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DESIGNING OF SOLAR POWER SUPPLY SYSTEM FOR DIFFERENT HP MOTORS IN IRRIGATION SYSTEM FOR RURAL AREA OF CHHATTISGARH

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ABSTRACT

The feasibility of using a solar photovoltaic array to drive water-pumping units for irrigation and drinking water in remote areas, where other sources of power are not available has been demonstrated. Solar energy, being very costly at present, is to be used very judiciously. MATLAB software is employing to do the simulations and perform the techno-economic evaluation [2]. Thousands of cases have been carried out to achieve an optimal system configuration based on the lower net present cost and levelized cost of energy. In this work, a case study is done for a remote area situated at Chhattisgarh as a representative example of a remote agricultural area in India was presented here. Finally, comparative studies of photovoltaic cell system with stand-alone diesel generation system and also with grid extension were considered in this study. Also this paper presents an optimized power management scheme for solar PV power driven different HP motor pump with energy storage for rural irrigation. The integrated PV system will supply power to the required demand of the 3 HP and 5 HP AC submersible pump and excess power will charge the battery via a suitable DC-AC boost Converter [1]. During PV Power generation deficiency, the battery will be in discharging mode to supply the required power to drive the pump depending on its State of Charge (SOC) and thus smooth the transient power during that period.

KEYWORDS: Solar photovoltaic, water pumping system, irrigation, DC-AC Converter, State of Charge (SOA), photovoltaic (PV) pumping system.

INTRODUCTION

Solar energy is the most abundant source of energy in the world. Solar power is not only an answer to today's energy crisis but also an environmental friendly form of energy. Photovoltaic (PV) generation is an efficient approach for using the solar energy. Solar panels (an array of photovoltaic cells) are now extensively used for running street lights, for powering water heaters and to meet domestic loads. The cost of solar panels has been constantly decreasing which encourages its usage in various sectors [10]. One of the applications of this technology is used in irrigation systems for farming. Solar powered irrigation system can be a suitable alternative for farmers in the present state of energy crisis in Chhattisgarh, India [7]. This is green way for energy production which provides free energy once an initial investment is made.

Today the generation is heading towards ultra-technologies. Water pumping has a long history; so many methods have been developed to pump water. People have used a variety of power sources, namely human energy, animal power, hydro power, wind, solar and fuels such a diesel for small generators.
The most common pumps used in remote communities are:

i) Hand pumps
ii) Direct drive diesel driven borehole pumps
iii) Electric submersible pumps with diesel generator
iv) Solar submersible pumps

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LOCATION AND LOAD DEMAND SPECIFICATIONS

In this work, the optimal design of PV renewable system is done for a remote area situated at Chhattisgarh, India. The site under study has good level of solar radiation. It receives an annual average solar radiation between 900 to 1200 Wh/m^2per day and the actual sunshine duration is about 9 hours per day. The amount of solar radiation in a typical year is presented as daily average solar radiation at horizontal surface (Wh/m2/day). The solar radiation data for the site under study are taken from department of CREDA in Chhattisgarh. The average solar radiation for each month data is shown in Figure. 1. June has the highest daily radiation (1200Wh/m^2/day) while the lowest radiation occurs during December (500Wh/m^2/day). The total average of the solar radiation per year is 850Wh/m^2/day. The site under study contains fertile land for cultivation within the desert land with mainly flat terrain. This area floats over large amount of aquifers and has high quality underground water, which can be used for irrigation purposes. The farm under study consists of six land pieces with a total of 15 acres. The water demand ranges between 350 and 500 m^3/day in hot seasons and between 200 and 250 m^3/day in winter seasons. The bore well has the following characteristics; 100 m static water level, 150 m well depth and 120m^3/hour well discharge rate. Irrigation based on drip systems are rapidly developing in rural area of Chhattisgarh. The water efficiency by these systems is extremely high. The combination of stand-alone renewable systems with drip systems is appropriate for isolated areas with no connection utility grid. Required water demand per unit area irrigated depends on the crop, weather conditions, and soil type. In general, the daily energy demand is 8 KWh with 10 kW peak demand. A typical monthly daily load demand of a year is shown in Fig. 2.

