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Solar Powered Automated Water Pumping System for Eco-Friendly Irrigation

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Abstract— **Many villages in India use fossil fuel based water pumping system for irrigation due to a shortage of electricity. Fossil fuel causes great damage to the environment as they release harmful greenhouse gases. Conventional generation of electricity by thermal and nuclear power plants also harm the environment. In this research work, we propose a solar energy based automated water pumping system which can be used in many villages as an alternative to the fossil fuel based water pumping systems. As the system is automated, the water pumps are switched on only when the moisture content of the soil is below a critical level which is determined by the moisture sensors planted in the fields. An intelligent microcontroller based circuit board is the heart of the system. As part of this research work, we conducted a case study in a village called Siruvani near Coimbatore district in the southern state of Tamil Nadu, India. Agriculture is the lifeline for most of the forty-four families that live in this village. Currently, they use diesel based water pumping system which is not only expensive but also harms the environment. The villagers' profit is greatly reduced as they spend a lot of money in buying diesel for running the water pump system. The study conducted by us shows that the proposed solar based automated water pumping system if implemented would be a boon to these villagers in terms of cost and profit. In addition, this can save a lot of water and is environment-friendly. In this paper we would discuss the design and implementation of the automated solar water pumping system along with the case study carried in Siruvani village.**

Keywords—fossil fuel, water pumping system, moisture sensors, water conservation, eco-friendly, solar energy

I. Introduction

The problem of global warming and environmental degradation can be removed completely if we take effort to maintain the ecological balance in the world. Only through collective effort through awareness and realization of the urgent need to address these issues, we can make this possible. Many countries depend on non-renewable energy sources for the production of power for household and industry usage. This creates a huge damage to the ecological system. Solar power energy production is a proven alternative source of renewable energy which is very much environmental friendly. In this paper, we discuss about the implementation of a smart system which uses solar energy to run motors that can irrigate an agricultural land. A survey was carried out in a village named Siruvani in Coimbatore district of Tamil Nadu state, India. The village has 44 families who depend on forest products and agriculture. The village has got Siruvani Waterfalls near it, which is a good tourist attraction for many people. So these people have also income through these tourists. Many of them have food stalls and forest products selling various agro products. They have a river flowing beside their village and ample amount of groundwater. This proposal of using solar energy to fetch groundwater and water from river would give them good results in cultivating and if this works as expected in this village, we can implement the same in many other villages across the world as solar energy is renewable source of energy and is eco-friendly.

II. Problem Statement

In the present world, pollution and global warming are increasing at an alarming rate. It is responsibility and duty of every individual, regardless of nationality to contribute towards the restoration of environment and to reduce further degradation of it. It is high time that we realize and act accordingly. Here in this paper, we have identified one such village in India where there are ample facilities but people are not able to access these facilities due to lack of awareness and monetary support. Siruvani is a small village in the district of Coimbatore, a city in Tamil Nadu, India which faces this problem.

Siruvani is a famous tourist attraction in the district for its waterfalls and tourism is one of their incomes. Apart from that, the tribe living here cultivates and involves in farming which constitutes of their major share of income. There is a river flowing near the village and can support the irrigational activities in the village. But the problem is with fetching the water from the river. Government has installed four motors to fetch ground water. The people of this village are so poor that they couldn't afford the cost of electricity required for the working of motor and the government had to cancel their electricity for agriculture five years ago. Only one farmer is currently using a motor pump which is run on diesel, but eats up most of his profit. 99% of the farmers here cannot afford diesel pumps because they are way costly. And moreover, diesel pumps emit lot of exhaustive gases which are harmful to the environment. We believe that if these people are provided some support and guided properly then there would be high productivity from the fields.

