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Construction and Installation of Solar Powered Borehole for a Primary Health Centre

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Abstract: The need for constant water supply cannot be over emphasized. This cannot be attained with our epileptic grid power supply while some rural areas have no grid power supply at all. In order to ensure constant water supply especially to remote areas without grid power supply, we must go for an alternative energy source to provide constant electrical power to the water pumping machine. The alternative energy source used in this work is the ever present renewable Solar Energy. In this installation, solar panels were used to harness the energy from the sun, CU200 controller to control the pumping mechanism and Grundfos SQFlex water pumping machine to pump out water from the borehole. The system is an automatic water pumping system which does not need an operator to control its ON/OFF state.

Keywords: Primary Health Centre, Solar Powered Borehole, Installation, Construction

INTRODUCTION

Water is one of the basic necessities of life. It is essential for life, food production and socio-economic development. The quality of the water depends on the source and the level of contamination (Akinbile, 2004). Once the quality of water is reduced as a result of human activities to the extent that it is less suitable for its intended use, it is said to be polluted (Ogedengbe & Akinbile, 2007). In many developing countries, the rural communities depend on rain water, flowing streams, stagnant ponds and shallow well while the privileged ones get water from boreholes. They have limited access to clean water. The WHO (1995) estimated that over 80% of illnesses in developing countries are water related. Yearly lots of death occur from the combined effects of unsafe water and poor sanitation (Rosegrant et al, 2002). Providing potable water can significantly improve the quality of life and therefore became a need to be satisfied by powered pumps.

Pumping water is universally needed and its introduction will enhance the provision of water for remote communities and households, for hospitals and other domestic uses. The availability of clean water in the rural communities will not only impact positively on the environment but also reduce long distance search for clean water especially from sources that may have been polluted (Nnaji et al, 2010). Due to the epileptic power supply in our country Nigeria, with the economic and the environmental costs of using non-renewable fossil fuels for electricity production, water pumping is becoming frustrating. This calls for an alternative means of energy for the power generation of the pumping machine for the water supply. This led to the use of solar energy for water pumping. This is particularly important to remote rural communities where grid electricity is not available. This energy source is readily available and inexhaustible and it is pollution free.

The solar pumping using the photovoltaic (PV) arrays is an extremely good way to harness ground water in a clean and profitable way (seintech, 2007). It can be used for the pumping and distribution of water to areas where it is needed (Nnaji et al, 2010). The first solar water pump for domestic use was installed in Nigeria in 1982 and many more has been installed for Agricultural purposes (Oparaku, 2003).

Solar pumps are high efficiency pumps specifically designed to run directly from solar panels and a wide variety of them are available (Lorentz, undated). The most common is the submersible borehole pumps which as the name suggests, are generally used for borehole pumping applications.
The aim of this work is to construct and install an automatic solar powered borehole which will ensure a steady water supply to the rural community especially the primary health centre where it is installed to provide enhanced hospital delivery services

MATERIALS AND METHOD

After the borehole has been carefully dug down to the aquifer level, the next step is installation of a system that will be pumping water out of the hole, into a reservoir. The power source used for this purpose is solar energy which is converted into electrical energy through the aid of photovoltaic arrays, this powers the DC pump which pumps out water from the hole through the connected pipes. The connected pipes serve as the vehicle which transports water from the hole to the reservoir which stores the water for easy access. The materials used for this installation are;

- Grundfos SQFlex pump
- 12V 85W Solar panel
- Float switch
- CU 200 controller
- 2.5mm plastic pipes

Sizing the photovoltaic array

The eight solar panels were connected in series with the aid of 2.5mm single core cable to achieve the desired output voltage. Each of the solar panel used for this installation has an operating voltage of 17V, open circuit voltage of 21.6V, power rating of 85W and an operating current of 5A.

Output voltage = voltage rating x the no of panels connected in series = 17 x 8 = 136V

In practical, the voltage varies depending on the intensity of the sun. This is so because the solar panel can give an output voltage of up to 20 volts or more depending on the intensity of the sun.

Grundfos SQflex

The pump used in this installation is Grundfos SQFlex pump which can be directly powered by solar. Input power of the range 30-300 voltage direct current (VDC) can be used to run the pump. They can operate on a series string of photovoltaic (PV) modules with a total peak power voltage over 30 volts, but the pump efficiency will be much higher at voltages over 100 VDC. SQFlex will fit into a 3" well or borehole. The SQFlex has built-in protection from dry-running, overload and overheating.

