Solar Energy Conservation in Domestic & Irrigation Water Supply

Sayantika Saha, Madhurima Santra, Soumyendra Nath Basu

Abstract—Energy is one of the major parameters for establishing growth and progress of a country. Solar energy is the most abundant source of energy in the world. Solar power is not only an answer today's energy crisis but also an environmental friendly form of energy. India has the second largest agricultural land in the world (World Bank data shows that about 60.3 percent of India's land area is agricultural land). With approximately 60% of the earth's fresh water being used to irrigate crops it is not reasonable to assume that all the farmers in the world grab their buckets and do watering of crops. However, typical irrigation systems consume a great amount of conventional energy through the use of electric motors and generators powered by fuel. Solar panels are now used for running street lights and to meet domestic loads. The cost of solar panels has been decreasing. One of the application of this technology is used in irrigation system for farming. The objective is to supply water for the fields through solar powered water pump and automate the system for better management of resources using GSM technique. This system conserves electricity by reducing the usage of grid power and easy to implement and environment friendly solution for irrigating fields. Solar power irrigation system can be a suitable alternative for farmers in the present state of energy crisis in India. The objective of this paper is to supply water for the fields through solar powered water pump and automate the system for better management of resources.

Index Terms— irrigation, solar energy, solar powered water pump, GSM

1 Introduction

INDIA has a significant level of solar radiation thought the year. A major portion of rural area is still starved of electricity for agricultural and domestic purposes. Solar energy conversion to electricity through solar panels (an array of photo voltaic cells) are now a day extensively used for running street lights, irrigation systems for farming and to meet domestic load. Solar water pumping is found to be economically viable in comparison to electricity or diesel based systems for irrigation and domestic water supply in rural, and remote areas. The investment payback for some PV water pumping systems is found to be 4–6 years. Solar photo voltaic (SPV) technology converts sunlight into D.C., directly and instantaneously. This system conserves electricity by reducing the usage of grid power. Proposed (SPV) system is easy to implement and environment friendly solution for irrigating fields. Consistent R & D efforts in the development of solar photovoltaic technology in India, the cost of solar panels has been constantly decreasing which encourages its usage in various rural sectors and likely to open a new chapter in India's irrigation economy in the years to come. Solar powered irrigation system is one of the best alternative methods for farmers in the present state of energy crisis in India.

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2 Literature Survey and Background Study

India's population is about 18% of the world's population (about 1.32 billion as of April 2016) but has only 4% of world's renewable water resources. With ever increasing population to support food requirement of more than 1.2 billion people irrigation water demand is increasing. As of now irrigation sector consumes about 80% of the total water use which may reduce to about 70% by 2050 due to competing demands from other sectors.

Agriculture, an important sector of Indian economy accounts for 14 per cent of the nation's GDP and about 11 % of its exports. Almost 70 to 74 per cent of the population depends on agriculture directly or indirectly. While 34.7 per cent of the 183 million hectares of agricultural land is irrigated Agriculture sector is the largest user of water which is about 83% of the total water consumption and consumes 25 to 30 per cent of total electricity consumption in agriculture sector annually.

According to survey report there are about 35 million pumps installed in the country, of which 10 million are diesel pumps and the rest are operated through grid power. Solar powered smart irrigation technique is the future for the farmers and a solution for energy crisis. Numerous research efforts have been made in the application of solar photovoltaic (PV) for water pumping systems.

