher the Ah of the battery, the more electricity that can be stored. The most common type of solar battery in the market is the lead-acid. Depending on the depth of discharge, a lead-acid battery has 200 to 300 charge cycles. The more efficient but costlier lithium-ion solar battery has 300 to 500 charge cycles. Batteries are arranged either in a series or parallel to achieve the desired output voltage, e.g. 12V, 24V or 48V.

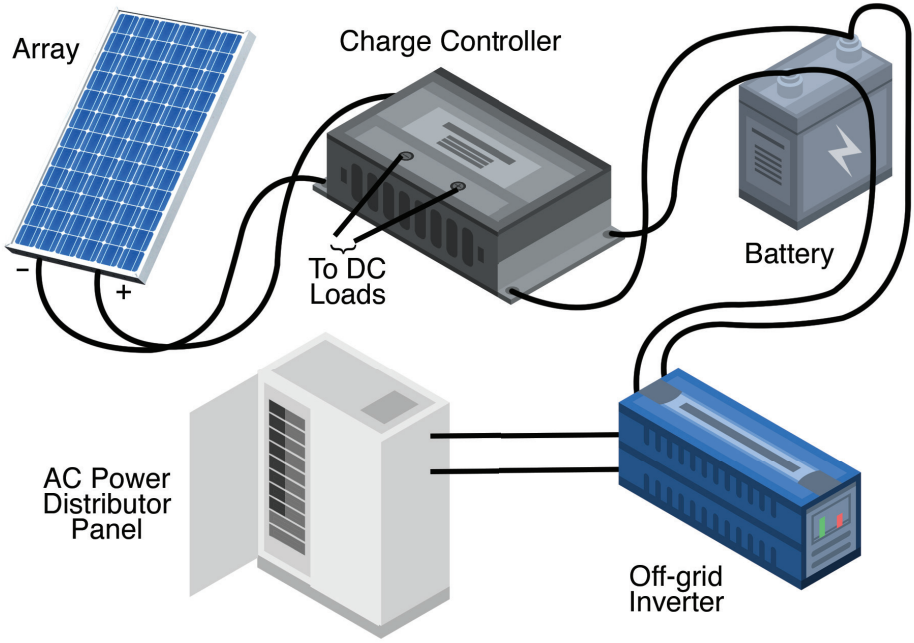
Off-grid solar is rated based on the total power capacity of solar panels and battery array. Solar panels are connected either in series or parallel to get the desired voltage and ampere of the system. Users should use a charge controller with higher capacity than the voltage and ampere output of solar panel arrays. A charge controller should also match the voltage output of your battery array.

Users of off-grid solar PV can enjoy its benefit 24-hours, seven days a week. However, it is costlier and require more maintenance because of the use of batteries.

