Renewable Energy, specializing in the maintenance of solar and wind systems.

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Abstract

Renewable Energy with a Specialization in Solar and Wind System Maintenance" addresses the growing importance of sustainable energy sources for the development of a clean and efficient energy mix. Solar and wind energy stand out for being renewable, abundant, and having a low environmental impact. Specializing in this field equips professionals to handle the installation, operation, maintenance, and monitoring of solar photovoltaic plants and wind farms, ensuring system efficiency, safety, and longevity. Furthermore, the training covers technical knowledge regarding components, fault diagnosis techniques, automation, and technological innovation, thereby contributing to the advancement of the renewable energy sector and promoting the transition to more sustainable energy sources.

Keywords: Renewable Energy, specializing, maintenance ,solar, systems.

Introduction

Nowadays, we all know that it is impossible to live without electricity. We are as dependent on electrical energy as we are on the food and drink required daily for our bodies, minds, and souls.

Electricity is an indispensable commodity in people's lives. Human activities in the modern world rely heavily on the availability and reliability of this resource; its unavailability can significantly impact the economy of a country or even the entire world.

There is no doubt that access to and use of electricity bring immense benefits to populations, whether in developed countries—which are highly dependent on it—or in developing nations.

While electricity alone may not guarantee development, it is a prerequisite for long-term economic growth.

Renewable energy sources are inexhaustible; they can regenerate and be reused without depleting the planet's existing resources.

Photovoltaic systems rely on physical interactions between incident radiation photons and the electrons of materials exposed to that radiation. Photovoltaic energy offers the significant advantage of allowing us to generate the energy we consume (using a renewable source), thereby reducing our reliance on the main electrical grid.

Proper sizing of a photovoltaic installation is crucial for both its optimal operation and the extension of its service life. Consequently, the system's components—specifically the photovoltaic generator array and the inverter—must be balanced appropriately, avoiding the use of more or less space than recommended.

The higher the panel power and battery bank capacity installed to meet consumption needs, the lower the likelihood of system failure; however, the economic cost will be higher.

Theoretical Basis of Renewable Energies

Renewable energies are alternative energy sources derived from natural resources that can replenish themselves, such as wind, the sun, and the sea.

These types of energy never run out and can regenerate, which is why they are termed "renewable."

Renewable energies are obtained from regenerative or renewable natural resources, such as the sun (solar energy), wind (wind energy), tides (tidal energy), and geothermal energy. Other examples include hydroelectric power, wave energy, and hydrogen energy. Newer forms of renewable energy include mini-hydro, biomass, geothermal, and biofuels (Paiva, 2007).

Hydropower

Hydropower is derived from the potential energy of a body of water; this energy is converted into mechanical energy via hydraulic turbines or waterwheels, which is then converted into electrical energy by an electric generator. Hydroelectricity is typically generated at hydroelectric power plants associated with large- or medium-capacity dams, or at small-scale hydroelectric facilities (with a capacity of less than 10 megawatts).

To illustrate the current situation in Angola: the country has an installed hydroelectric capacity of approximately 2.4 GW (Ministry of Energy and Water – Project for the Development of the Electricity Sector Master Plan in the Republic of Angola – Final Report). Angola's hydroelectric potential is estimated at 18 GW (Atlas and National Strategy for New Renewable Energies).

Hydropower is a renewable energy source that harnesses the force of river water, typically via dams.

Hydroelectric power is generated by hydroelectric power plants, which convert the kinetic energy of water into electrical energy.

The water used comes from rivers and streams, utilizing either natural elevation changes or structures designed to retain water, such as reservoirs or dams.

The force with which the water strikes the turbine blades increases with the steepness of the drop between the dam and the turbine. The water's kinetic energy can be increased by creating an artificial drop with a steep gradient.

Solar Energy

According to Gonçalves (2017), Generating energy from solar heat and light (solar radiation) is possible using photovoltaic solar panels or thermal solar panels. Photovoltaic solar energy (Solar PV) is a technology that converts sunlight into electric current. Solar PV technology is typically utilized in panels (hence the name "solar panels").

There are two basic types of photovoltaic systems:

a)Grid-connected systems (on-grid) – typically synchronized with the public grid.

b)Off-grid systems – used in remote locations.

Solar energy is sustainable, noise-free, and pollution-free; it is easy to install, requires minimal maintenance, and has a long service life. However, energy generation is intermittent (power is generated only when sunlight is available), costs remain quite high, and solar energy storage methods are still relatively inefficient.

In the case of Angola, solar radiation levels are high and consistent across the country, with an identified power generation potential of 17.3 GW (National Strategy for New Renewable Energies). A Presidential Decree was recently authorized for an investment to install solar panels in the localities of Bailundo, Benguela, Biópio, Cuíto, Lucapa, Luena, and Saurimo.

