PalArch's Journal of Archaeology of Egypt / Egyptology

Efficacy of Solar Powered Water Pumps for Rural Farmers in Odisha; India

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Nimay Chandra Giri, Debaraj Rana, Siba Prasad Mish, Bibhuti Bhushan Pani: Efficacy of Solar Powered Water Pumps for Rural Farmers in Odisha; India -- Palarch's Journal Of Archaeology Of Egypt/Egyptology 17(9). ISSN 1567-214x

Keywords: Sustainable Energy, Photovoltaic, Solar Water Pump, Water Supply, Irrigation.

ABSTRACT

The inadequate power supply and high fossil fuel costs worsened the general life, water supply and agriculture in rural areas of India. Pumps operated based upon solar energy as source can be appropriate alternative to electrical, and fossil fuel based irrigation pumps for water supply to farms. India has has around 22 million irrigation pumps, of which 43% are diesel engine operated and rest are electric operated. The photovoltaic (PV) technology adopted water pumping system; that uses solar energy to convert to electrical energy which can run on a DC/ AC motor in a hydraulic pump. The purpose of this study is to present different types of solar water pumping system, technology, environment aspects, efficient design, economic, and application in the rural and remote areas of Odisha. An action research has been adopted by Centurion University at Balasore, Koraput, Khordha to understand the concept and identify research gaps of solar power generators used for irrigation and community water supply systems. The payback period for the solar water pumping systems is about 4– 6 years. The recent Indian policy for adoption of reliable solar water pumping systems isalso discussed toidentify the potential research aerena..

1. Introduction

Renewable energy (RE) is fast growing the dominant space in India' s power sector, with innovative drifts and tasks are challenging for the related manufacturers and, policy architects. There is sudden swell and drip in generation of the wind and solar producers, and users replacing the fossil or coal power generators. On grid transmission technology to long distance transmission has been down scaled.

The growing energy crisis in the globe with surging demography and modernization has urged for SPV(solar photovoltaic) centered electricity produce can be one among possible solution which iscropping upprincipalsources among the non-conventional form of energy [1]. The SPV energy is a reliable technology for developing of smart agriculture system. India being a tropical country with 2/3rd of its population depends on agriculture and about 20% land is covered under irrigation system. The country has about 22 million irrigation pumps, of which 43% are diesel engine operated and 57% are electric operated.The use of solar pumps toliftwater minimally optimize the reliance on fossil fuel, hydrocarbon gases or coal grounded electricity. Grid based house supply Electric pumps are 2– 4 times are higher than a solar photovoltaic (PV) pump considering its life achievement. Solar pumps are eco friendly and involve small maintenance expenses without economic stress of fuel cost [1].

Considering the dearth of grid supplied electricity in villages and non-accessible areas throughout the globe. Solar pump is one among the most encouraging claims of solar energy applications. The novel technology is comparable to any conventional hydraulic pumps using sun as a source when the power supply source is sun. Various solar PV water pumps are gaining prominence in present days under scarcity of electricity and increase in fossil fuel prices. The flow rate of pumped water from a solar pump is reliant on incident solar irradiation and size of PV array. An appropriately designed PV solar system outcomes substantial long-term cost savings gadget when compared to conventional pumps. Overhead, underground or small water tanks can be used for storing water during day time and used for irrigation or water supply so that there is no requirement of storage batteries for storing electricity [2].

The state of Odisha is basically coastal, mountainous of hard rock, hills of Easter ghats belt, with irratic monsoon and uneven rainfall. Farmers in the area face difficulty for adequate supply of surface water for irrigation. The yield of the agrarian state is poor in comparison to other states of India. To ameliorate the irrigation system, the lift irrigation is gaining popularity to have water for agriculture during need of the crop cycle. Lift irrigation uses pumps to lift ground water. In the view of providing solutions to irrigation water scarcity of the farmers, solar powered water pumping system is the sustainable option.