Off-grid solar with DC load only



Off-grid solar with AC load

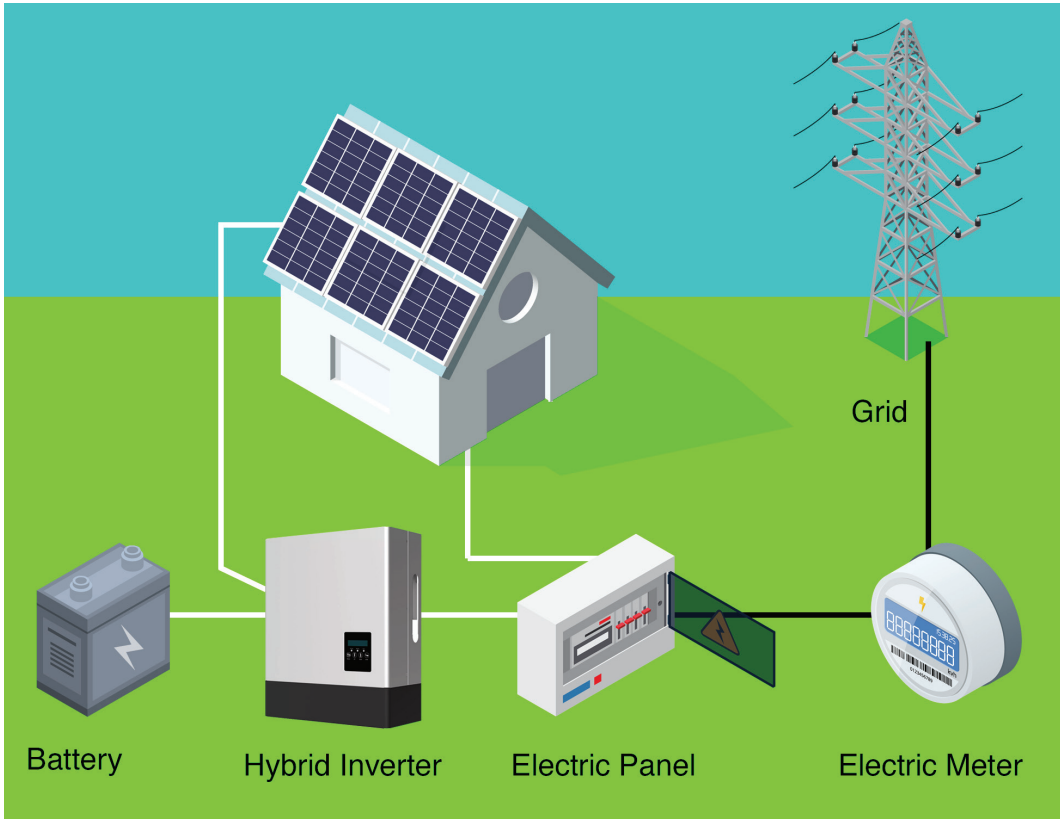


Hybrid Solar PV

This system combines both the function of grid-tie and off-grid systems. Users enjoy the benefits of solar during daytime and have a battery system that still power critical loads during blackouts. When we say critical loads, these are important devices in times of emergencies such as lighting, charging stations or refrigeration for medicines and vaccines.

Due to its function, hybrid solar PV systems are usually put in buildings where having backup power is very important such as emergency and DRR Centers, evacuation facilities, hospitals, rural health units, etc.

Hybrid solar PV is the costliest among the three mentioned systems. It also requires more user monitoring and maintenance.



System Accessories

Roof mounting. Aluminum rails with brackets are used to fix the solar panel to the roof. Clamps (end-clamp, mid-clamp) are used to secure the panels in the rail.

Many panels use an MC4 or single contact electrical connectors for easier and weatherproof connection to other panels.

A circuit breaker is a device that protects the electricity circuit from damage caused by excess current from an overload or short circuit. Breakers will trip or interrupt the current flow once a fault is detected in the circuit. Breakers are rated based on its ampere capacity and comes separately for DC and AC circuits.

Isolator switches completely disconnect a certain part of the circuit from others. This is also a protection device and very useful during maintenance. Isolator switches come separately for DC and AC circuits.

Solar PV wires are usually stranded wires. This type of wire consists of small gauge wires bundled or wrapped together to form a larger conductor medium. Stranded wires are more flexible than its counterpart, solid wires.

Sizing your Solar PV System

It is important to know your energy demand before you determine the appropriate capacity for your planned solar PV rooftop. An easy way is to list down the total power (watts) consumed by all appliances operating at a given time of the day. You can refer to the table.

Grid-tie solar PV is size based on your electricity consumption at daytime, from 6:00AM to 5:00PM. Normally, we recommend that the total size of your solar PV is not greater than your computed daytime consumption to avoid excess or power wastage.

$$\text{Solar PV}_{max} = \frac{\text{Electricity Demand (Daytime)}}{\text{Average Sun hours}}$$

The number of sun hours depends on the location. For the Philippines, solar designers usually use 4 for the amount of sun hours.

On the other hand, off-grid solar PV should be sized based on your computed electricity consumption for 24 hours.

$$\text{Solar PV}_{max} = \frac{\text{Electricity Demand(24-hours)}}{\text{Average Sun hours}}$$

Time	Watts	Time	Watts
AM		PM	
00		12	
01		01	
02		02	
03		03	
04		04	
05		05	
06		06	
07		07	
08		08	
09		09	
10		10	
11		11	

Technical Considerations

Here are other considerations when putting up a solar rooftop.

Before

- Grid electricity must be available if you plan to put up a grid-tie or hybrid solar PV system.
- Assessment of the roofing structure is very critical to determine if it can carry the weight of the panels. A 400W solar panel weighs roughly 10-15 kilograms. Installation of solar panels must be avoided in roofs with advanced rusting and physical deterioration.
- Ensure that there is an appropriate rooftop area for the panels. On an average, a 1kW solar PV requires an area of 10 square meters.
- Identify the area of the roof where there are no/limited shadows coming from nearby trees, buildings or any physical structure, e.g. chimney.
- Purchase your solar equipment from reliable solar suppliers that offer a good warranty period for their products.
- For first time users, it is better to look for a reliable solar service company to help you in your grid-tie solar PV installation.