Wind energy

According to Águas (2015), Wind energy results from converting wind energy into electricity via wind turbines, into mechanical energy via windmills, or into kinetic energy via sails (to propel sailboats). Wind farms are installed on land (onshore) or at sea (offshore) where the average annual wind speed exceeds 6 m/s.

Biomass

Biomass is organic matter that can be used for energy production. Biomass energy is generated through the combustion of organic material of plant or animal origin, creating heat that is converted into electricity.

Although it is a renewable energy method, this way of generating power can cause significant environmental damage. It is important to highlight that many countries use virgin wood to generate electricity—a practice we should not replicate in Angola.

Angola has an estimated biomass energy potential of 4 GW (Altas and National Strategy for New Renewable Energies). It is important to highlight that many countries use virgin wood to generate electricity—a practice we should not replicate in Angola.

Wave and tidal energy

Waves are formed by the force of the wind acting on the water. Wave size varies according to wind speed and duration, as well as the distance the wind blows in a single direction over the water. The water movement resulting from wind force carries kinetic energy that can be harnessed to generate electricity.

Ocean or tidal energy is essentially a concentration of the wind energy acting upon an area of the ocean. As we know, surface winds passing over the sea transfer part of their kinetic energy to the water in the form of waves. This creates similarities between wave energy conversion and wind energy conversion.

Geothermal energy

Also known as geothermal power, geothermal energy is generated from heat originating within the Earth (heat found in rock layers known as magma, which can reach temperatures of up to 6,000°C).

Hydrogen Energy

Hydrogen energy is a renewable energy source that has recently emerged and is poised for large-scale expansion.

Many respected voices assert and believe that hydrogen will become a major source of energy.

It essentially involves converting hydrogen-rich gases to generate electricity.

Hydrogen does not exist in isolation; it combines with other elements—such as oxygen to form water, or carbon to yield methane—and separating these elements requires vast amounts of energy. This means that hydrogen is only as eco-friendly as the energy source used to produce it.

The Importance of Renewable Energy

For over a century, fossil fuels have been our primary source of energy, currently accounting for about 80% of our energy needs. However, fossil fuels pollute the soil, air, and water, and release large amounts of carbon dioxide when burned. Carbon dioxide traps heat in the atmosphere, and rising levels of it cause or accelerate climate change—one of humanity's greatest challenges. Petroleum-based products, such as plastics and chemicals, also contribute to the pollution of our soils, rivers, and oceans.

Photovoltaic Energy

According to Àguas (2016), the commercialization of photovoltaic solar cells began with monocrystalline silicon cells, which still dominate the market. Over time, polycrystalline cells emerged; although they have lower efficiency, they are cheaper and offer the advantage of being manufactured in a square shape, thereby making almost full use of the solar panel's rectangular surface area. Amorphous silicon cells are also marketed—primarily for low-power devices such as watches, calculators, and portable radios—and more sophisticated technologies are currently emerging, such as thin-film semiconductors or combinations of various semiconductors designed to optimize the response to solar energy.

Solar panel

According to Creder (2000), we recommend that you thoroughly grasp the information presented here, as it will be very useful in your professional life. A single photovoltaic cell can only provide a voltage of a few tenths of a volt (approximately 0.6 V for a silicon cell) and a maximum power output of three watts. Therefore, to obtain higher voltages—such as the 6, 12, or 24 volts used in most applications—we must connect several cells in series. This assembly of multiple series-connected cells, properly encased and protected, is known as a solar panel or photovoltaic module. Low-power photovoltaic panel.

Physical and mechanical characteristics

According to Sullivan (2012), the panels are square or rectangular, with surface areas ranging from approximately 0.05 m^2 to 1.5 m^2. Their total thickness, excluding the protective frame, generally does not exceed 4 cm. Although they may appear very heavy (a panel of about 0.5 m^2 can weigh 5 or 6 kg), they are not; furthermore, they are capable of withstanding slight deformation, allowing them to adapt to the mechanical stresses to which they are subjected. The figure below shows a cross-section of a photovoltaic panel, illustrating its various components.

Electrical characteristics

The behavior of a photovoltaic module in response to incident solar radiation is determined by the cells that compose it and can be described by a series of characteristic parameters, defined below:

Short-circuit current (ISC or ICC, with U = 0 V): the maximum current value a cell can deliver to a load at zero voltage;

Open-circuit voltage (UOC or VOC, with I = 0 A): the maximum voltage a cell can deliver to a load when the current flow is zero. UOC can be measured with a voltmeter;

Maximum voltage (UMPP, VM, or UMáx) or voltage at maximum power: the electrical voltage delivered to a load at maximum power;

Maximum current (IMPP, IM, or IMÁX) or current at maximum power: the electrical current delivered to a load at maximum power;

