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An Approach for Solar Pumping System for India

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ABSTRACT
India is known for its diversified agriculture but the stability of agricultural production got affected by limited energy supply. Limited grid electricity and increased diesel prices made farmers opt to other means of energy to pump water for consumption. Solar photovoltaic pumping system provides reliable and environment friendly system as source of energy. Easy installation, low operating cost, low maintenance and long life are few advantages of solar PV pumping systems. Paper will discuss designing aspects of such systems.

Keywords- *Agriculture, Energy Supply, Solar photovoltaic, Pumping, PV, Environment*

1. INTRODUCTION

In country like India, irrigation is not assured. Agricultural income depends on uncertain production and fluctuating oil prices since irrigation largely depends on water availability and engineering pumps.

Solar PV pumping technology is independent of imported oil or centralized electricity, system has very low environmental impacts. Fuel cost saved can be invested in high yielding seeds, high value crops and contribute important role to food production. Proper sizing of photovoltaic system can check over-exploitation of groundwater and degradation of environment.

2. Solar Powered Water Pumping System Configuration

In any of the solar photovoltaic pumping system the main components are the solar array, power conditioning unit and a sun tracking mechanism for improving system efficiency.

Basically solar powered water pumping systems can be classified into two types and various factors must be considered while determining the optimum system for various applications.

2.1. Direct Coupled Solar Pump System

Direct coupled system enables electricity flow PV modules to pump so that pumps up water by the help of pipes and other arrangements like valves.

This system is designed to pump water during shining of sun; the amount of water pumped depends on amount of sunlight falling on PV panels and the type of pump. During the optimum sunlight time pump operates at about hundred percentage efficiency with maximum flow of water. At rest of the time it depends on intensity of sun and striking angle of sunlight on panels.

These systems are sized such that extra water can be stored on sunny days to compensate no or less working of system during night and cloudy days. Water storage capacity is important in such pumping systems, two to six days storage may be required as per water usage. Evaporation losses in summer and freezing during cold weather should be considered while deciding the storage of water as power climatic conditions.

Fig 1 Direct Coupled Solar Pump System

2.2. Batteries Coupled Solar Pump System

It consists of PV panels, charge control regulator, batteries, pump controller, pressure switch, tank and DC water pump. Electricity is generated by PV panels during daylight hours which in turn charge the batteries to supply power to the pump. Pump can be run at desired time in such system by the use of batteries, steady operating voltage is given to DC motor of the pump thus making pumping possible for longer period of time. Even though system efficiency is reduced by battery usage; operating voltage now is dictated by the batteries instead of PV panels, this new operating voltage dictated by battery can be one to five volts lower produced by the panels during maxing shining of sun. This decrement depends on charged amount and temperature of batteries also.

An appropriate pump controller can be used to boost the battery voltage supplied to the pump and so reduced efficiency can be minimized.

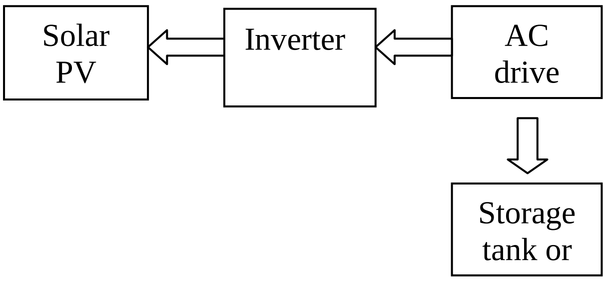

Fig 2. Batteries Coupled Solar Pump System

3. Sizing of pump and solar array

In general if water source is a shallow well then a surface pump works better whereas for a deep well condition submersible pumps are preferred. Similarly DC pumps are preferred for solar photovoltaic ground water pumping but AC pumps can also be used when higher capacity pumps are required, especially in class of submersible pumps. In such systems water can be obtained by various methods like filling up of overhead tank by the pumping of underground water through submersible pump, later stored water can be used for irrigation through gravity, or simply direct pumping can be used for irrigation. Also water can be stored into grounded tank, later on DC centrifugal pump can be used for irrigation. Designing specifications like capacity of pump, pumping depth, duration of operation decide and affect volume of water extracted from underground and the amount of water required for irrigation depends on types of group, growth rate, application efficiency, land topography and condition of soil.