III. Literature Survey and Background

The paper [1] talks about a system where they have proposed a system which uses solar energy to drive motors which can water a given field and with the help of a sensory circuit, they would get to know whether to water it again or not. But they have not implemented it anywhere. In the [2] paper, there is a new technique through which we can ensure maximum sunlight on to the solar panels and thus get maximum output. The authors in paper [3] discuss about a nanogrid solar power system for lighting and mobile phone charging in huts in a village in Haiti. The authors claim to have implemented the system successfully in two huts in this village. A centralized solar power station in a remote village Rompin, Pahang in Malaysia is discussed in [4]. This is similar to what we propose but for domestic applications in this village.

In yet another research paper [5] similar to [4], a solar-diesel hybrid power system for a remote village in El Salvador is proposed. The centralized power system would light up 17 villages and the power can be utilized for other domestic purposes too. Papers [6] and [7] discusses about producing power from pedaling sewing machines commonly used in Indian villages for stitching clothes. This power can be used for charging laptop batteries, mobile phones, lamps and emergency lights. This can be of great help to school students who commonly use kerosene lit lamps or oil lit lamps for studying at homes. In paper [8], they have discussed about a method which deals with a modern way of using solar energy in lighting up households in rural India replacing traditional kerosene lamps with solar based lantern lamps which also is a measure how India is transcending towards the usage of solar energy from depending on non-renewable energy. Paper [9] talks about a research behind a fully solar powered auto rickshaw. This solar vehicle incorporates many solar panels around its body for capturing solar energy from all possible sides and this stored solar energy is used to drive the vehicle. It can go at a maximum speed of 50 kmph and can travel a distance of 80-120 km upon full charge in 4-5 hours.

IV. System Architecture

This paper basically deals with the solar powered irrigation system which would include a module to convert solar energy into electrical energy that can be used in two ways: either directly, as soon as it gets converted or by storing the energy into an external battery. The second module would consist of the motors which would run on the electrical energy that is stored, from the external energy source. The system can be made automated by installing few sensors with it. The agricultural would be identified and moisture sensors would be fitted in the soil so that the moisture level of the soil is constantly monitored and when the moisture content is below a certain level, the motors would automatically turn on and the motors would start pumping water to the field. For this purpose we use a microcontroller which monitors the sensors and operates the motors.

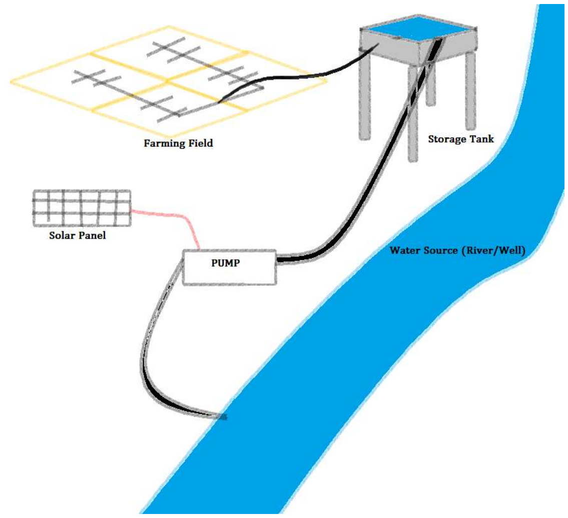

Fig. 1. Basic architecture of the smart system.

The system architecture is designed taking the village's geographical location and feasibility into consideration. There is a river which is a major source of water for the village and this can be utilized for their irrigation purpose as well. As mentioned earlier very few farmers are using diesel powered pumps to fetch water from the river. So this being replaced by solar energy, we implement the motor system which would fetch water from the river and would be powered by solar energy stored in a battery storage. This can be implemented to fetch the groundwater as well. The basic architecture consists of three major modules, which are as follows

- Powering unit
- Water pumping module
- Sensor module

A. Powering Unit

The powering unit is the heart of the whole system. This would consist the solar panels, placed all over the identified places around the field where the sunlight is expected to be more and intense. During daytime, these solar panels would charge the charge the battery provided along with supplying power to the motors installed.

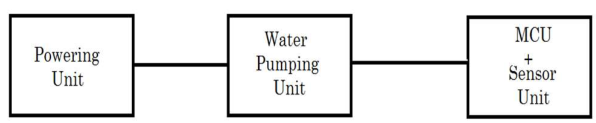

Fig. 2. Description of Powering Unit.