Methodology

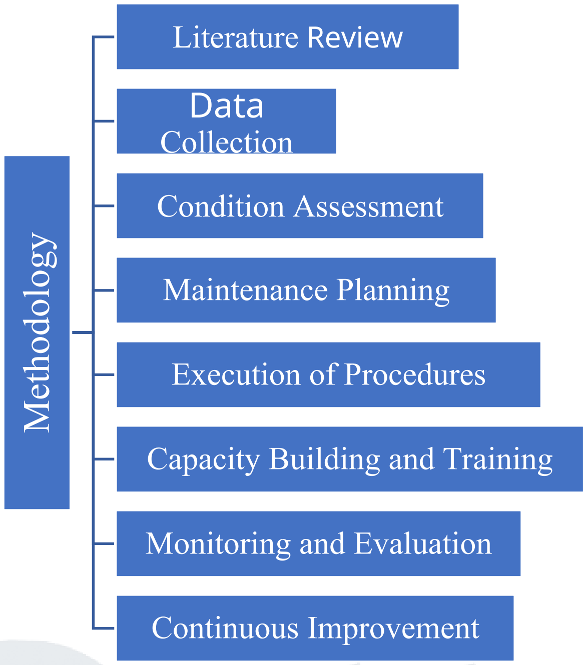

Figure 1: Methodology

Source: Authors

Discussion of Results

Sizing a Photovoltaic System

When installing photovoltaic systems, the designer uses an optimal tilt angle to maximize solar radiation capture. In Portugal, the tilt angle for solar panels is typically around 35°.

For photovoltaic installations in the Northern Hemisphere, the panels should face south; for those in the Southern Hemisphere, they should face north.

Note: I am assuming the system is being sized for year-round operation:

$$\beta opt = \text{Site latitude} - 5°$$

$$\beta opt = 35 - 5 = 30°$$

The PV modules are south-facing with a fixed tilt. The model selected for installation in this system is the LG330N1K-V5 (LG photovoltaic panel).

Number of PV modules

According to Filho (2014), when planning a grid-connected photovoltaic installation, the power to be injected into the grid must be considered. By knowing the power rating of the installation's PV generator array and the power rating of the individual PV panel, the number of panels to be installed is determined:

$$\text{Data: } Ppfv = 4.7 \text{ kWp}, \; Pmax = 330 \text{ Wp}$$

$$N = Ppfv / Pmax = 4700 \text{ Wp} / 330 \text{ Wp} = 14.24 = 14$$

$A = C \times L = 1686\,mm \times 1016\,mm$ =1,712,976mm²; converting to square meters, we get 1.71m².

Therefore, the number of panels to be installed is 14; calculating Total Area = total number of panels × total area of each panel:

Total Area = 14 × 1.71m² = 23.94m² = 24m² of occupied area.

Calculation of the DC main cable cross-section

The DC main cable connects the generator array junction box to the inverter.

Data: copper – 56 m/(Ω·mm²);

Justification: For this calculation, I will assume a cable length of 20 meters and a line loss factor of 1.

The cable connecting the inverter to the grid must be sized taking into account a maximum permissible voltage drop of 3%.

The following formula is used to determine the cross-section of the AC cable connecting the inverter to the single-phase grid:

(DC main cable) $S = (2 \times Ldc \times Ip\_max) / (56 \times \Delta U) = (2 \times 20 \times 1.25 \times 7.73) / (56 \times 4.774) = 1.445 \text{ mm}^2$

Conductor cross-section – S = 2.5 mm². According to standard IEC 6034-7-712, a main disconnect switch must be installed before the inverter.

$Igdc \geq 2 \times 1.25 \times Isc = 2 \times 1.25 \times 10.27 = 25.675$ A

Note: Based on the result obtained and market availability, I opted for 32 A DC bipolar circuit breaker (with residual current protection).

3.7.2 - Calculation of the AC main cable cross-section

The AC cable connecting the inverter to the grid must be sized taking into account a maximum permissible voltage drop of 3%. Justification: For this calculation, I will assume a cable length of 14 meters and a line loss factor of 1.

$\Delta U = 0.01 \times 230 = 2.3$ V

(AC cable) $S = (2 \times Lac \times 1.25 \times Inac) / (50 \times \Delta U) = (2 \times 14 \times 1.25 \times 9.6) / (50 \times 2.3) = 2.921$ mm^2

Conductor cross-section – $S = 4$ mm^2. According to standard IEC 6034-7-712, a main disconnect switch must be installed upstream of the inverter.

Conclusions

Finally, regarding photovoltaic installations, meeting energy requirements necessitates the use of multiple panels; consequently, panels must be connected in series and parallel configurations to achieve the required voltage and current levels.

The supporting structure and the orientation system are just as important as the panels themselves, as a failure in any of these components can lead to system malfunction.

Proper sizing of a photovoltaic installation is crucial for both optimal electricity generation and extending the system's service life.

The first step in sizing a photovoltaic installation is to clearly define the electricity requirements to be met—in this case, 4.7 kW.

E. Lorenzo's method was used to calculate and select the components for the photovoltaic installation to meet specific electricity consumption needs.

It is important to consider economic factors when selecting equipment.

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