



Overview of the off-grid photovoltaic diesel batteries systems with AC loads



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HIGHLIGHTS

- Off-grid Mini-grids can be implemented in different ways. It depends on the AC load profile.
- Not always the AC coupled is the best option.
- There are different PV inverters that can be used in the implementation.
- New PV inverter concept, multiport inverter, is being deployed in off-grid Mini-grids.
- In medium and high penetration the control strategy of all elements of the Mini-grid system is a key point.

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ABSTRACT

The target of this manuscript is to make a review about the Off-grid Photovoltaic Diesel Hybrid Systems (Off-grid Mini Grids) where only AC loads are connected. It will take into consideration the different types (performed through of the DC coupled, AC coupled or hybrid DC–AC coupled configurations), solutions (PV/Diesel and PV/Diesel/Energy Storage) related with the diesel hybridization of those systems and their main elements (power converters). So, it will encompass an analysis about the current state of the technique of converters implemented in those systems, including the stand-alone inverters, bidirectional, multiport and even the grid-connected inverters implemented in the AC coupled systems. In addition, the standardization in this topic will be analyzed too.

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1. Introduction

At present, a huge of inhabitants worldwide including still lack access to utility electricity, most living in small remote villages or isolated islands far away from power grid [1,2].

A utility grid extension to these off-grid locations is impractical and uneconomical due to such conditions as dispersed population or rugged terrain [3]. As a result, the electrical demand of such places is normally powered by diesel generators [4–6] or even with no power supply.

The significant rise of diesel price and subsequent environmental pollution concerns [7], however, have drawn extensive public attention to the need of renewable energy applications such as solar photovoltaics (PV) power.

Standalone renewable energy systems (RESs) have a reputation for being inexhaustible, environmentally benign, reliable, efficient, and with cost-effective characteristics and are hence seen to be the most likely viable energy supply solutions to such areas. Besides, renewable energy holds the key to future prosperity and a healthy global environment and is considered a promising means of solving the problems of environmental pollution [8–10].

Therefore, the last decade has witnessed a dramatic expansion in the use of renewable energies as substitutes of fossil-based energy, a noted by-product being the potential to reduce atmospheric degradation [11].

A potential solution for addressing these problems can be the use of the photovoltaic hybrid systems. A “photovoltaic hybrid system” is a system that is formed by combining two energy sources, at least, including the photovoltaic energy. They can be off-grid or grid-connected. Regarding off-grid, the PV Hybrid systems can be divided into: micro (less than 5 kW), small (5–30 kW), medium (30–100 kW), large (100 kW–1 MW) and very large (greater than 1 MW) systems [12–14].

Micro PV hybrid systems are related to residential solutions. Small PV hybrid systems are suitable for supplying the power needs of a small rural village where the energy consumption is quite limited; for instance a village with no, or very few, productive or commercial activities. Medium-size hybrid systems are suitable to supply the power needs of a village where productive and commercial activities use energy during the daytime.

In the literature there are some review manuscripts about the PV Hybrid systems. However, those paper reviews primary issues regarding the drivers, specific benefits of hybrid renewable energy systems (HRES) [15–20].

Then, this manuscript is focused in showing the state of the technique of off-grid PV Hybrid Systems, with elements such photovoltaic generator, genset and energy storage, where will be analyzed the current state of the technique of the power converters implemented in those systems and the solutions that can be implemented nowadays.

2. Power converters implemented in the PV Hybrid Systems

Power converters are a very important component in these systems, especially in view of evolution not just only in their quality and performance in recent years but rather for having arisen new challenges along with new opportunities. So, in those types of systems the following power converters often are used: battery charging systems and PV inverters.

2.1. Battery charging systems

They are based on the charge controller. Battery charge controllers regulate the flow of electricity from the photovoltaic generator to the battery. Its function is to regulate the voltage and current from the photovoltaic arrays to the battery in order to prevent overcharging and also over discharging.

There are four general types of charge controllers, categorized by the method used to regulate the charge from the solar modules to the batteries [21,22]: shunt type charge controllers; series type charge controllers; PWM (pulse width modulation) charge controllers and MPPT charge controllers.

The shunt charge controller is the first type of chargers developed and are the simplest ones still on the market today. They short-circuit the energy from the solar panel when the battery reaches the full charge. In general, shunt type charge controllers are low cost and reliable, with simple design and suitable for small off grid photovoltaic systems.

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