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ScienceDirect

Energy Procedia 83 (2015) 226 – 236

Energy Procedia

7th International Conference on Sustainability in Energy and Buildings

Performance Analysis of the Mini-Grid Connected Photovoltaic System at Algiers

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Abstract

This paper analyses the operating performance of the Grid connected Photovoltaic (PV) System installed on the terrace of the administrative building of the Centre de Développement des Energies Renouvelables (CDER) in Algiers. We present the results of the performance evaluation of the energy installation on a typical year. Energy losses and the most significant performance of the system are quantified. During this period, the system has produced an annual 10 981 kWh of energy injected into the grid. This means an average daily energy of 30 kWh, with performance ratio between 62 and 77%. In comparison with similar systems performance in other countries, the results indicate that the power generated by the CDER grid connected PV system meets the specifications required for such systems compared to international standards.

Peer-review under responsibility of KES International

Keywords: Grid Connected PV System; Monitoring; Performance Parameters; Inverter efficiency; System Losses;

1. Introduction

Photovoltaic (PV) grid connected systems have been rising at an annual rate of 40% during the last decade growing up from 0.2 GW at the beginning of the year 2000 to 55 GW at the end of year 2015 [1-4]. Linking PV generation to the main grid is performed, without battery storage, reducing considerably both overall system cost and maintenance.

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Peer-review under responsibility of KES International
doi:10.1016/j.egypro.2015.12.177

The use of appropriate performance parameters facilitates the assessment of energy efficiency of PV systems connected to the grid that can be different by design, technology or geographic location [5-11].

Algeria is a country with a privileged solar resource, which has already implemented stand-alone photovoltaic power systems in isolated areas [12-14]. In 2012, Algeria began a process of green power by launching an ambitious program of development of renewable energy and energy efficiency. This program consists of installing a renewable power of nearly 22 000MW between 2012 and 2030, will be dedicated to cover the national demand for electricity. In April 2014, a law concerning the energy feed-in tariff for photovoltaic installations over 1MW was promulgated. By 2030, about 40% of the production of electricity for domestic consumption is from renewable sources.

The grid connected photovoltaic system installed in 2004 at CDER is a pilot project whose main objective is to gain experience in the design, monitoring and maintenance and allow to show the benefits of this innovative technology. This system was one of the first implementations in Algeria. Monitoring of the plant, allows the analysis and quantification performance. It also permits:

- To develop a database of radiometric and electrical data recorded from the operation of the plant to calculate all parameters of performance such as energy produced by the PV generator and the energy injected into the grid.
- To study and analyze system performance according to international standards in order to optimize the design and predict the energy injected into the grid for a given PV power and for a given site

In this paper, we will use the coefficients of performance established by the International Atomic Energy Agency Photovoltaic Power Systems Program and described in IEC61724. We assess three performance parameters of this standard to define the overall system performance compared to the impact of energy production, solar resources, and all system losses. These parameters include the final PV system yield, reference yield, and performance ratio.

2. System description and monitoring system

The Grid-Connected PV system is installed on the roof of the CDER administration building, as shown in fig.1. The PV generator is composed of 90 mono-crystalline modules (Isofoton 106) coupled with 03 single-phase inverters (Ingecon 2.5). Each inverter is connected to 220V a phase, 50 Hz low-voltage grid. The generator is composed of three fields of 30 modules each. Each field of thirty modules consists of two parallel branches of 15 modules in series with a tilt angle of 29°C. The azimuth angle of the generator is 15 °C South-West according to the orientation of the building. The electrical module provides a short circuit current of 6.54A and open circuit voltage of 21.6 V, a current of maximum power point (IMPP) of 6.1A and a voltage of maximum power point (V_{MPP}) of 17.4V. Under these conditions, the nominal power of the PV array is around 9540 Wp.

The inverter can input a maximum current of 16A, voltage that varies between 125-450V with frequency of 50 Hz.

Fig. 1. PV array