Mathematically energy needed for pumping certain volume of water from particular depth can be related by designing specifications as;-

$E = \rho g h V$, (J)

where,

E = hydraulic energy needed in joules (J)

ρ = water density, i.e. 1000 kg per cubic meter

g = acceleration due to gravity, i.e. 9.81 Nm/ square second

h = water head in meters

V = volume of water required in cubic meter

Then same equation can be rewritten in given form;-

$E = \rho g H V / 3.6 \times 106$, (KWh)

where,

H = water head in meters after considering some percentage of pipe losses

And energy is obtained in form of kilo watt hour in later given equation

After this, hydraulic power required to pump water can be determined by

P = E / number of peak sunshine hours, (KW)

These number of peak sun hours depends on location of study, As we know motors are not hundred percent efficient, so motor power can be related with hydraulic power by

MP = P / Ƞ, (KW)

where,
MP = motor power required by pump (KW)
P = hydraulic power required to pump water (KW)
Ƞ = efficiency of the pump

These calculations can be explained by some assumptions and further calculating data from them

Thus, to lift 148 m3 of water and the it has to be lifted from a depth of 20 m and if pipe heat losses are supposed to be 10 percent of the total head, new head formed in calculation will be 22 m .

Now hydraulic energy needed will be
E = (1000 x 9.81 x 22 x 148) / (3.6 x 106)
= 8.87 KWh

Now hydraulic power required to pump water will be
P = 8.87 / 7
= 1.267 KW,

If pump is to be operated for number of hours equal to number of peak sunshine hours, here number of peak sunshine hours are 7 hours that is a valid figure of places like Rajasthan in India.

Then motor power required by pump can be calculated
MP = 1.267 / 0.7 KW
=1810 W,

If the efficiency of the pump is 70 % which is typical pump efficiency

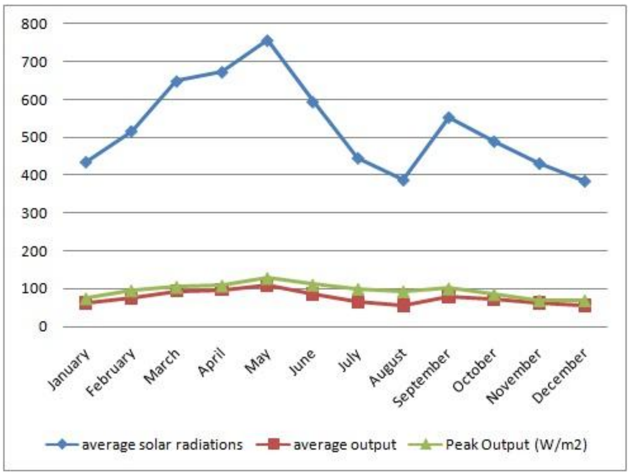

Fig 3. The mean monthly output variations in D.C. power output from 240 Wp solar panel at jaipur, Rajasthan.

Therefore we can take the pump size as 3 HP.
Solar radiations can be varied with time and do not strictly follow standard test conditions, but it has been seen in regions like Rajasthan that 3 HP pump could be operated well nearly for 7 to 8 hours daily at rated power of 2 KW and up to 2.6 KW, successfully. Winter months from November to January and even February show some low output. Hence it can be said in general that in country like India in most of the region for every horsepower i.e. HP, operating solar array size should be of 800 Wp to 1000 Wp for the successful and economical operations of solar pump.

4. Advantages and Limitations

One of the main advantages is that this system works with the flow of nature, water is pumped at the time it is needed most since it works on the principle of sun. Portability of pumping system is beneficial, solar array can be placed anywhere near or away from the well or pumping source. System has its own outstanding advantage of low operating cost which even surpasses attractive subsidies on non renewable resources like diesel and electricity. Last but not the least PV pumping system requires least maintenance, once or twice cleaning away dirt from panels is all that needed. That too is taken care of by most vendors due to after installation services. As comparable to normal pumps output of solar pumps are high but if high yielding is desired this pumping system does not provide high capacity, this should be taken care of. Also, while designing and installing the system its variable feature should be remembered, that is highest at noon and simultaneously decreased with disappearing sun. Better the quality of ground water better will be the pumping output, so pre cleaning and use of filters at the pipe ends are advisable to avoid sand and dirt in water which can hamper the functioning of system. And again physical protection of the system is needed since system is portable it should be protected against theft and other damages.

5. Conclusion

In this paper design and analysis aspects of any basic solar pumping system is presented. Method used in this paper can be used to design any solar powered pump as per requirements by the help of some manuals given by pump providers or by government units in case of subsidized solar pumps for farmers.

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