

Solar Powered Water Pumping System for Agriculture

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ABSTRACT: Agricultural technology is changing rapidly. Farm machinery, farm building and production facilities are constantly being improved. Agricultural applications suitable for photovoltaic (PV) solutions are numerous. These applications are a mix of individual installations and systems installed by utility companies when they have found that a PV solution is the best solution for remote agricultural need such as water pumping for crops or livestock. A solar powered water pumping system is made up of two basic components. These are PV panels and pumps. The smallest element of a PV panel is the solar cell. Each solar cell has two or more specially prepared layers of semiconductor material that produce direct current (DC) electricity when exposed to light. This DC current is collected by the wiring in the panel. It is then supplied either to a DC pump, which in turn pumps water whenever the sun shines, or stored in batteries for later use by the pump. The aim of this project is to explain and apply how solar powered water pumping system works and what the differences with the other energy sources are.

Solar water pumping system operate on direct current. The output of solar power system varies throughout the day and with changes in weather conditions. Photovoltaic module, the power source for solar pumping, have no moving parts, requires no maintenance and last for decades. A properly designed solar pumping system will be efficient, simple and reliable. Solar powered pumping systems are used principally for three applications town and city water supply, livestock watering and irrigation.

KEYWORDS: Off grid, Photovoltaic (PV), DC pump.

I. INTRODUCTION

A solar powered pumping 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. There are several technology alternatives for supplying power or lift to groundwater systems including wind turbines, windmills, generators, solar arrays, and hand powered pumps. The main driving factors for selecting the appropriate technology are regional feasibility, water demand, system efficiencies, and initial and long-term costs. Other factors often include the need for power and water reserves in the form of batteries and storage tanks. Solar-powered systems are often considered for use in developing countries instead of other forms of alternative energy because they are durable and exhibit long-term economic benefits.

Solar powered water pumping has been recognized as suitable solution for grid-isolated rural locations in poor countries where there are high levels of solar radiation. Solar powered water pumping systems can provide drinking water without the need for any kind of fuel or the extensive maintenance required by diesel pumps. SPPS is also not adequate for large-scale irrigation, but can work for small-scale drip irrigation systems. A largescale SPPS can be considered one that serves over 240 peoples. Photovoltaic (PV) solar panels are often used for agricultural operations, especially in remote areas or where the use of an alternative energy source is desired. In particular, they have been

demonstrated time and time again to reliably produce sufficient electricity directly from solar radiation to power livestock and irrigation watering systems.

Solar water pumps may be especially useful in small scale or community based irrigation, as large scale irrigation requires large volumes of water that in turn require a large solar PV array. As the water may only be required during some parts of the year, a large PV array would provide excess energy that is not necessarily required, thus making the system inefficient. Solar PV water pumping systems are used for irrigation and drinking water India.

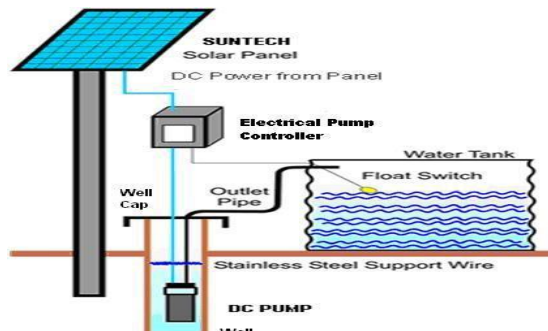


Fig. 1.Schematic diagram of water pumping system

II. OBJECTIVES

- To make a solar powered pumping system which is economical.
- To solve problem related to agricultural irrigation at minimum cost.
- To design the off grid system.
- To study the performance of solar pump at different condition.

III. PROBLEM STATEMENT AND REQUIREMENT

During searching of project idea we got a challenge from one of the society member. He wants daily water supply for his farm of cashews and mango trees but he didn't have electricity supply to that particular farm area. By understanding the concept we started the research to find out better solution. Finally with the help of project guide we decide to work with solar pumping water system .

Also his criteria was low cost for this project and daily 2000-3000 lit/day water supply without his actual presence on the farm location. So we decided to make a system fully automatic with timer control so it will start and stop automatically without manual control.

REQUIREMENTS

1. Daily water requirement of 2000-3000 lit water per day.
2. System should work automatically.
3. Cost of the project should be in the range of Rs 20000 to 25000.
4. Less maintenance.