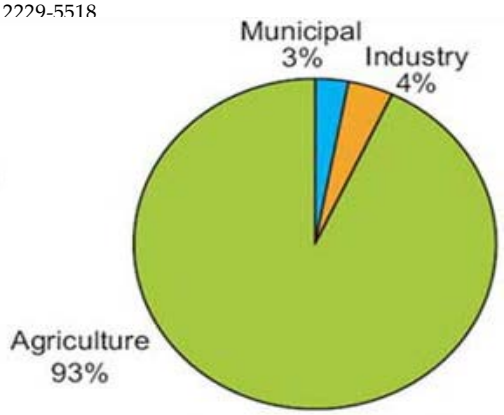

Figure 1. Water Consumption

3 Solar Photovoltaic in India – Present Status and Future Possibilities

India receives nearly 2,400 hours of sunshine every year, which is equivalent to 5,000 trillion kWh of energy. Worldwide generation of solar photovoltaic has been expanded by 50% per year over the last decade. Since 2000, the total installed capacity of SPV increased by more than 40% and reaches to 100 TWh in 2012. The growth of SPV market grew by 20.3% between 2012 and 2013 and the similar growth is expected in future. At present the majority of PV capacity is grid-connected with off-grid is estimated to 1% of the market. As predicted by the World Energy Outlook, the IEA, the solar PV capacity could enhance to 950 TWh in 2035, from 100GW in 2013. Large scale application of PV will be feasible if the generation costs are reduced to a great extent from the initial high of approximately INR 17/unit to about INR 6.5 /unit. However, further reductions in this price are still required to obtain grid parity. The SPV is expanding rapidly due to effective supporting policies and reduction in costs.The efficiency of mono crystalline solar cell was 13% in 1975 and 25% in 2014 as per NREL. Commercial mono c-Si modules have conversion efficiencies between 13 to 19% as per IEA solar photovoltaic roadmap and their efficiencies are expected to increase up to 23% by 2020 and up to 25% in longer term.

Government of India and industrial sector must increase R&D efforts to reduce costs and ensure PV readiness for rapid deployment, while also supporting longer-term technology innovations. Solar PV power is a commercially available and reliable technology with a significant potential for long-term growth. This roadmap estimates that by 2050, PV will provide around 11% of global electricity production and reduces 2.3 Gt of CO2 emissions per year. Cost reductions of PV cell may be achieved through i) higher conversion efficiency ii) using cheaper material iii) innovations in manufacturing iv) manufacturing process optimisation v) optimisation of system design. Six major cities in India viz., Chennai, Delhi, Jodhpur, Kolkata, Mumbai and Trivandrum can meet the energy demand in 2025 through SPV.The Ministry of New and Renewable Energy has supported the design and development of several other components and subsystems used in PV systems

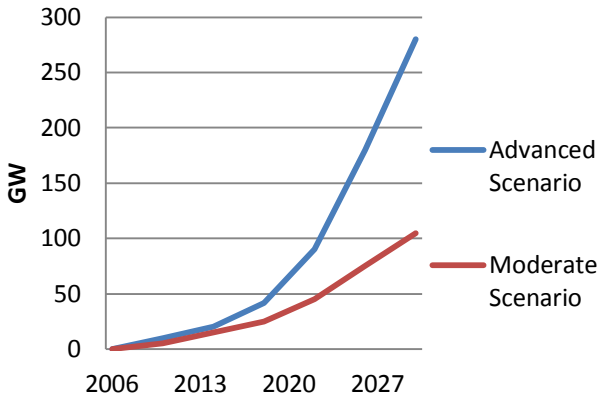

Figure 2 . Global PV annual installed capacity up to 2030

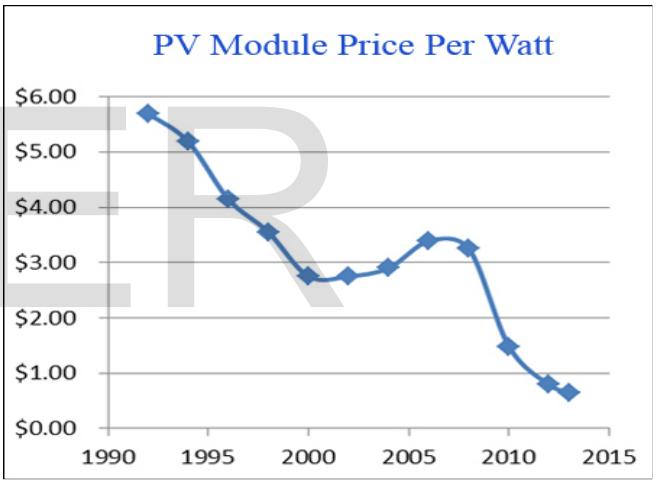

Figure 3. PV Module Price Per Watt

4 Auto Irrigation System using SPV

This paper is intended to present a thorough review on the design and development of irrigation system in the field of agriculture by using Solar Energy for sustainable development of farmers in India. Numerous research efforts have been made in the application of solar photovoltaic (PV) for irrigation systems. Automatic irrigation system optimizes the usage of water by reducing wastage and reduce the human intervention for farmers. A solar water pumping system is ideal in remote locations where grid electricity does not exist. It has been estimated that 1,000 diesel pump sets (3 hp) consume nearly 4,200 litres of diesel for six hours of running every day. This means in one year (240 days) approximately 10,08,000 litres of diesel is consumed per 1,000 pumps.

