

Review of Solar PV Array Fed Motor Drive-Based Water Pumping System

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Abstract— Solar energy such as photovoltaic is the most promising energy of the non-conventional energy sources which is capable to satisfy the energy needs of the isolated rural areas. Solar photovoltaic-powered water pumping systems are becoming very successful in regions where there is no opportunity for connecting the electric grid. This paper presents the discussion of various research works on photovoltaic based water pumping system, scope and limitations. Components and functioning of PV solar pumping system are also described.

Keywords— Water Pumping System, Photovoltaic, Solar, Sustainable Solution, Irrigation Technology.

I. INTRODUCTION

The photovoltaic technology converts solar energy into electrical energy for operating direct current (DC) or alternating current (AC) motor-based water pump. Irrigation is a well established procedure on many farms and is practiced on various levels around the world. It allows diversification of crops, while increasing crop yields. However, typical irrigation systems consume a great amount of conventional energy through the use of electric motors and generators powered by fuel. Photovoltaic water pumping system is one of the best alternative methods for irrigation. The variation of spatial and temporal distribution of available water for irrigation makes significant demand on water conservation techniques. Hence solar powered Automated Irrigation System provides a sustainable solution to enhance water use efficiency in the agricultural fields using renewable energy system removes workmanship that is needed for flooding irrigation. Environmental pollution is prevented with renewable energy and energy production from local resources is encouraged. The use of this photo-irrigation system will be able to contribute to the socio-economic development. It is the proposed solution for the present energy crisis for the Indian farmers. This system conserves electricity by reducing the usage of grid power and conserves water by reducing water losses. Proposed system is easy to implement and environment friendly solution for irrigating fields.

The system was found to be successful when implemented for bore holes as they pump over the whole day. Solar pumps also offer clean solutions with no danger of borehole contamination. The system requires minimal maintenance and attention as they are self-starting. 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 generation is an efficient approach for using the solar energy. Solar panels (an array of photovoltaic cells) are now a day extensively used for running street lights, for powering water.

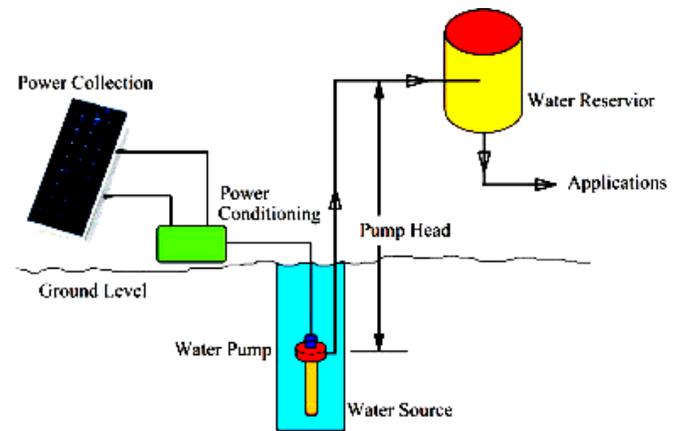


Figure 1: Solar power water pumping system

heaters and to meet domestic loads. The cost of solar panels has been constantly decreasing which encourages its usage in various sectors. 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 India. Nowadays, as the increasing shortage of water resources, promote water saving irrigation technology and has become the inevitable choice to fill the water crisis. 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:

- Hand pumps
- Direct drive diesel driven borehole pumps
- Electric submersible pumps with diesel generator
- Solar submersible pumps

II. BACKGROUND

A. Varshney et al.,[1] gives evaluated water release over the course of the day regardless of progress in climatic circumstances and feeds the excess power to the three-stage utility matrix. In addition, during shortcoming in any of the sources, the exhibition of the water pump stays unaffected. A high effectiveness RSM drive without position/speed sensor is used here to drive the water pump. A savvy power sharing idea, between the PV exhibit and the matrix, is utilized here, in which, programmed exchanging among all working modes occurs as per the accessibility of the PV cluster power and the framework supply. Additionally, the inclination is given to the PV exhibit power over the matrix supply due to its accessibility at no expense.

