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Performance evaluation of portable Solar Water pumping System

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Abstract: Solar photovoltaic water pumping system is becoming an important alternative for reducing the usage of fossil fuels and electricity to a large extent. Power from portable solar photovoltaic system was used for operation of Agriculture appliances thresher, chaff cutter, lighting, fan and water pump. A solar panel of 1280 W (4 solar modules of 320 W each with open circuit voltage 45.30 V) was used to operate the system. The direct current (DC) power of the solar panel was used to run the 1000 W AC used for lighting, fan and water pump. The portable system was tested for input and output current and voltage. The output capacity was found as 1 kW A 24 V/5 Ah may also be used to operate the portable power system in the absence of solar energy.

Key words: portable solar energy, Solar PV system, lighting, fan and water pump

INTRODUCTION

In the present scenario, the demand for agriculture is increasing abruptly due to the population in the world. In agriculture, irrigation plays a major role. As it requires electricity supply to irrigate the field, farmers find it an additional expense towards the electricity cost and also it is challenging to provide the uninterrupted supply to farmers. Though our government provides subsidies, the demand for electricity throughout the world is increasing. Especially as we tend to rely on agriculture for our daily life and considering the hardship faced by the farmers, nowadays people tend to move towards solar power but the existing grid connected system may lead to high cost, need of more space, and needs proper maintenance. The use of DC pumps overthrows the struggles of farmers and to pave a way to increases agricultural practices. The panel setup is placed in an appropriate location so that it could receive more radiation, as a result generates maximum power. The parameters like power, power quality and pumping rate has also been analysed under varying atmospheric conditions under specific period of time.

Day by day the uses of non-renewable energies have been increased a lot and now they are becoming extinct. The raw materials used to generate power i.e. coal, fossil fuels have been depleting very rapidly. People have been suffering a lot due to immense power cuts. To reduce these problems, the renewable energies like solar, wind, biomass etc. Agriculture is heart of a country and every individual depends on agriculture for food. Still, Farmers have been facing horrible problems due to power cuts. this performance and evaluation of solar photovoltaic power pack system for agricultural filed operation was provide a solution. To develop agriculture, we should take care of plants. About 90% of plant body consists of water. Due to unavailability of energy sources, we are unable to supply water to the crops. But we can supply water at all time by solar energy. The amount of solar energy available during sunshine hours (8 hrs.). if we use 5% of available energy it is 60 times the world energy requirement. During hot season water requirement increase and also solar energy will be available at higher level.

The solar photovoltaic system main renewable sources of energy that is used for electricity of agricultural filed operation. Appropriate use of these sources in electricity provides reduction of electricity, fuel and time. Choosing the right transportable power pack technique is thus important in the process of one or more agricultural field operation, especially in the Konkan region study but all India in this system is adapted. In rural area electricity is available for restricted and therefore most of the time farmers are solar water pump and other agricultural field operation. The urban area where electricity is available but not rural area electricity is available for restricted. Portable solar power system of agricultural filed operation is yet not developed in the India.

Lal et al. (2013) studied a photovoltaic array based water pumping system situated at Kota Rajasthan, India. The 2 hp DC motor with 2200 W (10 panels of each 225 W) used for discharge 30 m water head. The maximum discharge logged 163litre/minute between 11:00 AM to 2:00 PM at PV power output between 75 to 85 W/m^{2}and the system was operating approximately 8 hours in the winter season. The full day discharge was found to be 70995 litre and it was more than the average discharge given by the manufacturer at 50 m depth. It was revealed that PV array based water pumping system was suitable and feasible option for off-grid and drip irrigation system like the interior area, where clear sky days were more than 250 in a year.

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MATERIALS AND METHODS

In This experimental study on portable solar PV power system was carried out at the Department of Electrical and other Energy Sources, CAET, Dapoli. The Konkan region of Maharashtra is a long narrow strip between 15º 37' and 20º 20' N and 72º 7' E longitude comprises greater Mumbai, Thane, Raigad, Ratnagiri and Sindhudurg, Palghar district with geographical area of 29 lakh hectare. The region has hilly terrain and receives the heavy rainfall ranging from 3000 to 4000 mm mostly during June to September. The region endeavoured with the average solar energy availability of 450-600 W/m^2 for 7 to 8 hours in a day and 250 days in a year.