The key components in a solar PV pumping system are :

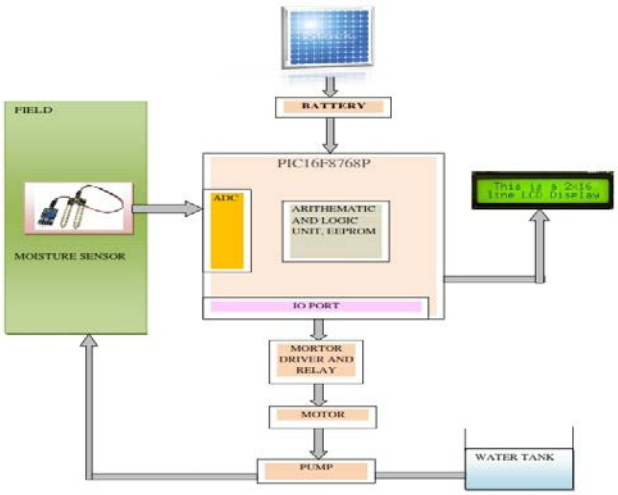

Figure 4. The key components in a solar PV pumping system

i) Solar array : The power of solar module is calculated on the basis of amount of solar energy received from the sun in a particular location. The size of array (solar modules) depends upon the volume of water pumped and the level of solar radiation level.

ii) Control systems : A microcontroller (PIC 16F8768P) in a solar PV pumping system is used to control the whole system. The control system optimizes the electricity production from solar energy and controls the operation of pumps as per requirements by controlling the current and voltage from the solar panel , charges the battery, and also stops the charging of the battery from over and undercharging conditions.

iii) In dry condition the microcontroller will switch on the motor and it will switch off in wet condition. Here we use an (PIC 16F8768P) series microcontroller to receive the input signal of varying moisture condition of soil. An LCD display is also interfaced to the microcontroller to display status of the soil.
The system can be enhanced by integrating GSM technology. Whenever the motor-pump set switched ON/OFF, immediately an SMS will be sent to the concerned person regarding the status of motor-pump set and the concerned person can control the pump through SMS.

iv) Motor Pump Set : For solar PV powered "Motor Pump Set" should have a capacity in the range of 0.2 HP to 5 HP. In India, the DC surface suction type (approximately 86% of solar pumping systems installed in India), DC submersible type (2%), DC floating type (2%), and AC submersible (10%). As per report of MNRE, 10,000 numbers of solar PV water pumping systems for the purpose of irrigation has been implemented in the country through National Bank for Agriculture and Rural Development (NABARD) in 2014.

v) Technical Specifications of Solar Deep Well Pumping System

TABLE 1

.Description	Model I	Model II	Model III	Model IV
Solar PV array	1,200 Wp	1,800 Wp	3000 Wp	4,800 Wp
Motor-Pump set type	Submersible with controller	Submersible with controller	Submersible with controller	Submersible with controller
Motor capacity	1 HP	1 HP / 2 HP	3 HP	4.6 HP
Water output in litres per day (on clear sunny day)	34 $x10^3$	51 $x10^3$	51 $x10^3$	82 $x10^3$
Total head (in metres)	30	30	50	50

Technical Specifications of Solar Shallow Well Pumping System

TABLE 2

Description	Model I	Model II	Model III
Solar PV array	900 Wp	1,800 Wp	2700 Wp
Motor-Pump set type	Centrifugal DC monoblock	Centrifugal DC Monoblock	Centrifugal DC Monoblock
Motor capacity	1 HP	2 HP	3 HP
Water output in litres per day (on clear sunny day)	77 $x10^3$	154 $x10^3$	115 $x10^3$
Total head (in metres)	10	10	20

vi) Rechargeable Battery : The Battery is used to store current which is produced from the solar panel and supplied to the corresponding loads. The number of batteries required depend on the load requirement.

vii) Tracking system : Manual and auto tracking systems are used to enhance the performance of SPV pumping system for irrigation.