I. Akhtar et al.,[2] The energy usage of various electrical machines in activity and their working boundaries like temperature, mugginess, proficiency and energy utilization and so on are thought about for the examination. The target of this work is to involve a fluffy rationale regulator for the energy utilization decrease examination in Kasganj city of Uttar Pradesh state in India, by utilizing the use hours of the sun based powered framework and the expected burden request involving the ideal opportunity for which the various machines are in activity. This examination has been begun with the overview of various structures to get the data on present energy use. The energy review introduced in this work just packed in the 5 structures in the Kasganj to take the genuine circumstances. Though, the fluffy regulator can set a limit of power from lattice and sunlight based energy framework that couldn't be surpassed as well as controlling the functioning long stretches of various machines, if not it will influence the energy viability of the savvy structures.

A. A. Stonier et al.,[3] presents the plan and execution of Secluded Staggered Inverter (MMI) to control the Enlistment Engine (IM) drive utilizing savvy strategies towards marine water pumping applications. The proposed inverter is of eleven levels and can handle the speed of an IM drive which is taken care of from sun based photovoltaics. It is assessed that the energy consumed by pumping plans in a locally available boat is almost half of the absolute energy.

Taking into account this reality, this work researches and approves the proposed control plan with diminished intricacy expected for marine water pumping framework utilizing an enlistment engine (IM) drive and MMI. The investigation of inverter is completed with Relative Essential (PI) and Fluffy Rationale (FL) based regulators for working on the presentation.

M. Kashif et al.,[4] In this work, a converse saliency (RS) talked type super durable magnet (PM) simultaneous engine (PMSM) other than its half and half versatile score channel (HANF) based self-detecting for driving a sun powered photovoltaic water pump framework (WPS) is introduced. The regular spoke-PMSM driven WPS encounters two kinds of issues. The engine, first and foremost, is worked with a transition debilitating current to deliver positive hesitance force, in this way expanding the PM demagnetization risk. Besides, an encoder is utilized to detect the rotor point, which thus influences the expense and unwavering quality. To tackle the main issue, the RS-PMSM is introduced, which works with a transition heightening current to create positive hesitance force. While second issue is settled by utilizing the HANF based rotor point assessment. Albeit traditional techniques give a gauge of rotor point, they don't wipe out both the DC-offset and predominant music..

S. Angadi et al.,[5] research towards AC engine based Water Pumping Frameworks (WPS) has gotten an extraordinary accentuation inferable from its various benefits. Further, taking into account the huge acknowledgment of sustainable sources, particularly sun based and wind, this work gives a nitty gritty survey of single-stage and multi-stage WPS comprising of inexhaustible source powered AC engines. The basic audit is performed in light of the accompanying figure of benefits, including the sort of engine, power hardware interface and related control procedures. Likewise, to add to the dependability of sun based PV WPS, crossover Wind-PV WPS will be examined exhaustively.

H. Rezk et al.,[6] give definite plausibility, a techno-financial assessment, and energy the executives of independent crossover photovoltaic-diesel-battery (PV/DG/B) framework. The proposed framework can be applied to supply a particular burden that is far away from the utility lattice (UG) association, and it is situated in Minya city, Egypt, as a genuine contextual investigation. The day to day required desalinated water is 250 m³. The all out harsh water requests are 350-500 m³ and 250-300 m³ of water in summer and winter seasons, separately.

Two unique sizes of opposite assimilation (RO) units; RO-250 and RO-500, two energy control dispatch procedures; load following (LF) and cycle charging (CC); two sizes of DG; 5 kW and 10 kW are viewed as for the situation study. The expense of energy, inexhaustible division, ecological effect, and breakeven framework augmentation distance are the fundamental rules that have been considered to decide the ideal size of PV/DG/B to supply the heap interest. HOMER ® programming is utilized to play out the recreation and advancement. For this contextual investigation, the base expense of energy and the base all out present expense are 0.074/kWh and 207676, individually.

R. Rai et al.,[7] centers around a proficient and hearty speed sensorless control for a sun based water pumping framework comprising of sun powered photovoltaic (PV) cluster took care of sub enlistment engine drive (SIMD). The speed assessment and sensorless control of SIMD are very exhausting assignments. Also, the engine boundary varieties lead to decay sensorless control. Thusly, a sensorless control of sub enlistment engine (SIM) requires precise and strong stator current control. The sliding mode based dc interface voltage controller is embraced for managing the engine power and the speed for single stage sun oriented PV geography.