The following operating parameters were measured during the each test. The Panel selected was from WAREE make, which had specific I-V Characteristics values mentioned below:-

Short circuit current (Isc)

This is the maximum current that flows in a solar cell when its terminals at P -side and N-side are shorted with each other, i.e., V = 0. The short circuit current is usually represented as current density and current per unit area, in terms of mA/cm2. Short circuit current Isc = 0.38A

Open circuit voltage (Voc)

It is the maximum voltage generated across the terminal of the solar cell when they are kept open, i.e., I = 0. Open circuit voltage depends on the light generated current and reverse saturation current. The Voc is in terms of mV or V. Open circuit voltage Voc = 10V

Fill factor (FF)

It is the ratio of maximum power (Pm = Vm*Im) that can be extracted from the solar cell to the ideal power (Po = Voc*Isc). The FF represents the squareness of the solar cell I-V curve. It is represented in terms of percentage. Where values for maximum power voltage Vm = 8.80V and maximum power current Im = 0.34A

Efficiency (η)

It is defined as the ratio of the power output to power input. The power output is maximum power point Pm of a solar cell, and input power is the power of solar radiation Prad. According to international standard for characterization of solar cell, Prad=1000W/m2. Where Pm was taken as product of Isc and Voc divided by panel surface area (S). For the selected panel it was calculated by dividing the peak power point by panel surface area. Panel surface area (S) was measured as = 0.18m*0.18m = 0.0324 m2.Thus the efficiency calculated as:

Solar intensity, (W/m^2)

The solar intensity is measured with the help of Solari-meter for 9.00 to 17.00 h. at an interval of 1 h on each day.

Wind velocity (m/s)

Anemometer is used to measure wind velocity at an interval of 1 h on each day.

Ambient temperature (ºC)

The ambient temperature was measured with the help of thermometer at an interval of 1 h on each day.

Safety disconnects:

Mathematically switches to manually shut off electricity in case of an emergency or maintenance. These switches usually installed between the solar panels and the controllers and between the controller and the pump

Tracking mode:

The tracking mechanism was provided to trolley for movement of solar panel according to the tracking angles. The tracking angle was set according to movement of sun with help of manually operated mechanical jack and movement of trolley East West direction

Discharge (Flow Rate) of the Pump:

Volume of water delivered by pump per unit time m3/h or m3/sec. the discharge of the DC pump used in the test was measured by volumetric method by collecting the water in 100 liters container and the subsequent time taken to fill the container was recorded using stopwatch. The same was repeated for five trails and the average of five trails was considered. The same method was carried out under tracked conditions.

Q = amount of water collected (liters) / time taken (sec)

RESULTS AND DISCUSSION

The performances of single phase (AC) surface water pump (1hp) during winter and summer season were evaluated using power output from portable solar photovoltaic power system at dual axis tracking mode. The variation of power consumed, discharge of pump and solar intensity with respect to operating time during winter season is shown in Fig.1 and 2, respectively. Fig 3 and 4 indicated the variation during summer season.

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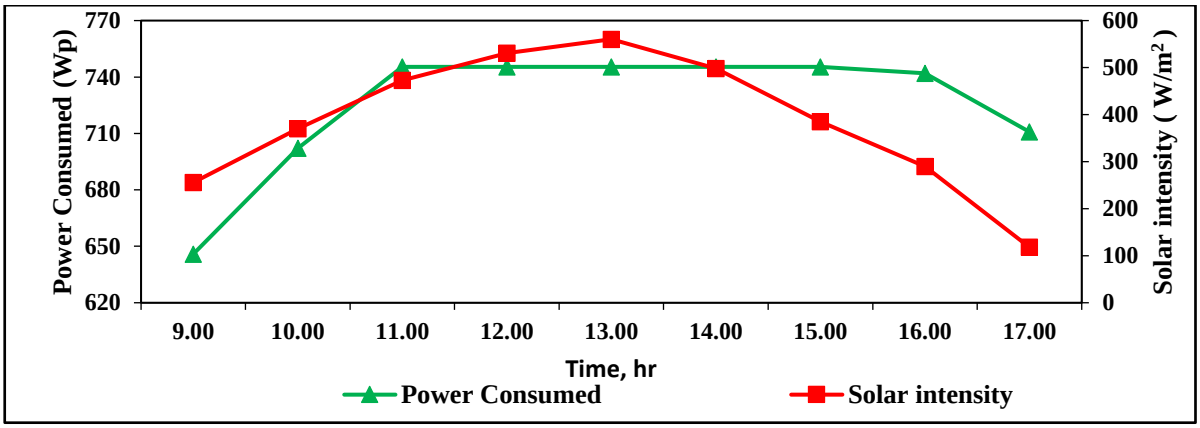