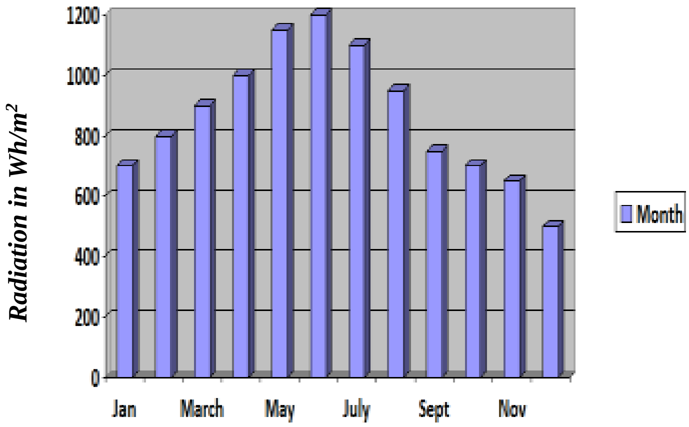

Fig.1. Monthly solar radiation data for the site under study.

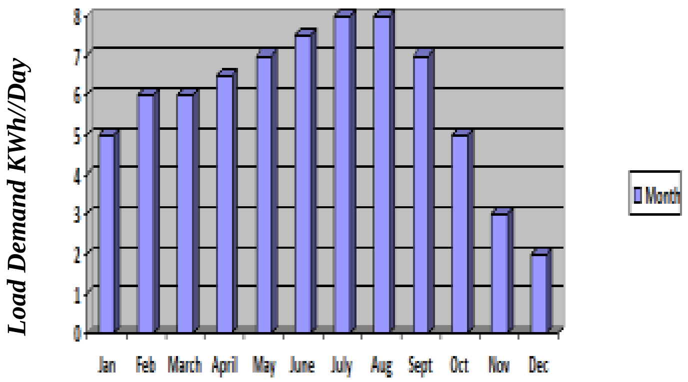

Fig. 2. Monthly daily average load demand.

MODELLING OF PV BASED WATER PUMP IRRIGATION

Photovoltaic cells

Photovoltaic cells are devices which 'collect the light and convert it into electricity. The cells are wired in series, sealed between sheets of glass or plastic, and supported inside a metal frame. These frames are called solar modules or panels. They are used to power a variety of applications ranging from calculators and wrist-watches to complete home systems and large power plants [2]. PV cells are made of thin silicon wafers; a semi-conducting material similar to that used in computer chips. When sunlight is absorbed by these materials, the solar energy knocks electrons loose from their atoms, allowing the electrons to flow through the material to produce electricity. This process of converting light (photons) to electricity (voltage) is called the "photovoltaic effect" [4].

General mathematical models of PV cell were proposed by various researchers. A single diode model of PV cell is selected whose equivalent circuit diagram is shown in Fig. 3.

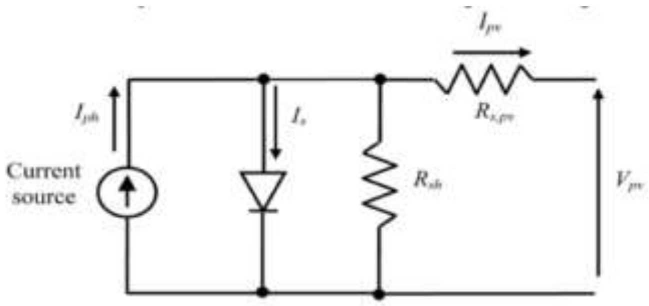

Fig. 3. Equivalent circuit of diode model of PV cell

The mathematical diode model of PV cell exhibits better performance. The relation between the PV output current and the circuit components are described in equation 1. A number of approaches for cells and modules parameter determination can be adopted using the datasheet parameters specified by manufacturer or measured. The performance of solar cell is normally evaluated under the standard test condition, where an average solar spectrum at AM 1.5 is used, the irradiance is normalized to 1000W/m^2, and the cell temperature is defined as 25ºC [5]. The specifications of the solar panel listed in Table I are used and implemented in the proposed power hybrid system.

