ISSN: 2455 - 1597

ijergs
Open Access

International Journal of Engineering Research and Generic Science (IJERGS)
Available online at: https://www.ijergs.in

Volume - 7, Issue - 2, March - April - 2021, Page No. 01 - 07

MPPT Controller for Smart irrigation Solar Pumping System: A Review

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Abstract

In recent years, one of the suitable solar photovoltaic (PV) applications is a water pumping system. The simplest solar PV pumping system consists of PV array, DC-DC converter, DC motor, and water pump. Solar energy has the potential to meet the requirement of energy for the survival of human beings on the planet earth if used wisely. Some of the applications consist of electric power generation with the help of solar panel/thermoelectric generator/Rakine cycle based technology, water purification, dryer for agriculture product and refrigeration. Solar energy is pollution free and it can be utilized for irrigation with the help of solar energy based pump and some system for distribution of water. Many solar energy based pumping systems have been reported by researchers around the globe. In this paper, a detailed literature survey related to PV system based irrigation pump system has been illustrated.

Keywords: Solar PV System, MPP Controller, Solar pumping system, Collectors, Irrigation System.

Introduction

In rural areas, standalone photovoltaic water pumping systems have become very competitive solution for water supply because the access to an electric grid is not available or costly effective. In Libya, standalone solar systems are gaining more interest than other renewable energy sources because many sunny days are available. Moreover, because of the environment issues such as global warming, researchers are led to develop the renewable energy sources such as solar systems.

One of the most important issues with PV standalone systems is its efficiency and performance over various operating conditions. In [1] a brushless DC motor solar water pumping system is described and simulated. The system model is developed from an individual component to assess the overall performance of the system. The results show that the efficiency of solar PV water pumping system over various operating conditions is improved compared to the existing systems. The performance of standalone solar systems is also associated with the parallel and series combination of PV module. For different solar irradiation and ambient temperature, a combination of series and parallel PV modules is analyzed in terms of their performance. The results show that a good matching cannot be achieved at low solar irradiation. A good matching can be achieved for a typical parallel and series combination of the PV module. Furthermore, the solar water pumping system performance is evaluated under fixed position and manual tracking of PV panel. The evaluation shows that the manual tracking for the water pumping system is 22.6% more efficient than the fixed PV panels.

Generally, the sizing of PV water pumping system is done on the basis of hydraulic energy demand and available solar energy. In previous research developed a mathematical model to acquire an optimal PV system by considering not only water demand or irradiance but also including natural process i.e. climate, hydrology, boreholes, pumping system, irrigation, agriculture and power supply. Climate determines the moisture, solar irradiance and water requirement for

irrigation. Climate inputs are needed to be treated especially throughout the entire period as those are stochastic parameters. Land and geological features decide water storage capacity of the soil. PV pumping system consists of PV generator, nominal electric power, motor-pump unit, and inverter. The authors put an importance on the need for compatibility between discharge capacity of the borehole and pumped water. The authors also adopted the cost-effective trickle irrigation method with the efficiency of 85%. Soil moisture determines the system condition and water requirement.

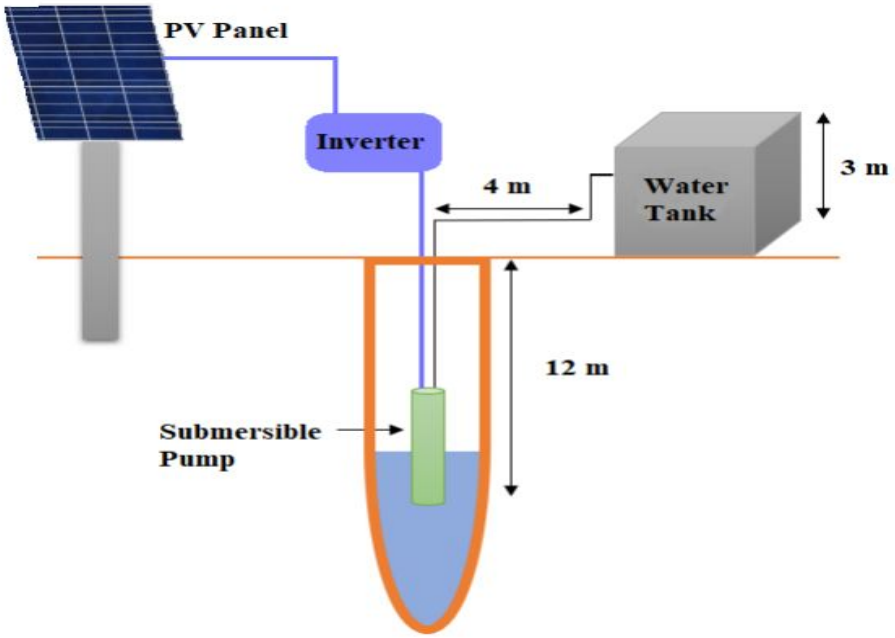

Figure 1: Block Diagram of Water Storage System [2]

Literature Review

According to the survey conducted by the Bureau of Electrical Energy in India in 2011 there are around 18 million agricultural pump sets and around 0.5 million new connections per year is installed with average capacity 5HP. Total annual consumption in agriculture sector is 131.96 billion KWh (19% of total electricity consumption).As cited in paper [1] solar powered smart irrigation technique is the future for the farmers and a solution for energy crisis. So for the proposed solar powered system we are using techniques analyzed in paper [2] and [4] and modified. Sine PWM technique has been used for inverter operation for minimum harmonics as given in paper [3] which further increases the efficiency of the system.

