IJCRT Publish Paper record is available at DOI: http://doi.one/10.1727/IJCRT.17146

Solar-powered agriculture pumps and its economic feasibility: A review

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Abstract - **For a country like India, water, food & energy security are of utmost importance. Lots of efforts are carried out for water management. Modernization of agriculture will lead to a sustainable development of rural India. To supplement this, the use of renewable energy in rural areas will lead towards sustainable agriculture, enhanced rural economy and development of rural India. The paper focuses on the importance and technology details of solar-powered agriculture pumps coupled with BLDC motors. Modern agricultural practices, coupled with solar energy will have a bright future. Though solar-powered agriculture may involve higher initial investment; assured availability, eco-friendly, very less maintenance are the important benefits.**

Keywords **– BLDC, solar-powered, micro-irrigation, tracker, controller.**

I. PRESENT POWER SCENARIO

In many parts of rural India, problems of power shortage and associated power quality are observed. The quality of grid supply is related to voltage and frequency fluctuations, scheduled and unscheduled power cuts and load restrictions. Load shedding is a major problem for which there may not be any immediate remedy in the near future, since the gap between the power demand and supply is increasing every year. This has led to increased usage of stand-by petrol or diesel generator sets and conventional battery inverter sets in both urban and rural areas. [1], [2]

Setting up of conventional power plants may be difficult in some areas, due to factors like inadequate infrastructure facilities, lack of communication facilities, difficult geographical conditions, dearth of skilled labour, etc. By virtue of physical location, sometimes, provision of grid electricity may not be technically and commercially viable. The costs to install and service the distribution lines are considerably higher for remote areas. Transmission line losses add up to the problems. Also, extension of utility grid lines experiences a number of problems such as high capital investment, high lead time, low load factor, poor voltage regulation and frequent power supply interruptions.

II. THE IDEA

Due to load shedding, farmers are unable to operate electrical pumps for the required duration and hence cannot fulfill the requirement of irrigation. This results in rotational irrigation wherein the rotation period ranges between 7-20 days. Further, due to such rotational irrigation, crops will not get water as per their seasonal requirements. As a result, crops suffer & yield is affected. In order to overcome this problem, use of renewable energy will be helpful. Since, solar energy is the easiest to harness (when compared with wind or bio energy), solar-powered pumps coupled with Brush Less DC (BLDC) motors can be a perfect combination for use with micro-irrigation systems. This will be an ideal example of water & energy conservation put together. Also, the farmer can be independent of grid-power and gensets. He can run the pumping system using this abundantly available renewable energy during day time & irrigate his crop.

III. PRINCIPLE OF OPERATION

Since the motor used is BLDC; it requires very low initial power and torque. So, the solar pump system starts operating, as soon as the sun rises. It runs throughout the day and stops automatically after sunset. Use of solar pumping system with micro-irrigation is a perfect combination for maintaining the favourable soil moisture conditions of the plants and ultimately helps in proper growth of the plants and increasing the yields. This is a real boon for the farmers. The water use efficiency can thus be increased by adoption of solar-powered micro-irrigation systems.

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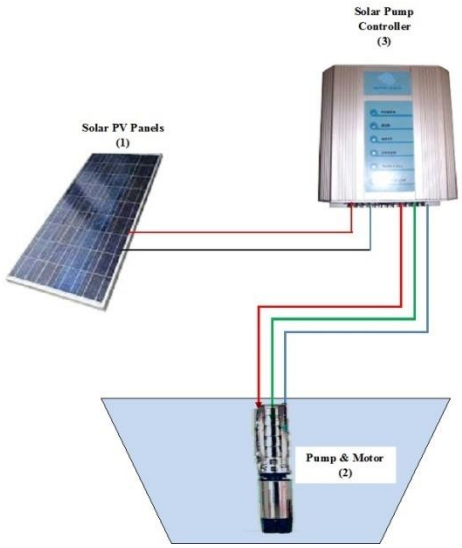

Figure 1: Typical Schematic of Solar-powered PV pump system

IV. OBJECTIVES OF USING SOLAR-POWERED MICRO-IRRIGATION SYSTEM

- In India, villages are remote and disperse. Connecting them in an electrical grid can be a costly affair. Solar-powered systems will give independence from grid.
- To ensure water for irrigation, even in the absence of electricity.
- To increase water use efficiency and maximize yields.
- To ensure economic well being of the farmers by providing reliable and assured water and power supply.
- To increase the GDP growth of the country by ensuring food security through water and energy security.
- To supply the water as per crop water requirements on daily basis.
- To provide trouble free pumping system to the farmers.