5 STATUS OF SOLAR PUMPS FOR IRRIGATION IN INDIA

The status of solar pumps for irrigation in India as on 31.01.2016) by various State Nodal Agencies :

TABLE 3

Sl. No.	State	No of pumps sanctioned	Installed as on 31 Jannuary 2016
1.	Andhra Pradesh	6725	2800
2.	Bihar	3516	216
3.	Chhattisgarh	2740	577
4.	Gujarat	2500	1487
5.	Haryana	873	0
6.	Jharkhand	1400	0
7.	Karnataka	5225	1918
8.	Kerala	1380	0
9.	Madhya Pradesh	3000	1719
10	Maharashtra	7540	0
11	Odisha	2560	0
12	Punjab	1600	0
13	Rajasthan	9902	3400
14	Tamil Nadu	5150	2620
15	Telangana	4225	0
16	Uttar Pradesh	7100	2874
TOTAL		**63,436**	**17,611**

6 ADVANTAGES AND LIMITATIONS OF SOLAR PV AUTO IRRIGATION

Advantages of solar PV auto irrigation :

1. Provides clean-green energy
2. Free and abundant
3. Cost effective - Low operating and maintenance cost
4. Reliable and noise free
5. No moving parts
6. Installation is easy
7. Local generation of power
8. Easy transportation
9. Energy Conservation
10. Water conservation
11. Environmental friendly – There is no harmful greenhouse gas emission
12. Low maintenance - Solar panels are relatively maintenance free. They may need to be cleaned every so often and replaced after around 25 years use, but other than that they do not need regular maintenance.
13. Availability of Government incentives

Limitations of solar PV auto irrigation :

1. Low yield – Though the output of solar DC pump is more than a normal pump, the maximum capacity available with the solar pump is very low.
2. Variable yield – As the operation of solar pump depends on solar radiation intensity, the water yield varies from morning to evening.
3. Theft : Theft of solar panels may be problems in some areas also may be damaged due to natural hazards like lightning.
4. Dry operation: The submersible pump has an in-built protection against dry run. However, the surface pumps are very sensitive to dry run. A dry run of 15 minutes or more can cause considerable damage to pumps.
5. Water quality : If the water contains sand or mud , it should be cleaned otherwise the pumps may be damaged.
6. Relatively Low efficiency level - Efficiency level is relatively low (between 14% to 25%) compared to the efficiency levels of other renewable energy systems.
7. Relatively low energy intensity- Energy intensity is around 8 to 12 m2/kW
8. Expensive to install
9. High capital cost - Solar PV panels are more expensive than panels designed for solar thermal energy.