S. Shukla et al.,[8] manages a photovoltaic-network coordinated framework working an enlistment engine (IM) coupled to a water pump. A straightforward dc-interface voltage guideline approach is taken on for the power move. This framework is used to essentially take care of the acceptance engine driven water pump and while water pumping isn't wanted, the power is conveyed to the utility. This framework requires two current sensors and two voltage sensors altogether for detecting and assessment reason. Acceptance engine stage currents are assessed from dc-interface current by adjusted space vector tweak (SVM) strategy.

S. Murshid et al.,[9] presents a solitary stage independent sun powered photovoltaic (SPV) exhibit took care of water pumping framework utilizing a long-lasting magnet simultaneous engine (PMSM). The crucial commitment of this work incorporates: 1) improvement of the clever changed vector control, which further develops the force reaction of the framework, 2) improvement of an original single stage variable advance size gradual conductance strategy, which gives a quick greatest power point following and kills the need of middle stage dc converter, and 3) presentation of SPV power feed-forward term, which speeds up the general reaction of the framework under unique circumstances.

This framework incorporates a SPV exhibit, a three-stage voltage source inverter (VSI), a PMSM and a pump.

K. Khan et al.,[10] a prescient current regulator (PCC) is planned and executed to control a voltage-source inverter of the proposed framework involving the single-stage geography of sun based photovoltaic (PV) cluster took care of a superior planned partial kilowatt enlistment engine drive (IMD) coupled to a water pump. The currents, in a coordinated reference outline, are taken care of as contributions to the PCC in the wake of changing it to $(\alpha-\beta)$ fixed outline. The IMD is taken care of from PV cluster, which works at a most extreme power point (MPP) utilizing a pinnacle power following irritate and notice conspire. The PCC is executed for this framework to accomplish better control of engine speed, quick powerful reaction, inborn decoupling between current parts, and improvement in force elements. The improved plan of an acceptance engine is examined utilizing the joined methodology of the plan of trial and semi Newton calculation for effectiveness expansion, minimization of beginning current, and boost of beginning force. At first, an examination of the acceptance engine is performed with the traditional way to deal with configuration machine and this strategy is checked by a clarification on the contemporary plan utilizing RMXprt and plan advancement method.

A. Varshney et al.,[11] a versatile d - pivot current control of a hesitance coordinated engine (RSyM) drive for a photovoltaic (PV) water pumping framework has been introduced, which consolidates effects of the cross immersion in realtime to remunerate the blunders in the speed assessment. The reaction of the RSyM drive is enhanced by versatile d - hub current assessment. A continuous evaluation of the d - hub inductance is completed to incorporate the cross charge into thought for working on the proficiency of the engine. The d - hub current is shifted for least worth to give the most extreme result force. Here, a two-stage sun based energy change framework is utilized to drive the outward pump coupled to a RSyM drive. A lift converter is utilized to streamline the PV power utilizing a steady conductance based most extreme power point following method. The lift converter supplies power to a dc-ac, a protected door bipolar semiconductor based inverter through a capacitor associated across the dc interface.

S. Rahman et al.,[12] presents the plan and execution of sun oriented powered V/f controlled single-stage capacitor-turn over acceptance engine. Staggered semi impedance source inverter controls the power moving from the photovoltaic (PV) exhibit to a solitary stage enlistment engine.



In sunlight based powered drive frameworks, the primary concern is steady expected activity of drive when exposed to varieties in power age of the PV cluster. For same ecological circumstances, the PV power extraction is different at various forces for consistent speed application. Because of this, the extraction of most extreme power with a MPPT calculation isn't accomplished with just engine load. To address this worry, idea of the battery stockpiling framework is presented in the framework that aides in accomplishing greatest power when the PV power age capacity surpasses evaluated engine input power. What's more, battery capacity framework can supply power to the heap when the PV power age is not exactly the appraised engine input power.

III. PHOTOVOLTAIC SYSTEM COMPONENTS

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. 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".

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

- Rural and urban households for domestic purposes like lighting.
- Communities, small industries and institutions like schools, for lighting as well as for powering television sets, computers, etc.
- Water pumping systems.
- Telecommunications, as these systems are often installed in isolated places with no other access to power.
- Health center vaccine refrigeration in rural areas. Such solar refrigerators are also utilized to store blood plasma. WHO supports programmers that install solar power for medical purposes.

System Components

The whole system of solar pumping includes the panels, support structure with tracking mechanism, electronic parts for regulation, cables, pipes and the pump itself.

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. 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. Earthing Kit

Earthing 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.

IV. CONCLUSION

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.



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