Another smart irrigation system was proposed in [4], which used the LM-35DZ temperature sensor. This system paid high attention to soil temperature, as it is one of the most important environmental factors, affected by the change of climate, topography, vegetation, and soil type. In addition, soil temperature was used to control all related processes, which included, crop planting time, tilling growth and wintering safety, etc. Soil moisture is a basic property that causes the resistance of the soil between two points to decrease with the increase of water content in it. Since water is a good conductor of electricity, in the presence of ions, the greater the number of electrolytes in the soil, the greater the conductivity of the soil will be, and vice versa. A circuit consisting of an oscillator that generates a 1 kHz sine wave at

one end of a probe was used. At the other end of the probe, there is a series resistance, and the output between the probe ends was con-nected to a half-wave rectifier, followed by a low pass filter. This setup generates DC signals that depend on the resistance due to soil moisture between the probes. The data processing unit is centered on P89v51 RD2 microcontroller and the com-plete circuit operated on a 5V power supply. This system was very compact, with low power consumption, more reliability and could be easily integrated within other designs. It has a GUI that receives commands from the user and takes actions, accordingly. Using a microcontroller reduced the cost of automation and provided more flexibility, as well.

Hossain et al. 2015 [5] stated that, according to the baseline survey, only 150 solar pumps existed in Bangladesh in 2010. Among them, 65% pumps were used for supplying drinking water and only 35% were used for irrigation purpose. They also stated that in Bangladesh small scale solar pumping system is available which ranges from 300 Wp to 1190 Wp and discharge capacity was 2000 to 80,000 L/d. They addressed the main problem that, in Bangladesh, panel cost was the major cost (45%) in solar irrigation system followed by installation (18%), motor (16%), pump (10%), and pipes and fittings (4%). Moreover, PV pumping system requires high capital cost, water storage for cloudy weather, and skilled personnel, as mentioned by Abu-Aligah 2011 [6].

Arrouf and Ghabrour 2007 [7] used buck-boost converter in the Simulink model for smooth operation. Malla et al. [8] designed a battery-less PV system in MATLAB/Simulink and described the control strategies. They adopted MPPT (Maximum Power point tracker) in their system. This paper represents dynamic simulation of battery-based and battery-less solar water pumping system for irrigation.

According to Arrouf and Ghabrour 2007 [7], the technology of solar cell is growing fast. Gopal et al. 2013 [9] stated that solar photovoltaic water pumping systems are the most widely used renewable energy source water pumping system for irrigation and domestic use. Abu-Aligah 2011 [6] also stated some advantages of solar PV system: unattended operation, low maintenance, easy installation, and long life. In this situation the Government of Bangladesh is promoting alternative sources of energy to meet the energy deficiency. Many governmental and nongovernmental organizations are encouraging people to go with renewable sources of energy. Bangladesh Government is giving subsidies for alternative energy projects. Many solar irrigation pumping system sites exist in Bangladesh.

A lot of organizations are coming forward to finance large renewable energy projects. Grameen Shakti is one of the nongovernmental organizations which has installed a large solar irrigation pumping system (SIPS) to irrigate a considerable land area in Bangladesh. Sherpa Power Engineering Limited provides the technical support. The project name is Grameen Shakti-Gorol or GS-Gorol project which is situated in Gorol (Kamlartari), Kaligonj, Lalmonirhat, Bangladesh (26°N, 89.28°E). The dynamic modelling of a solar irrigation pumping system with storage is performed based on this reference site.

Anis and Nour 1994 [15] designed a PV powered pumping system based on switched-mode operating system. He also analyzed the interdependence of the system parameter. According to Chandel et al. [16] DC or AC submersible/surface mounted/floating motor-pump sets are suitable solar PV pumping system. Argaw [17] concluded that PV arrays can be configured from V-I characteristic of a single cell and required rated power for the motor/pump. Pande et al. 2003 [18]

proposed a PV water pumping model to ensure uniform irrigation in arid regions using Openable Low Pressure Compensating (OLPC) drippers and manual tracking. Abu-Aligah 2011 [6] designed a direct coupled, battery-based, grid connected photovoltaic system. Benghanem et al. 2013 [19] studied the performance among four different PV array configurations for a deep well using helical pump. Two of them gave the optimum energy to lift water. Senol 2012 [20] studied small and medium size mobile solar PV power station for drip irrigation. He considered two different scenarios: (i) PV station used by a single farmer with maximum discharge of 18 m3/d and it had water storage and (ii) PV station used by four farmers with maximum water discharge of 52 m3/d and it had no water storage. Abul Hasnat et al. 2014 [21] proposed a hybrid solar irrigation. The pump was fed by bot solar PV array and grid electricity.