V. SYSTEM COMPONENTS & TECHNICAL INFORMATION

A. Solar PV panels

Figure 2: Solar Photo-Voltaic (PV) panel

Solar PV panels are usually made from high efficiency (typically in the range of 18% to 20%) mono / multi crystalline solar cells. The cells are encapsulated in a toughened glass using UV stable EVA sheets. The premium quality back sheet protects the cells from environmental conditions. The efficiency of panels is in the range of 14% to 17% and life span of PV panels is about 25 years. Panels are available in wide range from 3 W to 300 W. For solar-operated PV pump, panels in the range of 200 W – 300 W are typically used.

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B. Pump-end & motor

Figure 3: Submersible and surface pumps used for solar applications

Pump-ends are available as surface and submersible types. Typical range of surface pumps is from 0.1 to 3 Hp and of submersible pumps is from 0.5 to 25 Hp or even more. In a typical Brush-Less DC motor, the magnets (ferrite core) are on the rotor and the windings are on the stator. All the disadvantages related to brushes in PMDC (brushed) motor are absent in BLDC motor. Alternatively, energy efficient AC motors can also be coupled with the pump-ends.

C. Solar PV pump controller (SPC)

Figure 4: Solar PV pump controller

Depending on the type of motor, appropriate controller is selected. The controller is an electronic device that is responsible for all control functions of the pump. It also has all protections inbuilt such as, overload protect, level control switch, under load tripping, single phasing prevention, etc.

D. PV panel tracking system

Figure 5: Solar PV panel tracking system

This is very useful technology to rotate the panels in such a way that they continuously face the sun. Studies have shown that, by making use of this technology, the discharge can be increased up to 35%. There are three types of trackers: manual trackers, single-axis automatic trackers & dual axis automatic trackers. Each type has its own advantages and limitations.

VI. RELIABILITY OF SOLAR-POWERED PUMPING SYSTEMS

- In case, the motor is BLDC, there is practically very less maintenance.
- Premium quality Stainless steel (SS) materials ensure long life of pump-end.
- Batteries are not recommended. Hence replacement, discharging of batteries and other problems are eliminated.
- All the required protections are available in the electronic controller.

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VII. ECONOMIC FEASIBILITY

This depends on the specific model of the solar pumping system used. Pay back generally varies in between 3 to 5 years. For subsidized models, the payback is even less. As compared with electrical & diesel pump sets, solar pumping systems are viable. This can be confirmed from the following table. The table compares recurring operation of Electrical pump and Solar-operated PV pump. It can be concluded from the results that solar pump is the most feasible solution in the long run.

TABLE I
COST COMPARISON OF3 HP ELECTRICAL & SOLAR PUMPING SYSTEM

ELECTRICAL PUMP		**SOLAR-OPERATED PV PUMP**	
Parameters	**Values**	**Parameters**	**Values**
HP	3	HP	3
KW (Eff = 70%)	2.91	KW (Eff = 80%)	2.57
Operating hours	8	Operating hours	8
Units cons / day	23	Units cons / day	21
Total units/year (300 days)	6983	Total units/year (300 days)	-
Avg. Rate / Unit Agri (INR)	1.3	Avg. Rate / Unit Agri (INR)	-
Electricity charges / yr (INR)	9,077	Electricity charge / yr	-
Maintenance charges / yr (INR)	5,000	Govt. Subsidy (95%) (INR)	3,84,750
		Farmer's share (5%) (INR)	20,250
Total operating cost / yr (INR)	**14,077**	**Total Farmer's share (INR)**	**20,250**
Cost of Pump (INR)	15,000	Cost of Pump (INR)	4,05,000
		PAYBACK (YRS.)	**1.44**

A. Notes

- The solar-powered PV pumping system considered above belongs to scheme being implemented by Dept of Agriculture, GoM & MSEDCL in 20 districts of Maharashtra (Ref: Daily Lokmat, Jalgaon Edition, 30-09-2016)
- Availability of electricity in rural area is approx 8 hours and the average sunshine hours are also the same.
- The average electricity unit cost for agriculture is the present prevailing rate and may change with Govt. policies.
- The maintenance cost considered is average. It has been observed that it gradually increases every year.

VIII. CONCLUSION

The above table shows that solar-powered pumping system with BLDC motor is a cost effective solution in the long run. Though the initial investment is high, government is supporting the farmers by providing subsidy. This system also has the potential of replacing fuel-operated and electrical pumps; thereby providing a sustainable solution for meeting the irrigation requirements of crops. The system efficiency is also higher when compared with conventional pumping system and reliability is ensured.

ACKNOWLEDGEMENT

Photo courtesy – Jain Irrigation Systems Ltd, Jalgaon

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