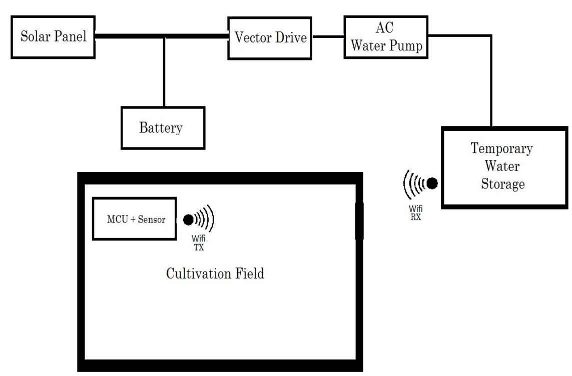

Fig. 3. Working of the system.

This Module mainly consists of solar panel, control unit, battery and an inverting system. In order to drive 5 hp motor pump at 2200 rpm we need 3KW power. For that we require 14 solar panel of size 2 X 1 m. Mono Crystalline Cells and silver lining are used for the construction of each panel. The panels are followed by a control unit and a 12V battery, which produce a constant output to the next state. The battery should have a capacity of 1800 Watt hour, i.e. 75 Ampere hour. The next state consists of a vector drive, which is actually a motor driving unit and consists of a maximum power point tracker unit (MPPT). MPPT can maximize the power extraction under all conditions. The vector drive can convert DC input to AC Signal, which is connected to the pumping.

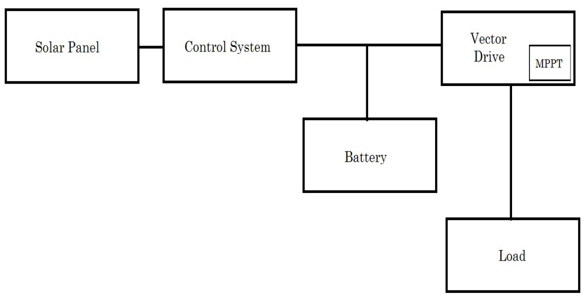

Fig. 4. Working of the system.

B. Water Pumping Unit

It actually consist of one 5 Hp motor followed by a water pump. In order to drive water up to 30 m height we require 2200 rpm. For that we require 2.7 KW power. The water pumping unit is followed by temporary water storage. A floating switch can be place in the water tank to control the pump the working. The major devices being used in the system are given in Table 1. These are solar panels which would convert the solar energy into electrical energy. Then this energy would charge the battery and the inverter would come handy when there is no sunlight and the field needs to be watered. So as the table shows, there are six controllers which would be interfaced with wifi modules and the moisture sensors. All these six modules would be connected to the master module which consists of a controller and wifi module for communication.

TABLE I. QAUANTITY DETAILS

S.No	Device	Ratings	Quantity
1	Solar Panels	100 W, 18V, 5.1 A	14
2	Inverter Battery	75 A,12 V	1
3	Moisture sensor	3.3V-5V Operating voltage	6
4	Arduino Uno	5V	7
5	Wifi module	+19.5dBm output power	7

A. Sensor Unit

The main part of the sensor unit is a soil moisture sensor (KG003 or KG005), which is available in the market. It can give exact output according to the soil conditions. The sensor is very cheap and operates between 3.3 to 5V. The sensor is followed by an Arduino UNO microcontroller. Male - Female probes of size 600 X 10 mm can be used to connect between the microcontroller and the sensor module. The wifi module is attached to the system for communicating from the field to the water pumping unit.