The advantages of solar pumps are very less maintenance, less skilled labour, no fuel and pumps water when needed. The purpose of this study is to present different types of solar water pumping system, technology, environment aspects, efficient design, economic and application in the rural and remote areas of Odisha. The skilled university Centurion University of Technology and Management, Odisha took the initiative for efficient design and development of solar operated pumping system for the sustained demand of water for agriculture of the people and their livelihood. To promote, Odisha Government has lunched Soura Jalanidhi Scheme to provide around 5000 solar pumps to the farmers with 90% subsidy.

2. Area Of Study

Odisha is coastal states of India located alongits east coast adjacent to the Bay of Bengal, having GPS coordinates of 20° 56' 27.3120" N and 84° 48' 12.4812" E. The total population of the state is about 420 lakhs people (2011 census). This study was undertaken for some of the agriculture based districts of Odisha i.e. Balasore, and Kundera blockKoraput district. As per the 2011 census data, these districts had total population is about 60 lakhs of the Odisha. The people of Jeypur, and Kundera blocks (≈98%)in Odisha, widely used electrically operated pumps and irrigation use for their farm. The farmers are encountering the problem of water for irrigating their crop fields in time (1-3). To mitigate the issue,pump mounted over a bi-cycles are used which can lift water and solar operated. The irrigation pumps are designed and fabricated to support the farmers for lifting water for irrigation. In hilly areas of Koraput district. This system employs PENTAIR DC functioned submersible pumps of capacity 0.5 HP, operating under maximum head up to 70m, discharging 310 Lit/ hour. The system have dual solar panels of 175 W capacity yielding ≈4.1A current. The systemscan be used in open dug wells, provided with an overhead tank to store water during day or when needed. The solar panels attached to the carrier or a fixed stand on the bicycle were employed for easy mobility from place to place or from one farmer' s field to another. This system is basically used for watering a small area of agricultural field or land used for farms or horticulture units to grow vegetables and flowers (4).

3. Methodology

A solar photo voltaic based water pump is an assembly of PV module/arrays, DC/AC motor pump -set, charge controller, connecting cables and ancillary electrical apparatuses , (Fig 1). The PV module/array is mounted on a suitable pedestal/structure with provision of manual or automatic tracking. Basically, solar pumps available in the market are either surface mounted or submersible or floating type. Water is pumped during day and stored in the tanks/ reservoir, for use during day or night time when

required. The water tank acts as storage reservoir and generally battery is not required for such units for storage except sun as source and Solar Photo Voltaic (SPV) arrangements for producing electricity. However, for specific purposes the electricity can be stored in batteries for use during emergency. The considerations are that all the mechanisms should match with national/international standards for use.

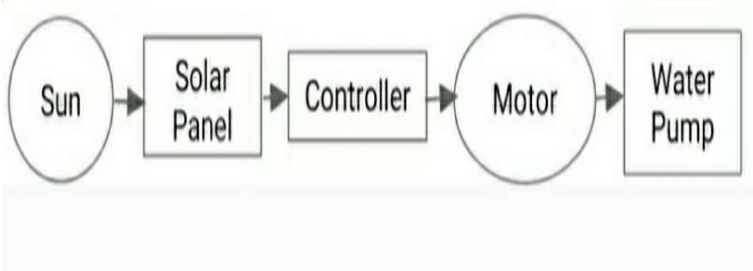

Figure 1. *Continuity block diagram of solar PV water pump from sun ray to pumping unit*

A. Methodology

Solar water pumping is based on PV technology that converts solar energy into electrical energy to pump water. The PV panels are fed to a motor (DC or AC) which converts electrical energy into mechanical energy then hydraulic energy. The controller is used to control the flow of current in the system.

B. Working Principle

The different types of current (DC or AC) configurations solar water pumping systems being used by people. These pumps utilizes solar PV system as power input and with or without batteries.

