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The application of solar technologies for sustainable development of agricultural sector

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ABSTRACT

Solar energy is one of the cleanest sources of alternative energy. Due to high energy demand in one hand and environmental negative impact of fossil fuels, on the other hand, many countries consider the alternative energy sources as a suitable and feasible option in industry and domestic usage. It was discovered that the different applications of solar energy in industries are being accepted more than ever. The present study is a state of art on the numerous new and feasible technologies of solar energy applications in the agricultural sectors. It discusses about the importance of solar energy as environmental clean technologies and the most reliable energy source. This study covers different types of solar energy systems like as solar photovoltaic and solar thermal for pumping water, drying crops, cooling the storages and producing heating/cooling greenhouses. It has been proven that photovoltaic systems and/or solar thermal system would be the suitable options in agricultural application and especially for the distant rural area.

Contents

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1. Introduction

"The sun radiates more energy in one second than people have used since beginning of time" [1]. The deep existent meaning of energy is the ability of sustaining and enhancing the life quality [2]. Energy has various forms like light, electricity, heat and radiation. For thousands of years, human used only renewable energy sources such as hydro, solar or wind, and agriculture in particular has been an action of employing the energy of solar to manufacture foods and besides that the human power was the only energy man used for it. Primary agriculture was first born from this model, which was soon changed when machineries came to the agricultural sectors to intensify outputs, which happened in all developing industrial countries. In fact, agriculture can be considered as one of the most critical industries that provides first necessities of living for human being who the same as other industries all activities and machineries in this area such as tractors, trolleys, cultivators, etc. also operate with conventional fuels such as petrol, diesel and fuel oil [3]. Moreover, industrial sectors have a major impact on the total energy consumption of all developed and under-developed countries [4]. Facing to the mechanized agriculture due to the many parameters such as land and labor cost and the energy sources is fairly different in different parts of the world [3,5]. For the time being, fossil fuels seemed to be adequate to support all human's energy consumption needs, but now a day not only it is not sufficient forever, but has diverse impacts on the environment either. One of the most critical concerns in the world during the past few years was energy matters especially since by increasing the population and industries, the demands of energy increased rapidly. Additionally environmental pollution as well as global warming or climate change that caused by the resources of conventional energy can be counted as the other significant issue in the world which all are the other main reasons to find a suitable alternative energy source [6,7]. As an example it can be addressed to the disaster occurred in 2003, which caused more than $10 billion losses in agricultural sector and death of 20 thousand people [8].

While, during the last few decades, the solar powered systems have been developed intensively and more often are considered as a feasible energy source in industry. Primarily, this is due to reduce fossil fuels consumption consequently CO_2 emissions for environmental consideration by using the zero emission-technologies and respond quicker to the demands of energy, especially in remote areas with available and more reliable energy source. While solar energy were first introduced for applying in electrification and telecommunication parts in rural sectors, moreover, there are huge requests of solar technology in other industries such as solar water heating, solar drying and solar PV [9,10]. The major objectives of this research are to: (1) classified all information about the present status of solar technology for supplying in different parts of agriculture sectors especially for remote areas and (2) introduce the different types of solar systems and discuss about their performances and advantages in altered applications.

In the context of this study, the different applied solar technologies in the agricultural sector are reviewed and classified. The solar irrigation systems will be reviewed first in Section 2 and then the solar refrigerator and cooling storage systems will be described in Section 3. The solar drying technologies will be evaluated in Section 4 and finally; the solar greenhouses will be presented in Section 5.

2. Solar irrigation systems

Comparing with conventional fuel, solar water pumping system has numerous advantages, for instance, besides of no cost for fuel and maintenance, the system it has no noise and pollution for the environment. Although there are solar water pumps with high capacity (10 of kW can be used), usually the pumps that are used in remote areas are small scale one (usually less than 1500 W) [11]. The main issue regarding to these systems is maintenance while at the same time 24 h electrical service is not demanded [12]. Solar water pump system is generally divided into two groups; solar photovoltaic and solar thermal water pumping systems.

General considerations of solar water pumping systems are described in Section 2.1. The different types of solar photovoltaic systems are explained in Section 2.1.1 and the effective parameters of the performance of the solar photovoltaic water pumping system are analyzed in Section 2.1.2.

2.1. Solar photovoltaic water pumping system (AC and DC motors)

Solar photovoltaic water pump consists of five parts, which are explained through the Table 1.

Solar photovoltaic water pumping usually does not include any battery backup, which appoints the system lower cost, stand-alone PV system and maintenance free, which make the photovoltaic system suitable for different pastures. The system is also equipped with automatic turn off mechanism, which shut down the pump when the tank is full. The system of photovoltaic that converts sunlight into electricity is based on the technology of

Table 1
Components of solar water pump system and their description.

Component	Application	Types	Description
PV array	Source of electrical energy	Amorphous, mono-crystalline poly-crystalline.(mono-crystalline has the highest efficiency while amorphous has the lowest).	PV array is analyzed based on the *I–V* curve and each array has its own disposition. Consequently many factors such as temperature, the load and radiation can affect the maximum power point or MPP.
The pump	Draws water from reservoirs, deep/shallow wells	Floating pump, submersible, surface pumps.	The selection of pump depends on; water requirement, the height of water (well), and the quality of water.
The motor	Pump and draw water from well	AC/DC, brushed/brushless, permanent magnet, synchronous/asynchronous, variable reluctance,	If the system works with DC, the PV array could be directly connected to the motor, otherwise an inverter/controller located between the motor and PV array.
The controller	Mandatory part if the motor is AC	N/A	Although it is one of the defenseless part of the system, but it can provides the optimum voltage/current by isolating different parts while also protects the motor from running dry and conserves water by turning off the system when the tank is full.
Water storage tank	Saving spare water	N/A	