Renewable energy and sustainable developments in Egypt: photovoltaic water pumping in remote areas

Elham Mahmoud[a,*], Hoseen el Nather[b]

[a]New and Renewable Energy Authority, Emtedad Abbas El Akkad Street, Nasr City, Cairo, Egypt
[b]Egyptian TV Channel 8, Aswan, Egypt

Abstract

This paper considers the economics of using photovoltaic (PV) technology for developing remote areas. ''East Owienat'' in Upper Egypt is the chosen region: there, the feasibility of using PV systems for the pumping of ground water in comparison with using diesel units, taking into consideration the different parameters affecting the costs and the present value of both systems, is considered. The study proved that PV-battery systems can be used efficiently for water pumping at East Owienat: the cost of the water unit pumped by PV systems is much less than that pumped using diesel systems, and the water cost is more sensitive to PV cells' prices than their life-time periods.
© 2002 Elsevier Science Ltd. All rights reserved.

Keywords: Sustainable development; Photovoltaic; Water pumping; Diesel systems; Total life-cycle cost

1. Introduction

Egypt is endowed with a significant amount of renewable energy resources. Some of these, such as solar and wind, have been used commercially while the use of the other resources is still in the research-and-development phase. This paper presents the results of an economic analysis for using Photovoltaic (PV) pumping systems to replace diesel systems used for irrigation at a specific remote area in the South-Western part of Egypt. The water cost indicator is used for comparison in three cases based on different prices of PV systems and for three different life times.

2. Case study

The case study considers a cultivated area in the East Owienat region, Egypt. Two irrigation systems; sprinkling and dripping are used. The hydraulic and electric energy needs to pump the water demands from the available underground water reservoir, are calculated taking into consideration the daily water demands suitable for the crop water requirements, the wells' data and the meteorological data of the site. Based on the daily solar insolation and the daily energy efficiency, the size of the PV array peak power is calculated using the procedure presented in [1] and the following site characteristics.

3. Site characteristics

The selected area for the study (East Owienat) is located at the west southern part of Egypt, it is between 22° and 24° latitude—north and 27° and 29° longitude—east. The average annual temperature is 25 °C. This area is one of the highest solar radiation levels in Egypt: it has an annual average of global solar radiation between 6 and 7 kWh/m²/day and the actual sunshine duration is about 11 h/day. The area has an open aquifer and high quality ground water, which is pumped for irrigation. Many diesel motor pumps are used at present for irrigating 28,000 feddans.

It is planned to cultivate 220,000 feddans at the same region making use of the huge ground water reservoir, which can irrigate these areas for 100 years. This area is about 400 km from the electric network and the gas and oil suppliers [2].

4. Economic analysis

The cost of one cubic metre of the pumped water for each of the two irrigation systems is calculated for three lifetime periods (20, 25, 30 years) and three water-heads (H = 40, 80, 120 m) for a PV-battery stand alone system and a diesel system using the total life-cycle cost procedure [1,3], with the following assumptions and equations:

$$P_{\text{hydraulic}} = (V * H)/367$$

$$P_{\text{electric}} = P_{\text{hydraulic}}/\eta_{\text{pump motor}}$$

where:

V	is the water volume in m³
H	is the water head in m
$\eta_{\text{pump motor}}$	is the pump-motor's set efficiency = 35%