Fig 1 Variation of power consumed by surface water pump and solar intensity (winter).

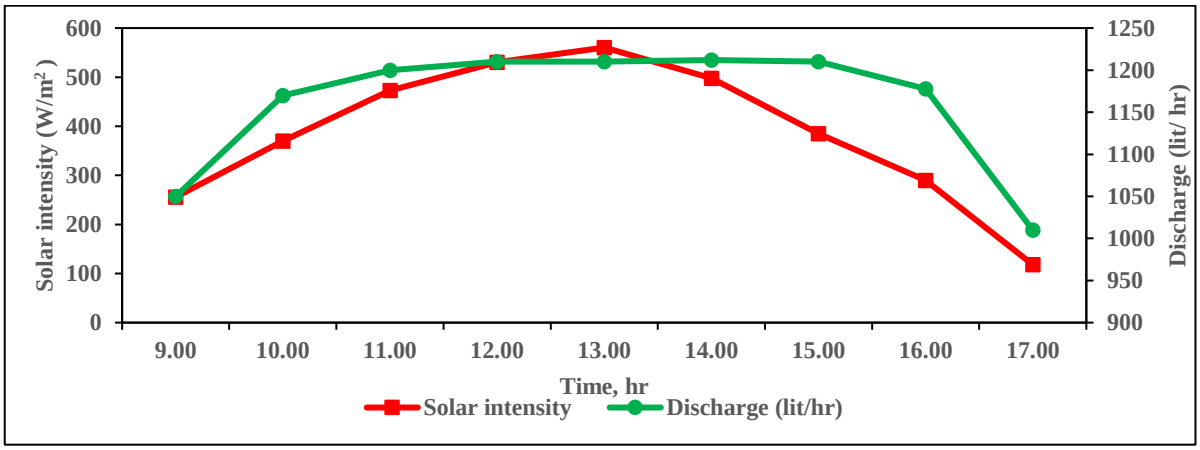

Fig 2 Variation of discharge from surface water pump and solar intensity (winter).

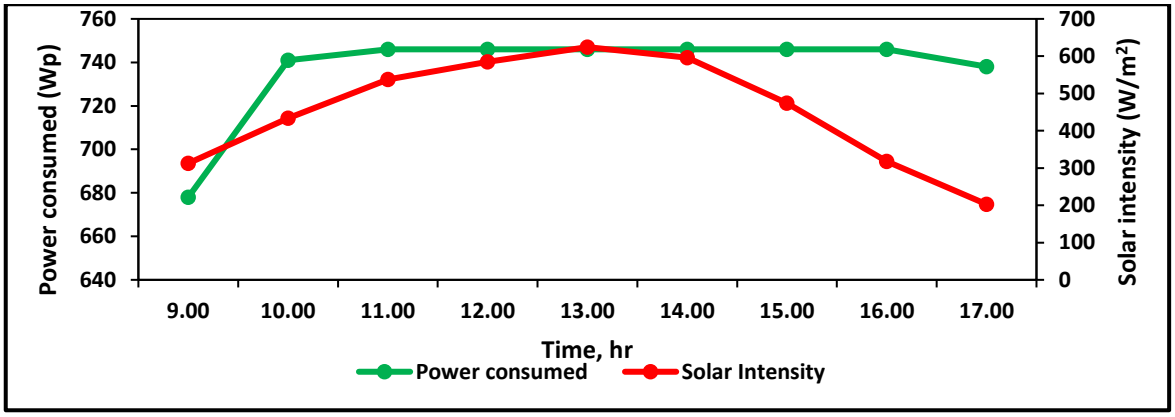

Fig 3 Variation of power consumed surface water pump and solar intensity (summer).