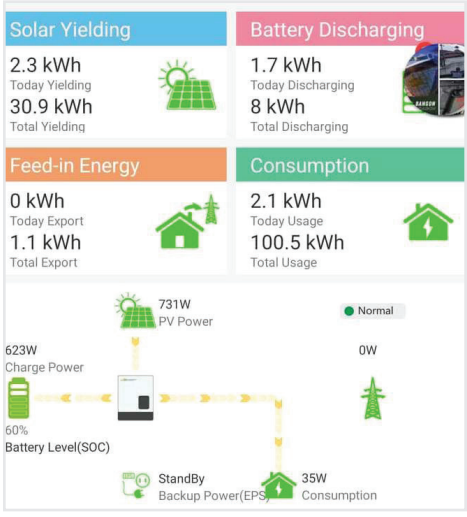
Installation

- When installing a solar PV system, ensure that all solar panels can be accessed individually for cleaning and maintenance.
- It is ideal to install the panels facing south to maximize the amount of sunlight.
- Inverters and other system components must be located in a secure space of the house and out-of-reach of children. Devices must be placed as close as possible to each other.
- Coordinate with your distribution utility or electric cooperative to apply for a net-metering program.

Operations and Maintenance

- Clean the panels at least once a year with soft/non-abrasive wet rags or towels to remove accumulated dust and dirt. For highly polluted areas, it might be necessary to clean more often. Use soap to scrub off grease and dirt. Clean thoroughly with water afterwards.
- Regularly monitor the power production of the system. New inverters also have smart functions so that users can monitor the performance of their solar PV system even if they are away.

Hybrid inverter with wall-mount lithium battery.



Example of an online solar PV system interface.

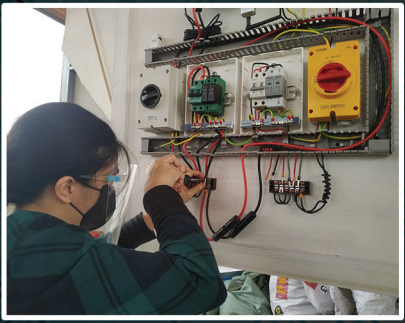
NOW OPEN!

CREST
microRenewables Learning Center

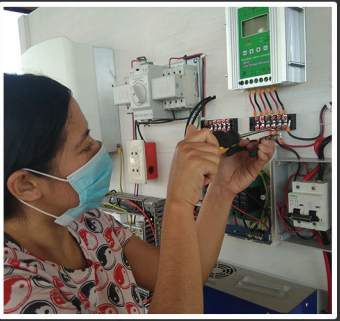
Do you want to expand your knowledge and skills on RE systems?

Visit our center and learn about different renewable energy and small-scale climate systems. The facility provides a venue for professionals, advocates and enthusiasts to learn practical applications for various microrenewable such as solar photovoltaic (PV) rooftop and wind technology.

The facility also has a regenerative urban garden system that combines an organic garden with rainwater harvesting, soil management, and composting.







The CREST's microRenewables Learning Center is located in **69 Bansalangin Street, Project 7, Quezon City**.
To know the training schedules and/or arrange visits, please contact **crestphilippines@gmail.com**

Go microRenewables!

Renewable energy is one of the fastest growing global industries. In the Philippines, solar PV rooftop has already achieved grid parity, and it is now the cheapest electricity source. Electricity produced from other renewable energy sources are also already cost-competitive with those produced from conventional fossil-fuel power facilities such as coal and oil.

Current and future innovations on renewable energy are already shifting to decentralized, small-scale systems. CREST sees the renewable energy industry today in a similar stage as the computer industry, when microcomputers were starting to be used by techies and increasingly by businesses. When these products reached a certain market volume, the economy of scale began to take effect, resulting in a virtuous cycle of steady price reductions and continuing market growth.

CREST releases this handbook to encourage all to adopt sustainable energy and climate systems in your own homes and business establishments. These learning products will be useful to interested local government officials, teachers and students, technical professionals, energy advocates, and even to individuals that have no deep technical background.

The adoption of sustainable practices in homes and workplace will result to healthier and safe environment for families, co-workers and fellow members of our community.