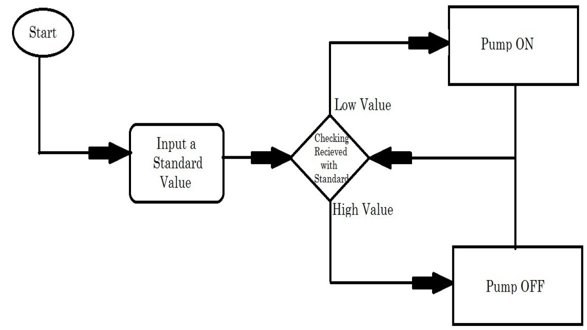

Fig. 5. Flow Chart of System.

TABLE II. COMPONENT DETAILS

S.No.	Component	Quantity
1	Moisture sensors	6
2	Wifi module	7
3	Arduino UNO	7
4	MPPT	1

V. IMPLEMENTATION

The flow chart of the control algorithm is shown in the figure 5. A threshold value is set in the MCU i.e. the moisture level monitoring. If the moisture level is above the threshold then the watering will not start. If it is below the threshold, the watering would begin until the moisture level sensor reading shows that the moisture level is below the threshold.

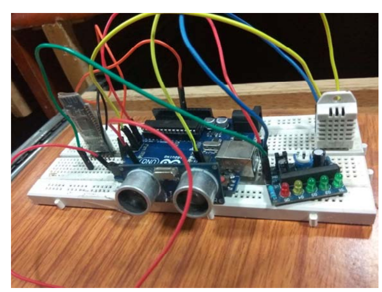

Fig. 6. Lab Test Setup.

The whole system was implemented and tested in the lab as shown in Fig. 6, but is yet to be taken to the field as such. The setup would be like there would be six modules of sensors placed in different parts of the field. Each moisture sensor would be connected to a microcontroller which would have a wifi module for data communication. This connection is wired and the microcontroller has to be well protected from external environment so that it doesn't get damaged. All these six modules would be connected to one master control which would be another controller, which can intelligently sense the input values and when there is some module sensing lack of moisture in a particular area, this controller would switch on the water supply. The water supply is from a tank which is situated at the corner of the field. The water which is accumulated in the tank from the ground and the lake would be useful at this time when there is need of water. Once the controller is requested for water, it allows the water to flow to that particular region from where the module has given request through pipes running to that area. Some of the power outputs from the solar panels are tabulated in Table III.

Table III values indicate the peak output is from 11am to 2pm which is close to 80% to 85% of the 90W output expected from 1 sq-m of the solar cell. It is nominal from 9am to 11am and 2pm to 4pm. Other times the output is minimal and doesn't contribute much to charging the battery. The readings are taken for continuous seven days for the timings given in the Table III and the power output is the average value of the seven days observation for the said timings as shown in the table.

TABLE III. SOLAR PANEL OUTPUT CALCULATION

S.No	Time	Solar Panel Output (W)(per solar panel)
1	6 AM	0.10
2	7 AM	3.68
3	8 AM	4.93
4	9 AM	62.67
5	10 AM	66.96
6	11 AM	77.77
7	12 PM	77.12
8	1 PM	76.98
9	2 PM	74.5
10	3 PM	66.368
11	4 PM	16.608
12	5 PM	15.916

VI. FUTURE WORKS

We are waiting for funding from IEEE SIGHT and if we get some enough funding, we would actually take the system to a field and implement it. This system has got a humanitarian application to it which would have an immediate and direct impact on village community all over the world. The underlying fact of the research is that this idea can be extended to places along length and breadth of India and thus to the entire mankind. Powerful monitoring systems at the panchayat level is possible, thanks to the advent of cloud computing. The data analysis might be helpful in providing tips to farmers in deciding the time at which to cultivate a particular crop and also the type of crop to be cultivated.

VII. CONCLUSION

The paper has discussed about the possibility of implementing a solar based smart irrigation system which has been tested in lab and is to be taken to a village in Coimbatore, India. A system with a solar panel, moisture sensor, Arduino Microcontroller Unit and battery is implemented and tested in the lab. The power requirements for the area of the irrigation field we are covering is calculated and accordingly number of solar panels, battery, microcontroller units, wireless interface modules and moisture sensors are decided.

VIII. ACKNOWLEDGMENT

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