TABLE I
SPECIFICATION OF SOLAR PANEL

Specification	**Value**
Peak power output in voltage	1000 V
Maximum power voltage	660 V
Maximum power current	6.75 A
No. and type of cell	9 x 36 cells
Working temperature	-40°C ~ 90°C

The perturbation of the output power is achieved by periodically changing (either increasing or decreasing) the controlled output power.

Photovoltaic pumping system
One promising area of research is the use of PV as the power source for pumping water. The use of photovoltaic power or water pumping is appropriate, as there is often a natural relationship between the availability of solar power and the water requirement increases during hot weather periods when the solar radiation levels are higher and the output of the solar array sis at a maximum. The water requirement decreases when the weather is cool and the sunlight is less intense. The whole system of solar pumping includes the panels, support structure with tracking mechanism, electronic parts for regulation, cables, pipes and the pump itself [4].

i) Solar panels or modules: Solar panels are the main components used for driving the solar pump. Several solar panels connected together in arrays produce DC electricity, interconnections are made using series or parallel combinations to achieve desired voltage and power for the pump.
ii) Solar pump: Centrifugal or submersible pumps are connected directly to the solar array using DC power produced by the solar panels which is the covert AC as per requirement of AC induction motors. Solar pumps are available in several capacities depending upon the requirement of water.
iii) Support structure and tracking mechanism: Support structure provides stability to the mounted solar panels and protects them from theft or natural calamities. To obtain maximum output of water, a manual tracking device is fixed to the support structure. Tracking increases the output of water by allowing the panels to face the sun as it moves across the sky.
iv) Foundations (array and pump): Foundations are provided for support structures and pump.
v) Electrical interconnections: A set of cables of appropriate size, junction boxes, connectors and switches are provided along with the installation.
vi) Earthling kit: Earthling kit is provided for safety in case of lightning or short circuit.
vii) Plumbing: Pipes and fittings required to connect the pump come as part of the installation.

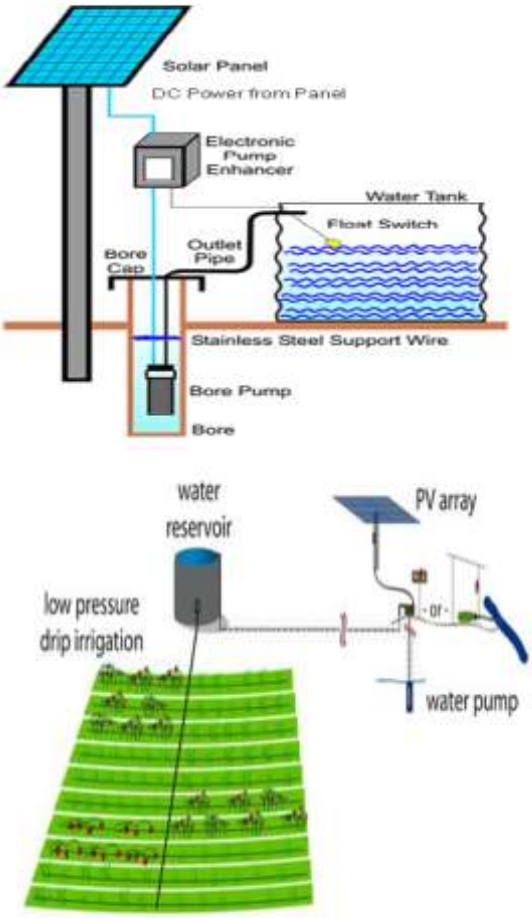

Fig. 4 Solar PV irrigation system.

