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Economical and environmental analysis of grid connected photovoltaic systems in Spain

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Abstract

In this article an economic and environmental study is carried out on PV solar energy installations connected to the Spanish electrical grid system. The study has been performed on installations situated in the city of Zaragoza (with an irradiation value approximately equal to the average value for Spain).

Initially, an economical study is performed, proposing different scenarios where different values of interest rate and energy tariffs are considered. The following parameters are used to determine the profitability of a PV installation: the Net Present Value and the Pay-Back Period. Furthermore, the environmental benefits of PV systems connected to the grid have been evaluated. This has been accomplished using the Life Cycle Analysis theory of the systems, calculating the recuperation time of the invested energy, the contamination or emissions avoided and the externality costs. Finally the possible effects of the application of the Kyoto Protocol have been studied.

Keywords: Photovoltaic energy; Economic aspects; Environmental aspects; Externality costs; Kyoto protocol

1. Introduction

A photovoltaic system connected to the grid is a type of installation where three elements intervene: the PV modules, the inverter and a conventional power line [1,2]. The function of the DC/AC inverter is to make the energy produced by the PV generator

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suitable for the specific characteristics of the power line. The installations of this type, at least in Spain do not include batteries.

In Fig. 1, the principal elements of a grid connected PV system are shown. The metered output of the PV system should be capable of measuring in both directions, and if this is not the case, an incoming meter should be included between the outgoing meter and the mains circuit breaker. The electrical energy invoiced to the utility will be the difference between the metered output and input energy.

In 2002 A.S. Bahaj [3] described the means of enhancing and promoting the use of solar energy. The current legislation in Spain [4] regarding the production of electrical energy originating from renewable energy source, waste and cogeneration, allows all the energy generated by the PV system to be injected into the grid, and the energy consumed by the system to be bought back from the utility at a price much lower than that of the PV energy sold.

For installations less than 100 kW of installed power, the energy tariff is established at 575% of the average electrical tariff or the reference (value which is updated yearly) for the first 25 years of the installation, and decreasing to 460% for further years. As an example, in 2004 the average tariff or reference was 7.2072 c€/kW h, for which the sale price per kW h generated by PV systems was $0.072072 \times 5.75 = 0.414414$ €/kW h. Previously the tariff was constant, (independent of the electrical tariff) and was at 0.396668 €/kW h.

2. Economical analysis

In Spain, as mentioned previously, all the energy generated by the PV system can be sold to the utility. Subsequently, and with this in mind, an economical analysis has been carried out on this type of installation, where various different scenarios have been considered.

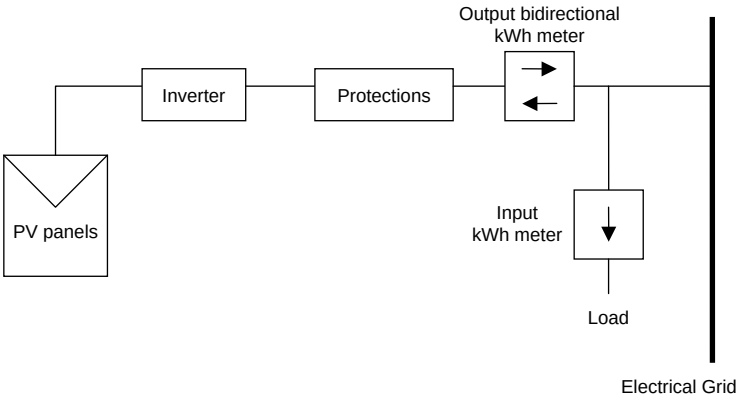

Fig. 1. Grid connected photovoltaic system.