

# Review on Solar PV based Drives for Water Pumping Application

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**Abstract:** *In remote and hilly areas water pumping for domestic usage can induce heavy cost due to high cost of power transmission to those areas. In recent years, photovoltaic (PV) power systems have been gaining importance in catering to the energy needs of villages and small towns for domestic purposes. Using diesel pump to deliver water for the agricultural needs causes problems both in terms of profitability and environmental perspectives. Higher price of diesel increases the operation costs of diesel water pumping system thereby reducing the incomes of farmers. The utilization of solar photo voltaic (SPV) energy is progressive at these areas. In this article we reviewed various works / studies involved in Solar PV based water pumping application.*

**Keywords:** Solar PV, Electrical drive, Solar water pump, Solar energy

## 1. Introduction

Despite the focus on industrialization, agriculture remains the dominant sector of the Indian economy, both in terms of contribution to the gross domestic product (GDP) as well as the source of employment for millions across the country. Over 70% of the rural households depend on agriculture as their principal means of livelihood. Renewable energy sources are beginning to play more of a role in urban areas such as building integrated photovoltaics, as well as in rural areas where wind, solar, biomass, and geothermal are gaining in popularity. When it comes to replacing the mass energy production of fossil fuels, renewable energy has not yet proven to be practical.

However, renewable energy sources do excel in local applications where there is limited or no access to an electricity grid, or where access to conventional energy is prohibitively expensive. They are most efficient in local applications because the energy production is at the same location as the end-use, hence minimizing the need for energy storage and transport. Of the energy consumers within agriculture, the timing of irrigation requirements conveniently coincides with an increase in insolation/intensity of solar radiation, creating great potential for the union of irrigation and solar energy, specifically photovoltaic systems.

A solar photovoltaic (SPV) powered PMSM drive for water pumping is presented in this study. In comparison with an induction motor, the PMSM have a high-power density, high efficiency, high torque/inertia ratio and unity power factor. The efficiency of an induction motor drastically diminishes under light loading as the excitation losses dominate. Thus, it causes reduced volume of water delivery under bad weather condition as compared with a PMSM, wherein no excitation loss takes place owing to its permanent magnet excitation. A high efficiency PMSM motor substantially reduces the size of SPV array and hence its installation cost.

The maximum power point tracking (MPPT) techniques are essential for the optimization of the efficiency in the photovoltaic systems. A DC-DC Cuk converter is used to operate the SPV array at its maximum power.

## 2. Literature Survey

The conventional sources like oil, gas and coal undergone compression due to the ever-growing energy demand of the world. Besides the utilization of fossil fuels have an adverse effect on the environment. More than 7700 million tons of CO<sub>2</sub> emitted by the consumption of fossil fuels every year by Global electricity supply sector which addresses 37.5% of total CO<sub>2</sub> emissions [1-2]. Moreover, the fossil fuel availability is also limited.

The increase in worldwide demand for energy consumption motivated scientists to search for environmentally friendly energy source. Sun's energy gave a promising source of clean energy. About 1.8\*10<sup>11</sup> MW solar power is interloped on the earth [3]. The solar energy which is available throughout the world can be used with added advantages by converting it to electrical energy by SPV systems. SPV systems has added advantages like less weight, simple structural equipment, can be used over wide areas, noise free operation, less maintenance [4].

The SPV standalone application is quite predominant in remote areas where transmission of power is difficult or impossible. The SPV energy is used in domestic appliances, fans, water pumping, air-conditioning lighting, heating and drying etc. [5-6]. The utilization of SPV energy will contribute 7% by the year 2030 and will rise to 25% by 2050 with an annual growth rate of 35-40% SPV is one of the fastest growing technologies throughout the world [7].

The standalone SPV system gives a promising solution with low maintenance and low-cost solicitation for water pumping system in remote areas [8]. MPPT conversion system is used to efficiently use the SPV system. Usually the conversion

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system is a dc-dc converter of which duty cycle is controlled in a way such that SPV system operates at maximum power.

The MPPT techniques that are prominent in tracking MPP are open circuit voltage method, short circuit current method, perturb and observe method, incremental conductance method, neural network and fuzzy techniques. In spite of simplicity open circuit voltage method and short circuit current needs periodic load shedding, whereas artificial neural network increases complexity.

Perturb and observe and incremental conductance techniques are simple linear techniques that can be implemented by low cost and has fast convergence speed. Choosing a befitting DC-DC converter plays a crucial role for optimum performance of the system. A non-isolated DC to DC converter gives optimum performance for low voltage conversion than isolated converter by exempting conduction losses that occur during energy transfer between primary and secondary windings.

Among various DC-DC converter topologies Cuk converter gives better performance than buck, boost, buck boost, SEPIC, zeta, Luo and canonical switching cell converters as Cuk converter gives non-pulsating input and output currents thereby external filtering is eliminated. It also provides unbounded MPPT region, the contrast of different converters is shown in Table 1.

For solar pumping systems below 5 Kw DC motors are generally used. For high power systems PMSM motor gives better performance than induction motors and DC motors as they provide optimal efficiency, high torque to size ratio and dynamic response along with system ruggedness reliability, maintenance free and helps in optimal sizing of SPV array and voltage source inverter (VSI).

**Table 1:** Comparison of DC-DC Converters

Converter	MPPT Region	Input Current	Output Current
Buck	Bounded	Pulsating	Non-pulsating
Boost	Bounded	Non-pulsating	Pulsating
Buck-boost	Unbounded	Pulsating	Pulsating
Cuk	Unbounded	Non-pulsating	Non-pulsating
SEPIC	Unbounded	Non-pulsating	Pulsating
Zeta	Unbounded	Pulsating	Non-pulsating
CSC	Unbounded	Pulsating	Pulsating
Luo	Unbounded	Pulsating	Non-pulsating

## 2.1 Problem identification

In remote areas SPV water pumping system can be used in many applications such as water for irrigation, agriculture purpose, and village water supplies. The utilisation of SPV energy is conservative particularly in isolated regions where the transmission of power is difficult. Conversion efficiency of PV systems has a significant impact on the wide application of PV generation.

The conversion efficiency of PV systems is mainly constrained by three factors, including efficiency of a PV cell, efficiency of power converters, and efficiency of maximum power point tracking (MPPT) techniques.

Improving MPPT techniques is much easier, low cost, and can also be easily implemented in the existed PV systems, hence it is the best choice of improving the efficiency of PV systems.

A solar photovoltaic (SPV) powered PMSM drive for water pumping gives optimum performance than induction motors and brushed DC motors as PMSM provide optimal efficiency, high torque to size ratio and dynamic response along with system ruggedness reliability, maintenance free and helps in optimal sizing of SPV array and voltage source inverter (VSI).

## 3. Conclusion

In agriculture, these systems are mostly to drive the water pumps. In view of these systems being eco-friendly and energy efficient, countries like India have made it a national mission to install a large number of SPV operated pump sets to irrigate remote and rural areas. Since the system has to be installed in technically unattended zones, it must be robust, economical and maintenance free.

The brushed DC motors using mechanized commutators and brushes need regular maintenance and are prone to failure. The drawbacks of these motors can be improved by the use of permanent magnet brushless DC (PMBLDC) motor, which has a good speed response, high torque, higher efficiency and better reliability. PMBLDC motor drives have received considerable attention recently as their performance is superior to those of the brushed dc motors and ac motors for servo and constant/adjustable speed applications.

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