IV. OFF GRID POWER SYSTEM DESIGN

1. Case 1

□ Total Load

1) Pump = 800 Watt

2) Fan = 60 Watt

3) CFL = 20 Watt

□ Total consumption /deg

$$= (800 \times 2) + (60 \times 4) + (20 \times 4)$$

$$= 1600 + 240 + 80$$

$$= 1920 \text{ Watt hour/day}$$



Let reserve power for 1 day only

Now DC load considering loss of inverter
Assuming 90% efficiency
 $=1920/0.9 = 2133.33$ Watt hour /day

Battery capacity (AH) Amp hour
 $= \text{no. of days for reserve power} \times \text{daily load} / \text{Nominal voltage} \times \text{maximum \% allowed discharge}$
 $= 1 \times 2133.33 / 12 \times 0.80$
 $= 222.22$
 $= 250$ AH

Inverter capacity
Total wattage of appliance
 $= 800 + 60 + 20$
 $= 880$ W

We have to go for 1 KW capacity inverter

Panel calculation

Assuming avg hours for full capacity solar power $= 4$ hours/day
DC load demand $= \text{AC load} / \text{Inverter efficiency} \times \text{system voltage}$
 $1920 / 0.8 \times 12$
 $= 200$ Amp hours

Module output errors $= \text{no of hours} \times \text{current by same module}$
 $= 4 \times 7$

$= 28$ Amp hour
No. of module in parallel $= 200 / 28$
 $= 7.1428$
 $= 8$ panels

No of string in series $= \text{system voltage} / \text{module voltage}$
 $= 12 / 12$
 $= 1$

Total power needed $= 2133.33$ Watt hr $= 2200$ Watthr

Now if I want to run appliance while charging battery .then I need some extra power

Assuming 4 hrs work while charging
 $= 880 \times 4 + 2200$
 $= 3520 + 2200$
 $= 5720$ Watt hr

Each panel capacity $= 5720 / 8 \times 4$
 $= 178.75$ Watt

We require set of 8 panels of 180 to 200 Watt 12 volt capacity

Monocrystalline is efficiency but cost about 45 to 50 /Watt

We go polycrystalline panels

But in poly availavle wattage are 100,150,260,270,315

We go for 8×200 watt 12 volt monocrystalline

• Charge controller

PWM

Pulses direct connection
from solar to battery
-voltage parallel to battery
voltage
-Lesser cost

MPPT

Converts voltage to
battery voltage
-Expensive

Each solar panel hr

$V_{oc} = 22$ V



Vmp=17 V
 i=8.68 Amp
 module
 $8 \times 8368 \times 1.25 = 86.8 = 90$ Amp PWM charge control

<input type="checkbox"/> Inverter	
Modified sine wave	pure sine wave
Simplest cheapest	complex costly
But suitable for our Application	

As per practice two time greater capable inverter should be selected
 $880 \times 2 = 1760$ watts
 =1500 watts

Option 1

Table 1

Cost component	Cost/unit	No. of units	Total cost
Battery 120AH 12volt	8700/-	2	17400/-
Panels[mono] 200w;12volt	10000	8	80000/-
Inverter 1100va solar 12v	6000	1	6000/-
1HP sub pump. With controller	10000/-	1	10000/-
Wire and other electric essential			5000/-
Stand for panels			6000/-
others			4000/-
total			1,28,000/-

But it was rejected due to high cost

Option 2

Table 2

DC solar pump of 1 HP capacity	
1hp dc pump	12000/- approx..
Solar panels (poly)(300 W,12)*4 =1200 watt	40000/- approx...
wiring	2000/-
Charge controller	2000/-
Piping	3000/-
Base	2000/-
total	79000/-

But it was also rejected due to high cost

Option 3

Table 3

China mode DC pump 180 watt 12 volt dc 13 Amp current	6000/-
Solar panels (150 w,12 v)*2	12000/-
Charge controller	2000/-
wire	2000/-
Pipe	2000/-
total	24000/-

Accepted and implemented

MATERIAL SELECTION:

1. **The Source:** Water sources can be deep drilled wells, streams, springs, ponds, rivers, etc. The main variables, in addition to initial cost, that factor into system design are the recharge rate of the source and the volume of the source reservoir. Ideally, the source should recharge faster than pump can take water out of it. For example, if the pump will produce three gallons per minute, the source should be able to recharge at a rate that is equal to or greater than three gallons per minute. If the pump takes water away faster than the source can recharge, the reservoir can run dry, the pump will then be run dry, and that should be avoided to prevent damage to the pump

2. **The pump:** This is the heart and soul of the solar water pumping system. Pumps fall along a spectrum of high-flow/low-head to low-flow/high-head. In other words, for a given power input, the pump produces a unique combination of flow and pressure. When selecting a pump you are basically selecting that combination of performance characteristics. Solar pumps are rated according to the voltage of electricity that should be supplied. A 12 volt pump is a small one, 24 volt is more the norm, while 48 volts and upwards will require more power and might pump more water. Smaller wire sizes can be used in higher voltage systems without sacrificing power output from panels to pump. Some pumps require certain accessories to function optimally. These include filters, float valves, switches, etc.