Float switch

Float switch is the device used to detect the level of water inside the reservoir. It is connected to the CU200 controller. When the float switch is submerged due to the water level increase, it sends signal to the controller that the reservoir is full and the pump will stop pumping. It will automatically restart when the water level reduces (http://en.wikipedia.org/wiki/Float_switch).

CU200 controller

This is the brain box of the system. it is a user-friendly control unit that maintains two-way communication with the pump, float switch, solar modules and monitors the operating conditions. Built-in diagnostics indicate faults and dry-running, indicates operating status and level switch input.
Communication between the CU 200 and the pump takes place via the pump power supply cable. The system monitor display on the CU200 shows the following:

1) Pump operation
2) Full tank
3) Input power (Watts)
4) Alarm indicator for dry running, overvoltage, overload and over-temperature.

Sizing the depth of the borehole

Considering that the borehole was dug before the installation, it is paramount to determine the actual depth of the borehole. To measure the depth of the borehole, a slim hard object (25cl coke bottle) that has a weight which will suppress the uptrust from the water was tied to a rope of about 91.44m (300 ft), the rope with the object were gradually sent down the hole until it reached the top water level called the static water level (SWL), the depth at which it reached the static water level was noted**.** It continued to go down the hole until it was observed that it has reached the depth of the borehole (DB). It was noted also. This will serve as the depth of the borehole (DB). To get the water column (WC),

Static Water Level (SWL) = 37.80m
Depth of the Borehole (DB) = 51.51m
Water Column (WC) = DB – SWL
= 51.51m – 37.8m = 13.71m

The WC is very important because it enabled us to know the actual depth to place our pump to ensure that the water pump is appropriately submerged in water with the sensor. The pump was submerged 6.09m down the static water level to ensure that the pump and the sensor are completely submerged even during the dry season.

Sizing the water pipe

Considering the size of the water outlet from the pump, a 2.5mm Plastic pipe was used. Plastic pipes were used to avoid rust which is evident with metallic pipes. This is used to channel the water from the borehole to the reservoir. Each full length of the pipe is 5.49m (18ft). To determine the exact length of pipes needed we used the parameter from the sizing of the borehole;

Static Water Level (SWL) = 37.80m
Depth of the Borehole (DB) = 51.51m
Water Column = 13.71m

From sizing of the depth of borehole, the SWL is 37.80m, WC is 13.71m and the length of the pump plus the sensor when measured is 1.22m (4ft) and it must always be submerged in water. To ensure that the pump and the sensor are always submerged in water even during the dry season, they have to be submerged 6.09m (20ft) into the water column (WC).

To size the pipe
Total Length of the pipe (TLP) =
SWL + 6.09m = 37.80m + 6.09m = 43.89m

A pipe length of 43.89m is needed and each full length of the pipe is 5.49m. To get the number of 5.49m pipe that needed,

No of full length pipe needed = Total length of pipe / 5.49m = 43.89m / 5.49m = 8 full lengths.

INSTALLATION AND TESTING

With the prerequisite materials in place for the installation process, a 2.5mm single core black and red cable is used to connect the photovoltaic array in series to actualize a higher voltage for higher pumping efficiency, and the connected array is placed in a metallic rack to hold it firmly. The rack is positioned well for maximum tracking of the sun light.

A 3mm three core cable of about 43.89m length is used to increase the length of the terminal ends of the controller. A 43.89m length is used because the cable has to go down the same length as the connected pipes and 6.09m above the ground to where it is boxed.

The float switch also known as the level switch dictator is hung inside the reservoir and the terminals is channeled neatly down to the box for connection to the controller unit as shown in figure 2.

A marine rope is fasten to the end of SQFlex pump for easy lowering down the hole, with the aid of the fastened marine rope the pump and the pipes are sequentially connected and lowered down the hole starting from the outlet of the pump. When the final pipe must have been connected the pump will be place 6.09m down the SWL. The hole is covered and the remaining marine rope is fasten to the body of the cover, this will ensure that the pump is safety placed and gives easy access during maintenance. The remaining 6.09m pump terminal cable is channeled to the box for termination to the controller.

The pump terminals are terminated to the CU200 controller followed by the float switch while the solar panel array terminal is the last to be terminated. The CU200 is placed inside the box to protect it from harsh weather. Finally the box is locked to avoid unauthorized personnel from having access to the controller system.