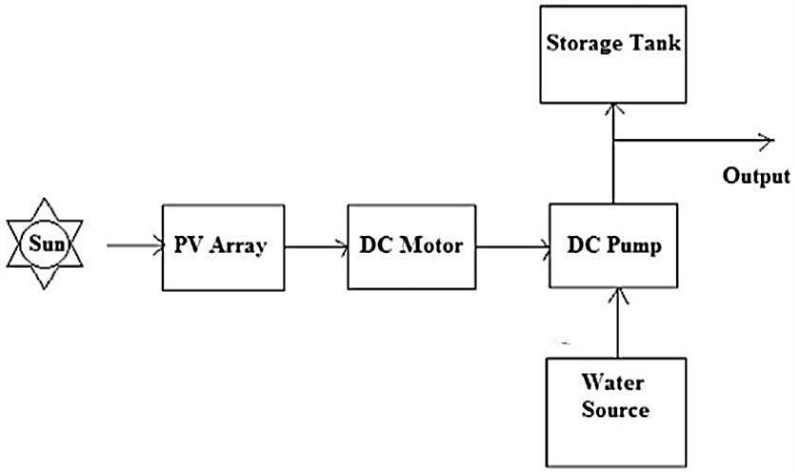

Figure 2.*The continuity diagram of various blocks of a SPV DC water pump (Type II)*

The motor used DC signal (off-grid) to pick up the water from soil, thus there is no need for inverter or battery.The motor used AC signal to pick up the water from soil, thus there is a need for inverter.

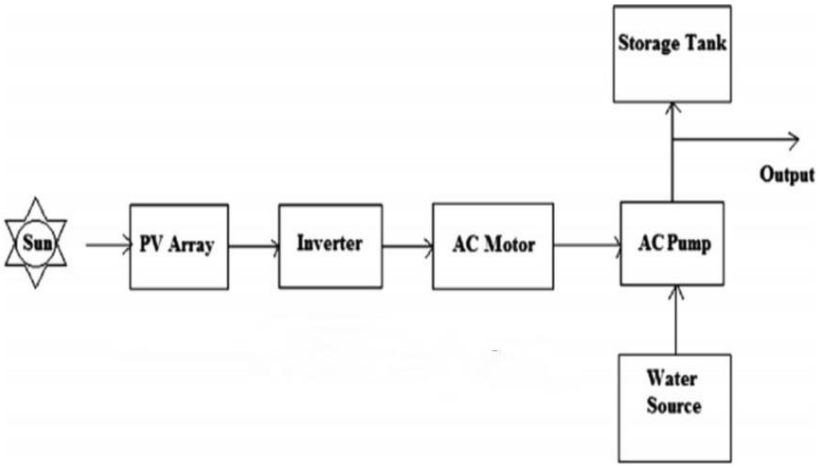

Figure 3. *The continuity diagram of various blocks of a SPV AC water pumping system (Type II)*

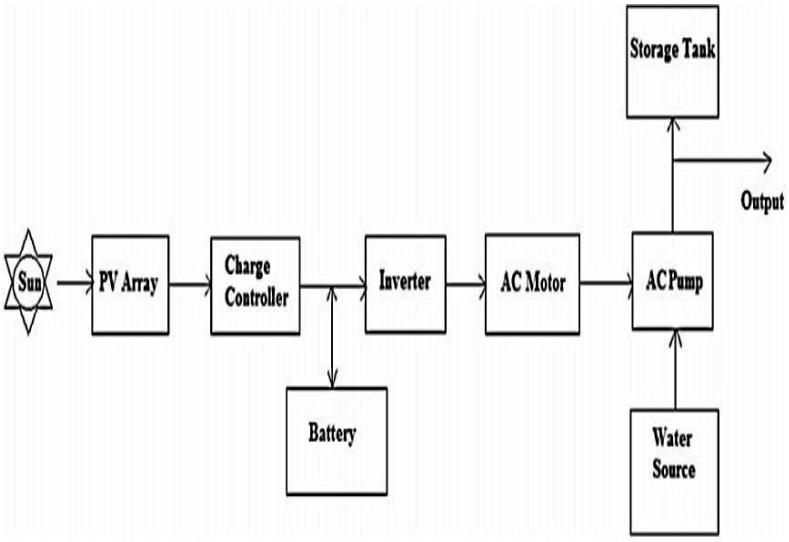

Figure 4. *The continuity diagram of various blocks a battery operated SPV water pump (Type III)*

Four types of solar operated hydraulic pumps that can be used in the field and their block diagrams are Fig 2, Fig 3 and fig4. The motor is often battery operated to pick up the water from soil, thus either charge controller or inverter will be used to control the operation25" .

