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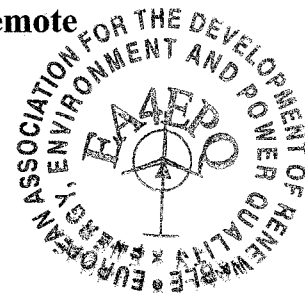
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A Modified Cooling System for Stand Alone PV Greenhouse in Remote Areas

N. M. Ahmed, H. M. Farghally, F. H. Fahmy and A. A. Nafeh

Electronics Research Institute,

El-Tahrir St., El-Dokki, Giza, Egypt



Abstract. Agricultural efforts are normally carried out in remote areas where electricity from national electric grid may not exist or grid connection is very expensive. Greenhouses industry is one of the most important agricultural practices in remote areas. Greenhouses help in extending the gardening activities and allows us to cultivate certain plants all over the year; by controlling air temperature and relative humidity inside greenhouse. In greenhouses, cooling and pumping equipments dominate the demand for electricity. Therefore, a stand-alone photovoltaic (PV) system is necessary to feed that demand. Medicinal herbs, for example are the most suitable plants to be cultivated in the greenhouses. They often need a temperature range of 15 - 21 oC and about 70% relative humidity to grow. As the climate in Egypt is not suitable all over the year to cultivate these medicinal herbs, it is preferable and necessary to use PV-based control greenhouse to cultivate these medicinal herbs in Egyptian remote areas. This paper presents a proposed greenhouse cooling system, which uses a stand-alone PV system to feed the electrical loads of the greenhouse. At the same time, it introduces the complete sizing procedure of the greenhouse stand-alone PV system.

Key words

Greenhouse, cooling system, pump, sump, PV system, battery.

1. Introduction

The main purpose of a greenhouse is to improve the environmental conditions in which plants are grown. Greenhouses are usually equipped with some environmental modification devices such as cooling, ventilation and heating systems. Ventilation can remove excess heat, increase air

mixing, and reduce temperature stratification in the greenhouse [1]. During summer, in Egypt, ventilation alone is not enough to maintain optimum interior temperature. Therefore, water evaporative cooling systems are usually used to reduce the interior air temperature to an acceptable level. The cooling of these systems is commonly accomplished by using an electrically driven fan, pad and a certain shading technique [2]. The function of the fan and pad is to prevent greenhouse overheating and cool the plants during hot weather. Whereas, the function of the shading technique is to absorb the solar thermal radiation and penetrates only the sunlight that is necessary for growing of plants. Therefore, to electrify the previously mentioned cooling equipments, that are used in remote area greenhouses, it is necessary to use a well designed stand-alone photovoltaic (PV) systems. The main objective of this paper is to introduce a proposed greenhouse cooling system, which uses a stand-alone PV system to feed the electrical load of the greenhouse. At the same time, it introduces the complete sizing procedure of the greenhouse PV system.

2. Proposed cooling system

This system is responsible for reducing the air temperature inside the greenhouse that affects the greenhouse environment and consequently the growing of cultivated plants. The proposed cooling system consists mainly, of four components, as shown in Fig. 1. These components are aluminum pad, cool air fan, pump and sump. The pad-fan system requires sufficient makeup water to replenish the water evaporated from the pad into the incoming air.