The system connected to the solar panel array terminal, is meant to start running. The installation was completed very late in the evening and considering that the insolation level has reduced, the LVD (Low Voltage Disconnect) mode was activated by the controller due to low input voltage. The next day when the insolation level becomes high the LVD mode is automatically deactivated and the pump started running. The system was monitored until around 2pm when the float switch indicated that the reservoir is filled up. Automatically the system stopped running, when the water level reduced due to collection of water by the community, the level indicator signaled the controller to start the pump.

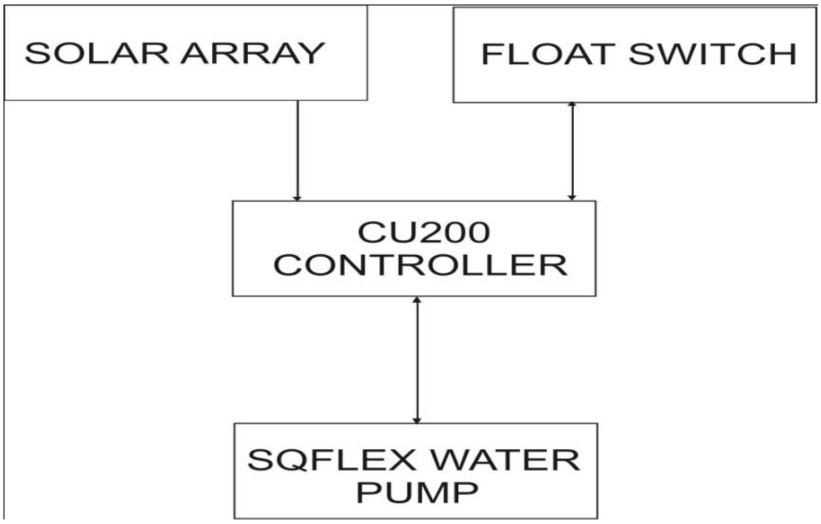

Figure 1. Block diagram of the communication line between the solar powered borehole components.

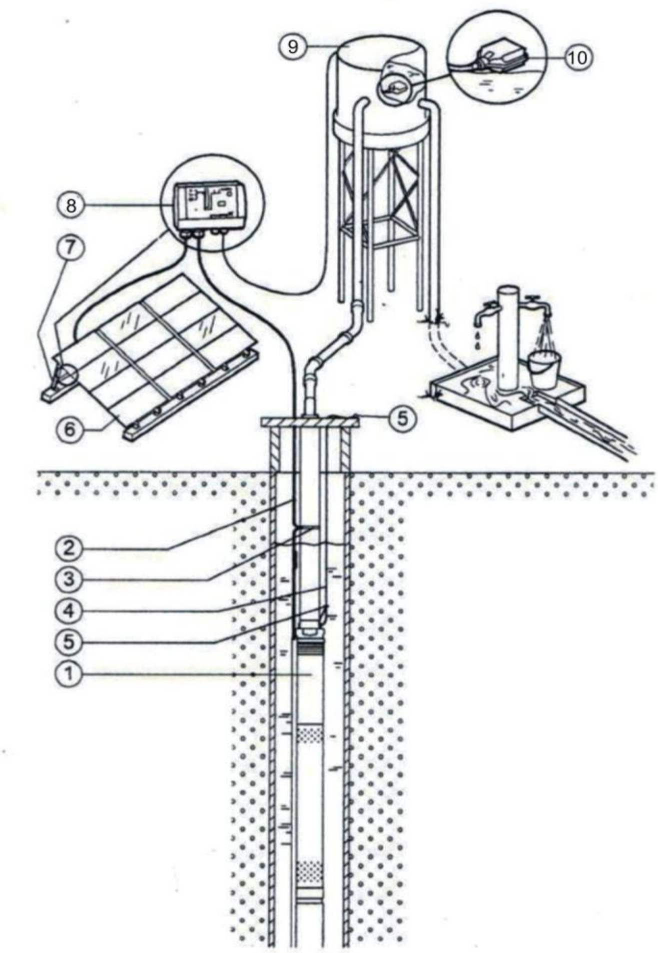

Figure 2. Schematic diagram of a solar powered borehole

CONCLUSION

An automatic solar powered borehole has been successfully constructed and installed. This system works automatically and ensures constant water supply to the community and primary health center where it is installed. The automatic state of the system stands it out from even the ones powered with our epileptic grid power source or our generators which needs an operator to be controlling and fueling it. It can be installed in remote, inaccessible areas like forest, deserts, mountains, off-shore platforms, and rural areas. The installed system needs little or no maintenance and it is environmental friendly.

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