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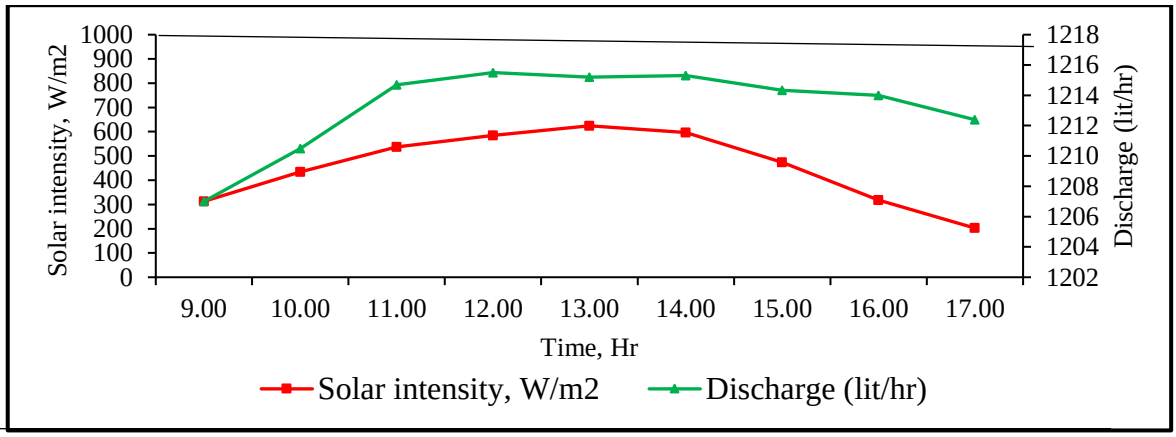

Fig 4 Variation of discharge from surface water pump and solar intensity (summer).

Fig 1 and 2 revealed that, the average power consumed by the surface pump (1 hp) was found to be 727.3 Wp. The surface pump consumed more than 740 wp during the 11.00 AM to 15.30 PM period. The average discharge from surface (AC) pump running on portable solar photovoltaic power system was found to be 1156 lph. The pump delivered more than 1200 lph water from 11.00 hrs. to 15.30 hrs. Which is more than 80 % rated capacity of the pump (1250 lph).
Fig 3 and 4 revealed that, the average power consumed by the surface pump (1 hp) was found to be 737 Wp. The surface pump consumed more than 740 wp during the 10.30 to 16.00 hrs period. The average discharge from surface (AC) pump running on portable solar photovoltaic power system was found to be 1193 lph. The pump delivered more than 1200 lph water from 10.00 hrs. to 16.00 hrs. Which is more than 80 % rated capacity of the pump (1250 lph). The overall performance of water pump operated on portable solar photovoltaic power system in term of season, solar intensity, power input, power output and discharge on daily basis was evaluated. The result obtained are summarised as below in Table 1. The Pictorial view of the water pump is shown in Plate 1

Table 1 Performance of surface water pump operated on portable solar photovoltaic power system

Season	Solar intensity(W/m^2)	Input power (DC)	Output power (AC)	Discharge (lit/hr)
Winter	374.7	905.23	727.3	1156.00
Summer	453.59	906.1	737.00	1193.00

1 Pictorial view of water pump operating on portable solar photovoltaic power system

From the field / load study of portable solar photovoltaic power system for the utilization of water lifting pump at remote location revealed that, the developed system is technically suitable for the water lifting operation. The developed portable solar photovoltaic power system is suitable to operate during 9.30 hrs. to 15.30 hrs. during winter and 9.00 hrs. to 16.00

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hrs. during summer season for water lifting with single phase 1 hp AC pump. The output power, discharge and operating period of water pump was higher in summer season than winter due to higher solar intensity during summer season.

CONCLUSIONS

The average power consumed by the surface water pump (1 hp) was found to be 727.3 Wp and 737 Wp during winter and summer season, respectively. The pump delivered more than 1200 lph (> 80 % of rated capacity) of water for 3.5 hrs during winter and 06 hrs during summer season using developed system.

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