PV applications

Solar panels are used in a variety of applications. The applications vary from small simple lanterns to large elaborate power plants.

i. Rural and urban households for domestic purposes like lighting.
ii. Communities, small industries and institutions like schools, for lighting as well as for powering television sets, computers, etc.
iii. Water pumping systems.

iv. Telecommunications, as these systems are often installed in isolated places with no other access to power.
v. Refrigeration of vaccines at health center in rural areas. Such solar refrigerators are also utilized to store blood plasma. WHO supports programmers that install solar power for medical purposes,

SIMULATION RESULTS

The Solar Photovoltaic battery storage pump system has been modeled and a comparative analysis has been made with two different 3 HP and 5 HP induction motors. The simulation of PV set is shown in Fig. 5,

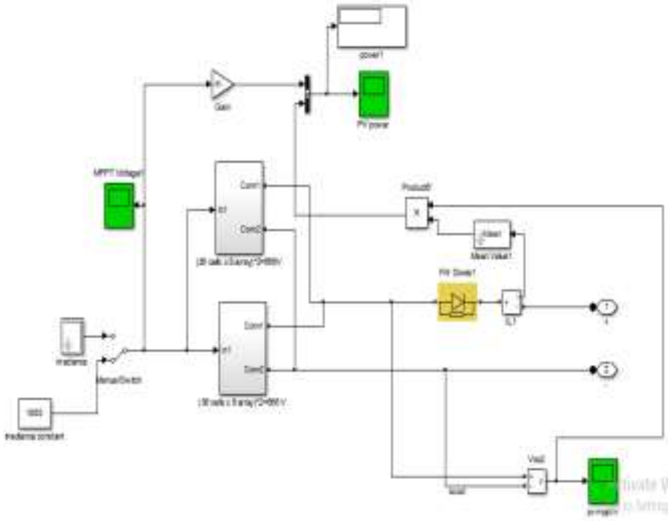

Fig. 5 The simulation of PV set

Fig 6-7 represents the output waveform voltage of two panel (9 x 36 cells) and output power irrespectively.

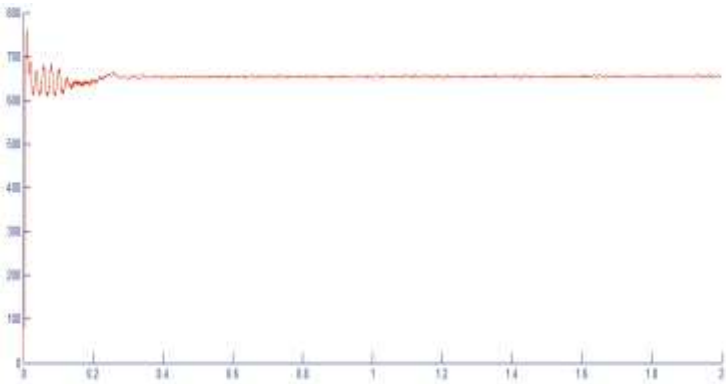

Fig. 6 Voltage output of 2 panel (9 x 36 cells)

The output voltage of 2 set panel (9 x 36 cells) is about 660 V within 0.2 sec.

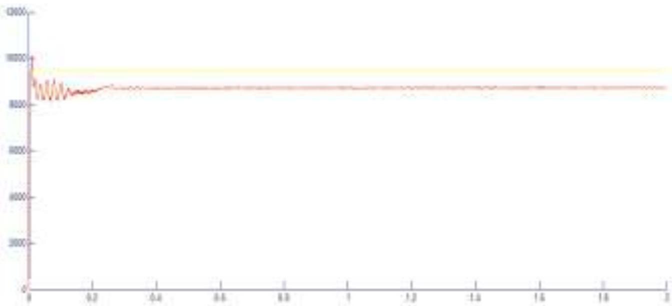

Fig. 7 Power output of 2 panel (9 x 36 cells)

The output power of 2 set panel (9 x 36 cells) should be about 9.5 KW within 0.2 sec. but it will be 8.5 KW within 0.2 sec. hence we can say that about 1 KW of power has been collaps in losses during generation.
The final simulation with battery storage and converter (PI with PWM controlled) is shown in fig 8.