Fig. 2.Pump

3. **Photovoltaic (PV) panels:** The photovoltaic panels make up most (up to 80%) of the systems cost. The size of the PV-system is directly dependent on the size of the pump, the amount of water that is required (m^3/d) and the solar irradiance available. A panel is rated in watts of power it can produce. The SPV water pumping system should be operated with a PV array capacity in the range of 200 Watts peak to 5000 Watts peak, measured under Standard Test Conditions (STC). Sufficient number of modules in series and parallel could be used to obtain the required PV array power output. The power output of individual PV modules used in the PV array, under STC, should be a minimum of 74 Watts peak, with adequate provision for measurement tolerances. Use of PV modules with higher power output is preferred. Indigenously produced PV module(s) containing mono/ multi crystalline silicon solar cell



Fig.3.Photovoltaic panel

4. **Mounting structures :** The PV modules will be mounted on metallic structures of adequate strength and appropriate design, which can withstand load of modules and high wind velocities up to 150 km per hour. The support structure used in the pumping system will be hot dip galvanized iron (G.I). The G.I. structures for mounting the Solar panels could be so designed, that these can be manually/ auto adjusted for optimal tilt throughout the year



Fig.4.Mounting structure

5. **Controller and Inverter:** The purpose of the controller is twofold. Firstly, it matches the output power that the pump receives with the input power available from the solar panels. Secondly, a controller usually provides a low voltage protection, whereby the system is switched off, if the voltage is too low or too high for the operating voltage range of the pump. This increases the lifetime of the pump thus reducing the need for maintenance. It changes the direct current from the solar panels into alternating current for the pump. The supported power range of inverters extends from 0.15 to 55 kW and can be used for larger irrigation systems. However, the panel and inverters must be sized accordingly to accommodate the inrush characteristic of an AC motor.

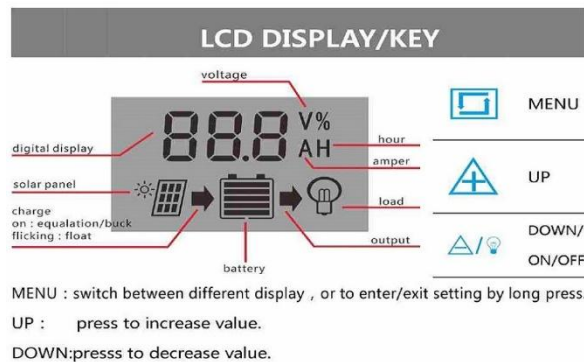


Fig.5.Controller

V. RESULTS AND DISCUSSIONS

VOLTAGE AND CURRENT CHART FOR ONE DAY/HOUR

DAY	TIME	VOLTAGE	CURRENT
DAY 1	8:00 AM	19.5 V	9 Amp
	9:00 AM	19.47 V	11.45 Amp
	10:00 AM	21 V	12 Amp
	11:00 AM	25 V	12.7 Amp
	12:00 AM	26.5V	13.2 Amp
	1:00 PM	30 V	14.1 Amp
DAY 2	1:00 PM	30 V	14.1 Amp
	2:00 PM	31 V	14.9 Amp
	3:00 PM	29 V	13.2 Amp
	4:00 PM	26V	12.1 Amp
	5:00 PM	21V	11.9 Amp

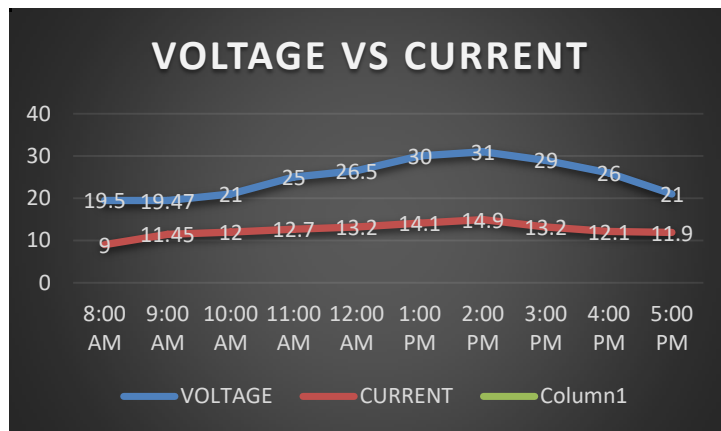


Fig.6. Voltage vs Current graph

The system work very well as per the requirement and supplies required amount of water on the daily basis automatically.

Since the increase in price per increase in unit power output of a photovoltaic system is greater than that for a diesel, gasoline, or electric system, photovoltaic power is more cost competitive when the irrigation system with which it operates has a low total dynamic head. For this reason, photovoltaic power is more cost-competitive when used to power a micro irrigation system as compared to an overhead sprinkler system. Photovoltaic power for irrigation is cost-competitive with traditional energy sources for small, remote applications, if the total system design and utilisation timing is carefully considered and organised to use the solar energy as efficiently as possible. In the future, when the prices of fossil fuels rise and the economic advantages of mass production reduce the peak watt cost of the photovoltaic cell, photovoltaic power will become more cost-competitive and more common

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