

# Design and Performance Evaluation of a Solar Water Pumping System: A Case Study

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**Abstract**—This paper is concerned to design of direct coupled solar water pumping system without using batteries. Technical, economic and environmental parameters are considered in the design procedures. Performance evaluation of solar water pumping system is studied using three expressions; yield factor (YF), water to water energy efficiency (WWEE) and system performance index (SPI). A full monitoring system is presented to evaluate the operation of the system. The proposed monitoring system measures a real time data of system parameters. A case study of 45-kWp solar water pumping system in El Wahat, Egypt is studied. The recorded data using the monitoring system shows that the average daily water volume was 788 m<sup>3</sup> over one year. The maximum output water volume was 887 m<sup>3</sup> in summer with yield factor 5 (kWh/kWp/day).

**Index Terms**—AC pump, centrifugal pump, monitoring system, performance evaluation, Solar photovoltaic, Solar water pumping.

## I. INTRODUCTION

Solar water pumping system is considered the promising solution to solve those challenged issues. It presents a clean source of supplying water for irrigation with low maintenance required and with a reliable system that matches the generated energy with water needs for irrigation. It also synchronizes with water irrigation needs of the agriculture crops where the increasing requirement of water in summer matches the increasing generated energy of solar system in summer.

Using solar water pumping in the remote area is an environmental friendly, it has no running cost, long life time when compared to diesel generator [1].

This paper represents a direct coupled solar water pumping system without batteries. The presence of batteries in the solar water pumping systems have many disadvantages [2] like decreasing the total life time of the system -due to short life time of the battery in comparison with the system components-, increasing the system cost, decreasing the overall system efficiency and increasing the maintenance cost of the system -due to the high maintenance requirements for the batteries-. Those reasons make water storage in tanks a better option than storing electric energy in the batteries.

Figure 1 represents the proposed system components. The complete solar water pumping system consists of PV modules, combiner box, inverters, sensors, protection system, cables, water pumps and monitoring system.

The PV arrays are connected directly to the controller that works on tracking the maximum power point from PV modules, and converts the DC energy from PV to adequate energy, to provide smooth operation of the connected electrical motors. Three types of motors are commonly used; DC brushed motor, DC brushless motor and AC motor. The AC motor represents a reliable, low cost and maintenance work requirement. This motor shaft is directly coupled to the pump [3].

The positive displacement (PD) and centrifugal pump are commonly used in solar water pumping systems [4]. The piston pumps require less power than centrifugal pumps and have a capability to work at low flow with a constant pulsating flow.

The centrifugal pumps provide good performance for medium and high capacity fluid with low or medium pressure. They can work with smooth variable flow without the capability to work at low flow. The common use of the centrifugal pumps is due to their simplicity, low cost and less maintenance requirements than other types [5]. Those features make centrifugal pumps more adequate to be used.

The monitoring system measures the real time parameters including the weather conditions, DC output power (W), from the PV plant, the output AC power (W) from the inverter, the output flow rate (m<sup>3</sup>/ hr) from the pump and water pressure in the pipes (bar). This real time data are recorded and transmitted to be able to monitor the PV station remotely.

Sizing the solar water pumping system is a challenge due to the large variables that affect the system sizing. The technical, economic and environmental parameters should be considered to produce an efficient, reliable operation and cost efficient solar water pumping system [6].

Accurate identification of the daily required water (m<sup>3</sup>) and the total dynamic head (m) of irrigation system will lead to proper sizing of the PV system. In [7] authors studied the feasibility of using solar energy for irrigating different crops. They also discussed the water requirements for each crop.

This paper is organized as follows, in section II design of solar water pumping system is illustrated, section III the performance of the proposed solar water pumping system is evaluated, section IV describes a case study of 45-kWp solar water pumping system in El Wahat, Egypt. In sections V, VI and VII comes the Conclusion, Acknowledgments and References respectively.

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web oct 9 2017 information shared during clinical handover includes as a minimum the patient s current health status medications and treatment plans as well as advance directives and any important changes in the patient s status tools and handover structures such as sbar situation background assessment recommendation have been

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