Voltage profile analysis and performance of a photovoltaic power plant in a small low voltage distribution grid in Tenerife Island.

D. Cañadillas-Ramallo[1], J. Barrera-Santana[1], B. González-Díaz[2], S. González-Pérez[1], J. F. Gómez-González[2], E. Pereda[2], J. A. Méndez Pérez[3], R. Guerrero-Lemus[1*].

[1]Departamento de Física, Facultad de Ciencias, Universidad de La Laguna (ULL), Avenida Astrofísico Francisco Sánchez. 38206 La Laguna (Tenerife), España.
[2]Departamento de Ingeniería Industrial, Escuela Superior de Ingeniería y Tecnología, Universidad de La Laguna (ULL), Avenida Astrofísico Francisco Sánchez. 38206 La Laguna (Tenerife), España, email: rglemus@ull.edu.es.
[3]Departamento de Informática y Sistemas, Escuela Superior de Ingeniería y Tecnología, Universidad de La Laguna (ULL), Avenida Astrofísico Francisco Sánchez. 38206 La Laguna (Tenerife), España.

Interest of the work

Renewable energies (RE) are playing an important role in grid connected systems in order to satisfy the increasing world energy demand.

In the case of the photovoltaic (PV) power plants, the variability of the radiation can produce some fluctuations in the electrical generation and therefore, several problems as frequency response of the grid and undesirable variations on voltage profile could be detected.

Regarding small grids, due to the size of the generation systems and the impedance between them, the integration of the RE presents even harder challenges to avoid the related problems.

In order to analyze the future difficulties of new PV power plants, the analysis of actual installed systems is extremely important to avoid upcoming problems.

Objectives

The main objective of this work has been analyzing the voltage profile and the energy production problems of a PV power plant located in the south of Tenerife Island.

Main contributions

In order to carry out this study, a 45 KW rated power plant, in the south of Tenerife, the Canary Islands, has been selected.

The power plant is located in the town of Arico, with coordinates 28º10'N and 16º29'W. Due to the tradewinds, the Island presents a moderate climate and the irradiation in the zone allows a performance close to 1,800 solar equivalent hours.

Despite the fact that this power plant is dedicated to sell electricity to the pool, it is connected to the same point of the grid than a wine cellar with a contracted power of 60 kW and with an installed capacitor bank of 50 kVAr.

The characteristics of the PV power plant, the nearest transformer centre and the cell wine are depicted in Figure 1. According to the rated power of the PV plant and its location, it was expected to produce about 79 MWh/year and 539 MWh between 2009 and 2015.

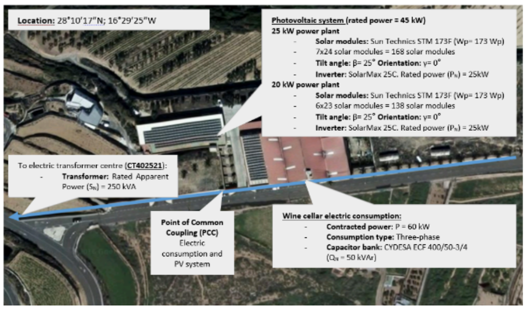

Figure 1: Description of the PV power plant and the wine cell consumption.

However, the real energy production was close to the 58 % over the estimated energy production, slightly higher than 314 MWh (Figure 2).

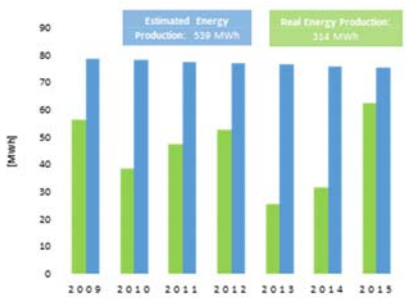

Figure 2. Estimated and real energy production.

In order to clarify the source of this situation, three network analysers were installed: (i) one at the point of common coupling (PCC) of the wine cellar, (ii) one at the PCC of the PV power plant and (iii) the third inside the transformer centre, at the beginning of the low voltage line (feeder) in which both the PV plant and the wine cellar are connected. Figure 3 to Figure 5 show the measures at the PCC.

From Figure 3 and Figure 4, it can be deduced that there is a significant unbalance between line voltages and between the loads of each phase. Although in general the worst scenario regarding overvoltage is experienced with low load conditions, the presence of the capacitor bank in the installation produces an excess of reactive energy input to the feeder, which contributes to exacerbate the problem. For that reason, the coincidence of the highest load periods with maximum PV production time produces voltage rises which overpass the legal imposed limits. On the other hand, according to Figure 5, the PV plant injects almost the same amount of electricity in each line.

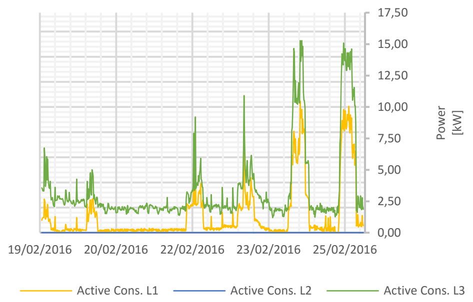

Figure 3. Active power consumption in each line in the wine cell.

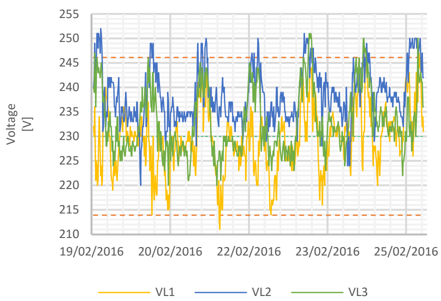

Figure 4. Voltage measures in each line at the PCC of the wine cell and the PV power plant.

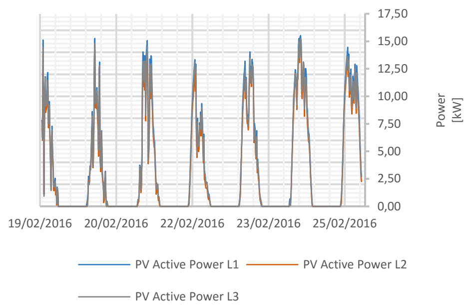

Figure 5. PV active power injection in each line at the PCC of the wine cell and the PV power plant.

Power flow analysis has been carried out in python to define the behaviour of the installation under different situations and to analyse the PV power plant behaviour and diverse solutions.

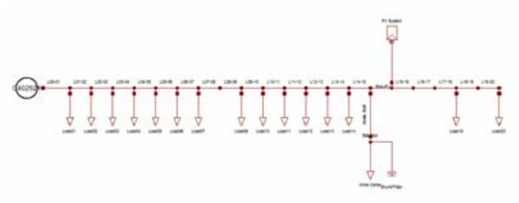

Figure 6. Diagram of the power line under study.

The results reveal that the capacitor bank plays a fundamental role in both the voltage increases and the voltage unbalance. The application of measures such as Line Voltage Regulators (LVR) and reactive power compensation have been successfully studied, among others.

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