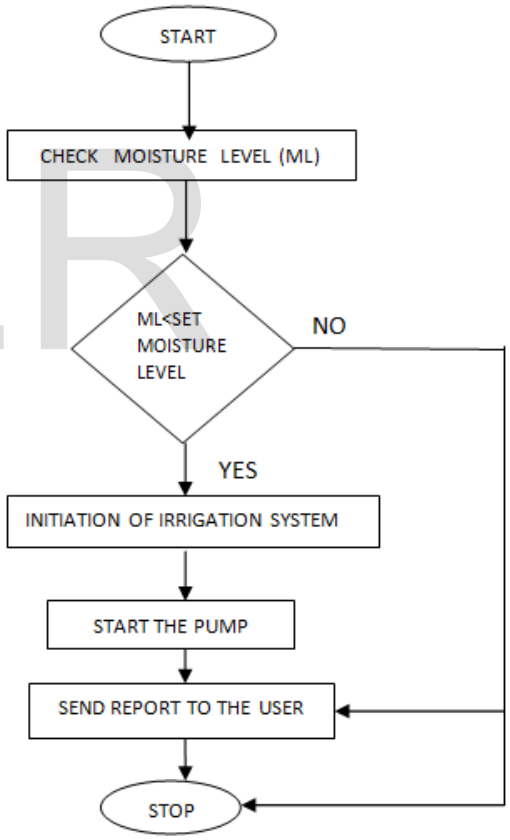

Figure5 . Flow Chart

7 SYSTEM DESIGN AND SIMULATION

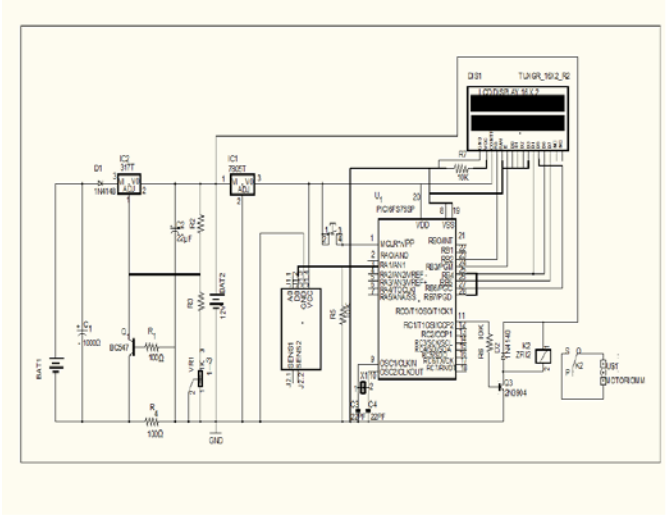

Figure 6. Circuit Diagram

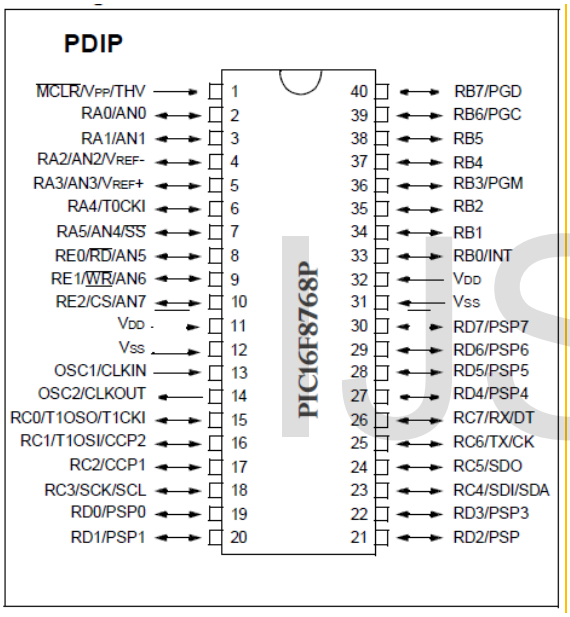

Figure 7. Pin diagram of PIC16F8768P

8 Working Principle

Solar charge controller is used to charge 12 volt battery. The basic purpose of solar charge controller is to avoid over charging and over discharging of battery. The solar panel is used to charge 12 volt 7.2 AH battery with the help of solar charge with voltage regulator.

Moisture sensor is main component of the circuit which is used for the measurement of moisture in soil. It works on the principle of change in resistance. Basically, moisture sensor is a metallic strip. Resistance of metallic strip changes according to moisture level in soil. As moisture increases the conductivity of metallic strip increases. If moisture is high, resistance will be low and when moisture in the soil is low, resistance will be high and conductivity will be low. PIC microcontroller is used to measure the change in resistance of moisture sensor. This change in resistance of moisture sensor is used to turn on or turn off dc water pump with the help relay interfacing with the microcontroller (PIC16F8768P). Here the Liquid crystal display is used to display battery voltages, moisture level and water pump status of Solar Energy Conservation in Domestic and Irrigation water supply according to the programming of the microcontroller.

PCB Design

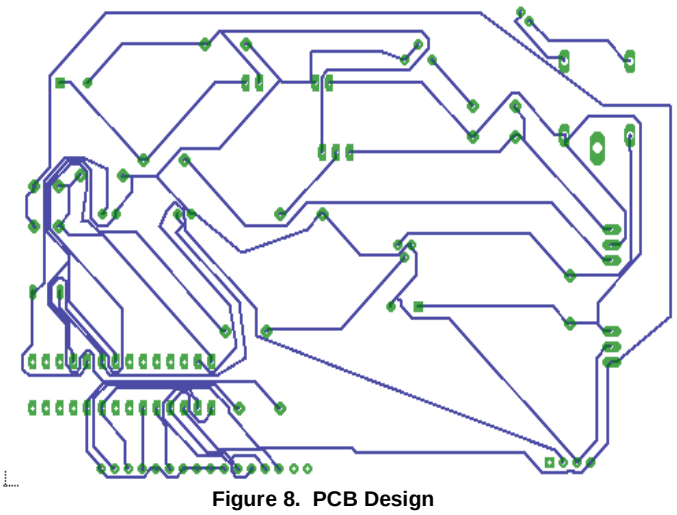

Figure 8. PCB Design

9 Conclusion

The application of solar photovoltaic irrigation will be able to contribute socio-economic development of the country. It is the only solution for the present energy crisis for the Indian farmers by reducing the grid power which is the conventional power system in rural areas for irrigation and domestic water supply. Technological progress and continuous financial support through subsidies and incentives provided by the government will play a crucial role for implementation of solar PV systems in irrigation and domestic water supply. The key barrier to the use of solar PV water pumps is the high capital cost incurred by the farmers as compared to the conventional pumps. In conclusion application of SPV for irrigation is cost competitive compared to the traditional energy sources if the system is properly designed.

10 References

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