C. Advantages

- Easy to install
- Can be portable

- Lower electricity bills
- Low upfront cost
- Less payback period
- Brings economic stability
- Cost of Energy to the farmer is nil
- Cost of Energy to the Society is nil
- Carbon foot print is nil

D. Applications

The installed solar DC irrigation system (0.5 HP) at Koraput district and 1 HP at Balasore district is illustrated in the figure 5 & 6 respectively.

Figure 5. *Cycle mounted solar PV irrigation system*

Figure 6. *Ground mounted solar PV irrigation system*

The installed solar AC water pumping system (1 HP) at Centurion University campus is illustrated in the figure 7.

Figure 7. *Solar powered AC water pumping system*

4. Result And Discussion

Various solar water pumping system and their design has been done by inspecting the sites of installation after collection of respective empirical data. The type of solar pumps required considering the site conditions and topography. Suitable SPV water pumping systems have been recommended because of divergent site condition and since last two decades versatile and so also attractive advanced solar pumps are available as per suitability.

It is observed that in many areas across India; farmers are using on-grid pump, where surplus power is fed to the grid and an additional income can be made by the multi users farm owners. The pumps also can be installed by large farmers or community based. The pumps of higher capacity can be installed for multiple uses like lifting, lighting, cooking and water supply in large farms. This will help to develop local entrepreneurshipand generate employment opportunities to the skilled workers in the line Mishra and Giri et al., 2020 [13]

The DC solar pumps without solar battery are still of low cost, simple and reliable for small irrigation than AC, hybrid and on-grid types.SPV water pumping can be economically usable for water needs of rural communities.

The performance of solar water pumping system depends on;

- Solar radiation availability at the location
- Environment condition
- Size of the system
- Total Dynamic Head (TDH)
- Total quantity of water requirement; and Hydraulic energy: potential energy required in raising the water to discharge level
- Stefan Boltzmann law

The apparatus used in the above projects for one, 2 HP pumps are given in Table 1 and Table 2

TABLE 1. *APPARATUS OF A 1 HP SOLAR WATER PUMP*

Item	Specification	Qnty
Solar Pump (DC)	1 HP	1
Solar Panel	1 kW	1
Controller	12V 10 A	1
Pump Head	30-45 meter	1
Output Voltage	30-80 V	1
Input power	1000 Watt	1
Discharge	6200 – 38400 Liters/day	
Warranty	3-5 years for complete system and 25 years for solar panel	
Price	Rs. 8,00,00	

TABLE 2. *APPARATUS OF A 2 HP SOLAR WATER PUMP*

Item	Specification	Qnty
Solar Pump (DC)	2 HP	1
Solar Panel	2 kW	1
Controller	12V 10 A	1
Pump Head	50-86 meter	1
Output Voltage	30-85 V	1
Input power	2000 Watt	1
Discharge	12,000 – 40,000 Liters/day	
Warranty	3-5 years for complete system and 25 years for solar panel	

Price	Rs. 14,00,00	

5. Conclusion

You The present study focuses on different types of solar water pumping system, technology, performance, efficient design, economic and environmental aspects. Based on the study main conclusions are as follows:

- Solar PV water pumping technology is reliable and economically viable for irrigation and community supply.
- SPV water pumping is an alternative option to electric and diesel water pumps.
- Solar DC water pumps are easy to install with less cost than AC and hybrid types.
- As installation cost of on-grid solar water pumps are very high, so more subsidy is required to the farmers by government to make the technology more attractive.
- Performance of the system can be improved by the use of highly efficient solar modules or efficient bifacial modules and more efficient design are areas for further research for lowering the cost, improving the performance and enhancing pumping system life time.

Thus, suitable solar PV water pumping is a crucial for drinking and irrigation applications in rural, urban and remote areas of both developing and developed countries of the World.

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