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Simulation of photovoltaic installation connected to the grid with storage system

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Abstract

In the present paper, a new approach for the management of energy resources in a research laboratory is proposed and evaluated. A simulation study for the photovoltaic (PV) installation was conducted under the Tunisian-Italian cooperation project DE.DU.ENER.T, using renewable energy and economic criteria. The aim of the study is to improve the energy efficiency in order to minimize the electricity cost consumed in the laboratory. A Hybrid Renewable Energy System consisting of a photovoltaic field of 12KWc was installed to reduce the exorbitant bills, due to intensive energy equipment such as drying ovens and workstations, using sustainable, green and clean sources. In addition, a sizing theoretical study of the PV system was primarily realized in order to evaluate, in the first hand, the compatibility between different equipment and to compare, in the second hand, with results given by two software SMA Sunny Design and PV*SOL. We designed and managed these systems optimally to promote the self-consumption of the electric energy in the LPT Research laboratory building. The focus would be on the use of the PV system by evaluating the impacts of electricity generation using renewable energy levied on electricity grid (energy injection and extraction) and the economies that can be achieved during operating hours. Results of PV-SYST study obtained by the simulation of our installation will be discussed.

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Keywords: Heat Transfer, Hybrid Energy System, Renewable Energy, Photovoltaic panel, Simulation

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Introduction

Hybrid Energy System (HES) is an electric energy system, which is made up of a single or many electric sources. These sources could be renewable, traditional, or mixed and work in connected or off-grid [1-3]. If the HES system contains only renewable energy sources it will be named "a Hybrid Renewable Energy System (HRES)" such as the photovoltaic system, the wind turbine. HRES can address emissions, reliability, efficiency, and economical limitations of single renewable energy source [3].The HRES systems are becoming famous for standalone power generation in the non-isolated and isolated area due to the growing, the improvement and efficiency in renewable energy technologies [4]. Actually, they have huge potential from an environmental point of view as they can reduce the gas emissions especially CO2 and limit pollutants emissions due to the not consumption of fuel or natural gas. Financially, The cost of solar and wind energy can be competitive comparing to the classical grid installation. The cost of these systems predictable and not influenced by fuel price and they can be easily installed and deployed for other utilizations [5-8]. Various hybrid renewable energy systems have been already deployed in different countries. It has been reported that it significantly reduce buildings energy consumption as the latter accounts for 40% of the overall energy consumption worldwide and correspondingly are responsible for carbon emissions. Efforts have been made to reduce CO2 emissions focusing on green energies. Studies for this purpose have explored the performance analysis of demonstration systems, the development of more efficient and innovative photovoltaic (PV) panel and innovative batteries and the storages systems [7]. This work will focus only on the study and the sizing of the PV installation for the DE.DU.ENER.T Project [8].

Nomenclature

Symbol	Description	Unit
$U_{mppt,max}$	Maximum input Dc voltage to the inverter	V
$U_{mppt,min}$	Minimum input Dc voltage to the inverter	V
U_{mpp}	Maximum voltage of the PV panel	V
U	DC Voltage drop	V
I, I_{Mpp}	Maximum current of the panel	A
L	Cable length	m
u	AC Voltage drop	V
b	Coefficient	No unit
s	Cable section	mm^2
$cos\varphi$	Power factor	No unit
λ	Linear reactance	Ω/m
I_b	Maximum output current of the inverter	A
Δu	Relative voltage drop	V
U_0	Nominal voltage	V
ΔV	Voltage difference	V
βV_{0C}	Temperature coefficient	%/°C
V_{string}	String voltage	V
ΔT	Temperature difference	°C
V_{max}	Maximum input voltage to the inverter	V
$I_{string\ input}$	Maximum input current per string	A
ρ,ρ_1	Resistivity of the conductive wire	$\Omega.mm^2/m$

2. Tunisian prototype

1.1. Description of the prototype

The Tunisian prototype of the DE.DU.ENER.T was installed near the Laboratory of Thermal Processes, a part of the Research and Technology Centre of Energy CRTEn, to reduce the energy