According to Anis and Nour [15] increasing the water tank size is more economical than increasing both array and battery size. Hoque [22] concluded that for consecutive three seasons' irrigations, the unit cost of water is cheaper in case of PV water pumping system comparing with diesel engine system. Abu-Aligah 2011 [6] did the cost and reliability analysis between PVDC and diesel engine system and PVDC system turned out as more reliable system. He also did the Life Cycle Cost (LCC) analysis for a period of twenty years and found that the solar energy system was cheaper although the initial cost was high for it. Senol 2012 [20] performed economic analysis for three different cases: (i) no subsidy, (ii) 50% subsidy (not including PV module cost), and (iii) 50% subsidy (including PV module cost). The investigation proved that PV powered pump is preferable. Abul Hasnat et al. 2014 [21] concluded that hybrid solar irrigation was more feasible than solar irrigation project as payback period decreases about five to seven years. According to him, before five years of operation, LCC is lower for diesel engine, but it became lower for solar PV pump after five years of operation. He also suggested that investment in solar pump is more profitable and risk free than diesel engine operated irrigation system.

Hamidat and Benyoucef 2008 [23] found that DC engine with a positive displacement pump is more efficient and discharges more water than AC engine with a centrifugal pump for a wide range of total dynamic head. Mokeddem et al. 2011 [24] monitored the performance of a small direct coupled DC photovoltaic water pumping system at different test conditions by varying irradiance and operating voltage for two different static heads. He found that the system is suitable for low delivery flow rate application. Katan et al. [25] showed that the performance of a PVDC system could be increased by using MPPT and Sun tracker. Khan et al. [26] suggested that using a buck converter would ensure the smooth operation but not increase the cost of the system. Abu-Aligah 2011 [6] compared the effectiveness between solar PV and diesel engine system. Abul Hasnat et al. 2014 [21] found that operating time increased and idle time decreased for a hybrid irrigation system.

A comparison of energy storage methods and detail dynamic modelling of solar water pumping system is missing in literature.

Proposed methodology

Particular need for equipment and machinery depends on the form of irrigation methods, such as groundwater recharge where water is transported over the ground of agricultural property, localized irrigation such as spray or trickle or drip system where water is transferred to neighboring to each crop, and sprinkler irrigation where water is poured to and dispersed to one or more central areas throughout the field. A solar cell set that drives a bore well pump or ground pump

forms a conventional solar-powered pumping device's key components. The total device's capacity depends on the pump capacity, the volume of water needed each day, and the amount of electricity provided from the solar cells. The water is frequently injected into a reservoir or immediately into the ground from a bore-well or river. The solar-driven irrigation system has three critical components: the motor pump, the pump controller, and the solar screen.

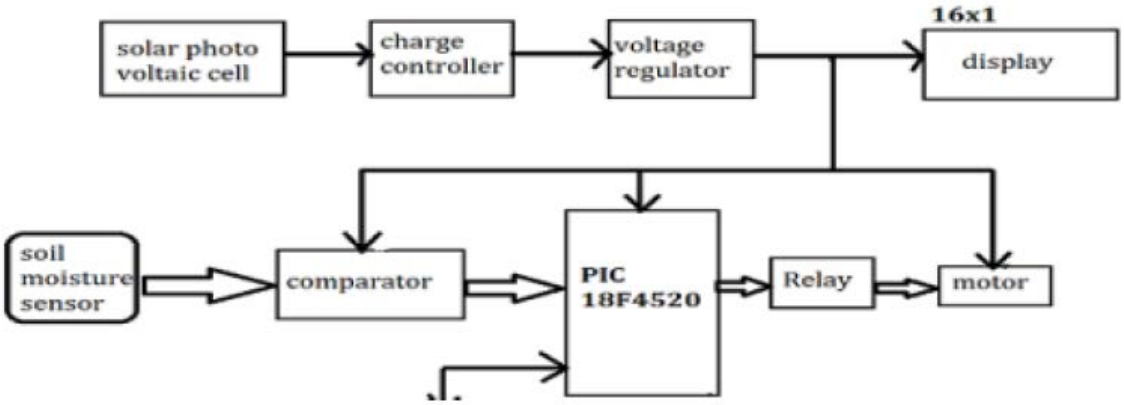

Figure 2: Solar power automatic irrigations system

Discussion and Conclusion

Renewable energy system offers an alternative way for sustainable development of a country. Renewable energy system offers an alternative way for sustainable development of a country. This research indicates that the solar water pumping system can be integrated to irrigation systems in Bangladesh as it is a feasible solution for a longer period. For twenty five years of the life cycle, solar PV system will cost half of the diesel engine operated system. The proposed automated solar water pumping system for irrigation is the economically feasible solution to meet the irrigation challenges faced during the dry season.

By using the automatic irrigation system it optimizes the usage of water by reducing wastage and reduce the human intervention for farmers. The excess energy produced using solar panels can also be given to the grid with small modifications in the system circuit, which can be a source of the revenue of the farmer, thus encouraging farming in India and same time giving a solution for energy crisis.

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