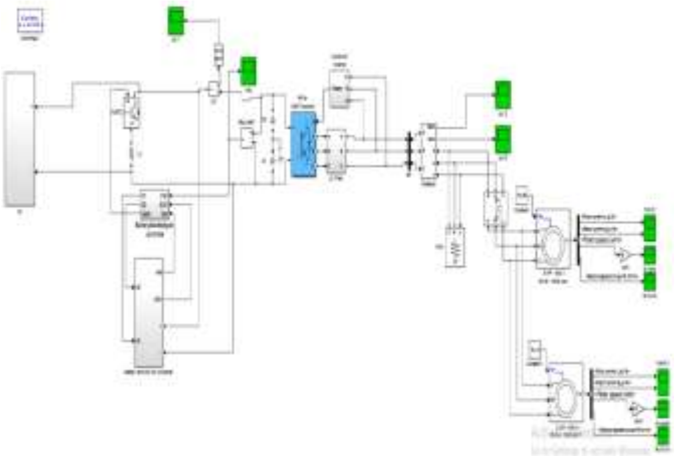

Fig.8 Simulation of PV based irrigation system

Fig. 9-10 represent simulation results after conversion of DC solar panel to AC form as per requirement of AC induction motors.

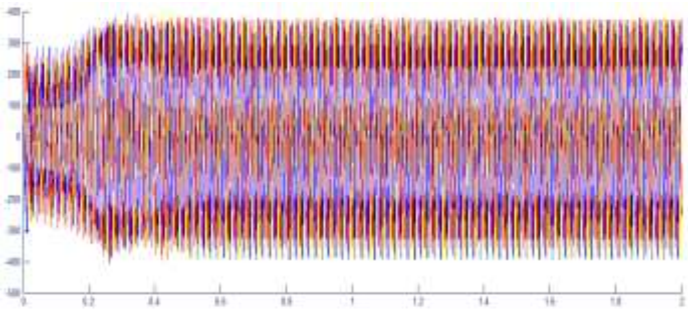

Fig. 9 AC voltage output after conversion

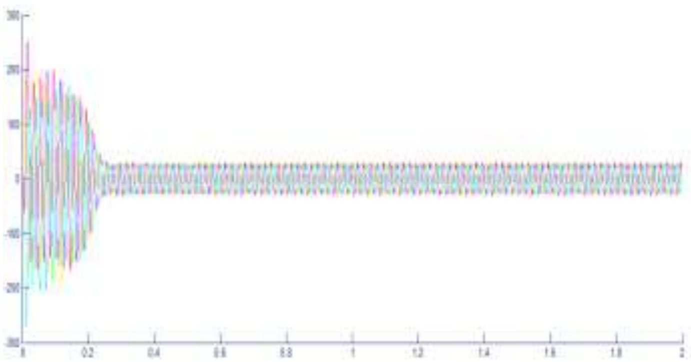

Fig. 10 AC current output after conversion

Generally for 5HP and 3 HP motors supply voltage and current should be 440V and 16A irrespectively. In here 8.5KW solar panel maintain about 400V and 15 A which is the comfortable supply for both motors in irrigation system of rural area Chhattisgarh.

Fig. 11 to Fig. 14 compares the different type of HP motor performance in photovoltaic operation for irrigation. Compare parameters has stator current, rotor current, rotor speed, torque etc.

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Stator Current

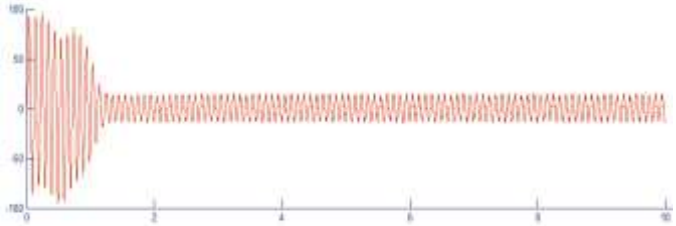

Fig 11 (a): Stator current of 3 HP motor

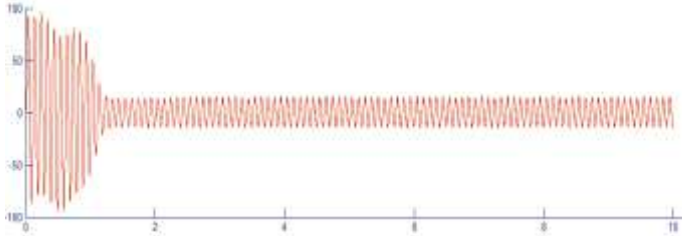

Fig 11 (b): Stator current of 5 HP motor

Rotor Current

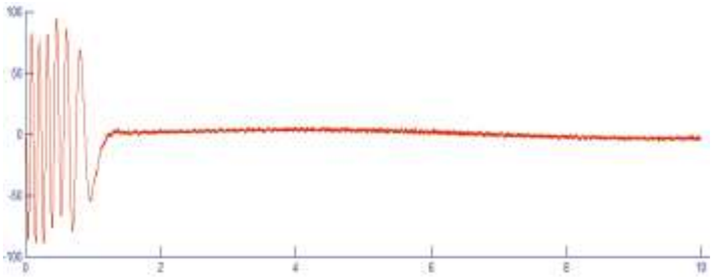

Fig 12 (a): Rotor current of 3 HP motor

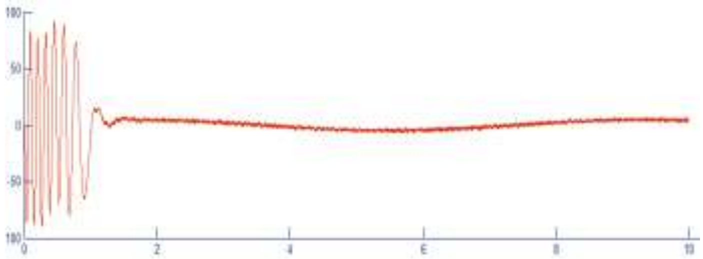

Fig 12 (b): Rotor current of 5 HP motor

Rotor Speed

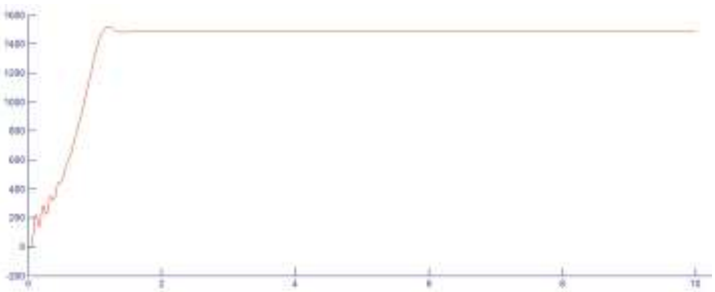

Fig 13 (a): Rotor speed of 3 HP motor

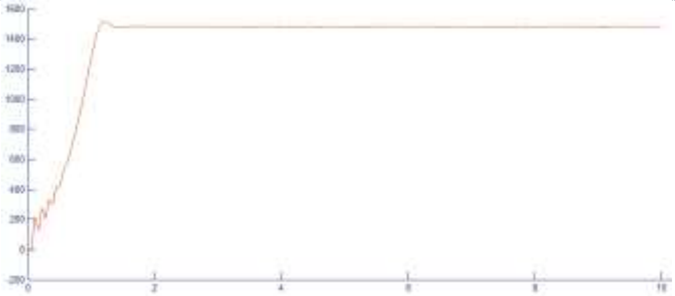

Fig 13 (b): Rotor speed of 5 HP motor

Torque

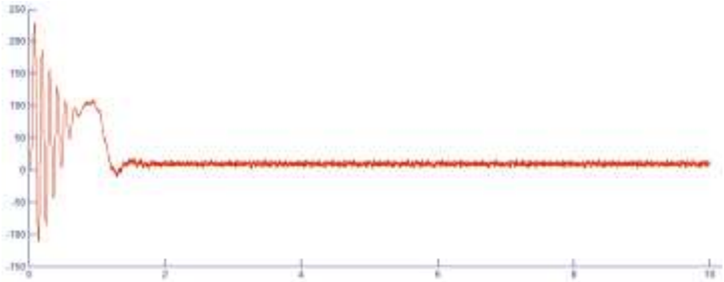

Fig 14 (a): Torque of 3 HP motor

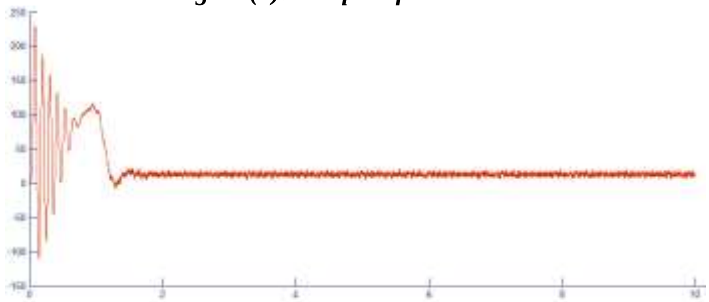

Fig 14 (b): Torque of 5 HP motor

Comparison table II between different HP induction motor as per characteristics above Fig 11 to Fig 14.

S. No.	Rating	I (stator)	I (rotor)	N (rpm)	T (N-m)	Irrigation output (per day)
1	3 HP	14A	4 A	1490	9.35	2 acre
2	5 HP	16 A	6 A	1480	12.95	3 acre

CONCLUSIONS

Photovoltaic systems are especially designed to supply water and irrigation in areas where there is no mains electricity supply. Their main advantages over hand pumps or internal combustion engine pumps are their practically zero maintenance, their long useful life, that they do not require fuel, that they do not contaminate, and finally that they are straightforward to install. Another important characteristic is that, as they use the sun as their energy source, the periods of maximum demand for water coincide with the periods of maximum solar radiation. When compared to diesel powered pumping systems, the cost of solar PV water pumping system without any subsidy works out to be 64.2% of the cost of the diesel pump, over a life cycle of ten years [9]. Solar pumps are available to pump from anywhere in the range of up to 200 m head and with outputs of up to 5 acre/day. 5 HP motor pump irrigate water about 3 acre/day and 3 HP motor pump irrigate water about 2 acre/day. The electrical characteristics represent with the help of simulation result which is shown in MATLAB program. In this paper we represent in form of comparison table II. A solar irrigation pump system methods needs to take account of the fact that demand for irrigation system water will vary throughout the year. Peak demand during the irrigation system seasons is often more than twice the average demand. This means that solar pumps for irrigation are under-utilized for most of the year. Attention should be paid to the system of irrigation water distribution and application to the crops. The irrigation pump system should minimize water losses, without imposing significant additional head on the irrigation pumping system and be of low cost [6].

REFERENCES

[1] A report on Solar PV Applications in India, published by Center for Study of Science, Technology and Policy (2006-07)
[2] Odeh, I, Yohanis, Y.G., and Norton, B. Economic viability of photovoltaic water pumping systems. Solar Energy 80 [2006], pp. 850-860,
[3] Kamel, K. and Dahl, C. The economics of hybrid power systems for sustainable desert agriculture in Egypt. Solar Energy [2005], pp. 1271-1281,
[4] Cuadros, F., Lopez-Rodriguez, F., Marcos, A. and Coello, J.A. procedure to size solar-powered irrigation [photoirrigation] schemes. Solar Energy 76 [2004], pp. 465-473,
[5] Foster, R.E., Gupta, V.P. and Sanchez-Juarez, A. Field Testing of CdTe PV Modules in Mexico. ASES Solar 2006: Renewable Energy: Key to Climate Recovery. Jul. 8-13, 2006, Denver, CO, 6pp..
[6] Daud, A.-K. and Mahmoud, M. M. Solar powered induction motor-driven water pump operating on a desert well, simulation and field tests. Renewable Energy 30 [2005] pp. 701-714,
[7] Clark, R.N. Photovoltaic water pumping for livestock in the Southern Plains. American Society of Agricultural Engineers Paper No. 94-4529, 1994.
[8] Vick, B.D. and Clark, R.N. Comparison of Solar Powered Water Pumping systems which use Diaphragm Pumps. ASES 2007: Sustainable Energy Puts America to Work. July 7-12, Cleveland, OH, 6 pp.
[9] Clark, R.N. and Vick, B.D., Performance Comparison of Tracking and Non-Tracking Solar Photovoltaic Water Pumping Systems, American Society of Agricultural Engineers. 1997, ASAE Paper No. 97-4003,
[10] Clark, R.N., Vick, B. D., and Ling, S., Remote water pumping using a 1 kilowatt solar-PV AC system, American Society of Agricultural Engineers Paper No. 98-4087, 1998, 12 pp.

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