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SOLAR-POWERED WATER PUMPING SYSTEM FOR CATTLE WATERING IN MUBI CATTLE MARKET

I.U. Haruna[1], W. Ibrahim[2]
[1]Department of Mechanical Engineering, Federal Polytechnic Mubi, Adamawa State, Nigeria
[2]Department of Mechanical Engineering Technology, Federal Polytechnic KauraNamoda, Zamfara State
Email: heldabuk@yahoo.com; wadaasy@gmail.com

ABSTRACT
Cattle like other creatures require water supply for survival.The shortage of water supply for cattle in Mubi cattle market is a thing of concern for all and sundry. This inadequate water supply in the cattle market apart from directly affecting the health of the animals, it also affects the cattle marketers from economic standpoint. Instead of relying on the supply of water by water tankers and truck pushers, this paper attempts to design a solar-powered water pumping system for cattle watering in the market. The average daily water requirement by the cattle is obtained from daily number of cows in the market for two years. A deep well jack pump with 75-volt dc motor is used. The worksheet employed in this design reveals that an average pumping rate of 2405 1litres/hr of water can be produced by71 Modules of 917 Watts. This technology can go a long way in addressing the inadequate water supply in the cattle market and in any other cattle market having similar problem.
Keywords: Solar, Pump, Water, Cattle, Worksheet

INTRODUCTION
Living creatures require adequate and healthy water supply for survival. In fact water is considered as one of the nature's important gift to living things. In many developing countries like Nigeria, herdsmen depends largely on traditional sources of water such as streams, ponds, wells, etc to water their animals. In communities where there is acute shortage of water supplies, there tend to be competition between the livestock and the settlers on the sources available which often results into a clash between the herdsmen and the settlers. To avoid such problem and to have adequate water and forage, the herdsmen often move their cattle farther from the village or town. This movement of cattle also causes clash between the herdsmen and settlers as a result of the absence of defined cattle routes or the deliberate trespass of farmlands by the herdsmen. In dry season, there tends to be a concentration of cattle on the available surface water source. This excessive livestock pressure on the available surface sources often cause nutrient loading, streamside vegetation damage, erosion, pollution, and decreased animal growth and health [1][2].

There are many cattle markets in Nigeria and practically all of them rely on rainwater and other sources such as streams and water purchase from water tankers and truck pushers. In the dry season, the water supply to these markets is often inadequate as the water tankers and the truck pushers also supply water to people for domestic usage. This practice affects the quantity of water intake by the cattle which invariably affect their health and performance. Studies have shown that the average water requirement of a cow is 75 litres per day [3]. Therefore, if there are many cows in the market meeting their daily water needs using the traditional sources especially during the dry season is difficult. Since cows in the cattle market are often confined until they are sold, the use of alternative water sources is imperative. Studies have shown that the installation of watering system in a cattle market will go a long way in minimizing water shortage problem.

Study has shown that to cut down cost the installed pump should be electrically powered if the distance from the point of installation of the pump and the grid lines is less than 1000 feet [4]. Studies have shown that most of the cattle markets in Nigeria are located at a distance of less than 1000 feet from the utility grid but the epileptic nature of the electricity supply in the country would impede the smooth operation of the pump. Although, mechanical windmills, diesel-powered and gas-powered generators are also used to run the pump, the cost advantages of solar pumping are generally strongest in low-head and low volume situations [5]. Nigeria, especially the northern part, is blessed with abundant sunshine which can be utilized to run the water pumps. In fact in hot season, there is a natural match between the volume of water produce by the solar-powered water pumping system and the quantity of water requirement by the cows. Therefore, this work is an attempt to design a solar-powered water pumping system for cattle watering in Mubi cattle market.

The Study Area

The cattle market is situated in Mubi-South local government area of Adamawa State, Nigeria. The town is located on latitude 10.5° and longitude 13.5°[6]. The market is one of the biggest cattle markets in Nigeria and one of the major sources of revenue for Mubi-South LGA and the state. It has a size of approximately 1100ft by 950ft. The number of cows in the market is a function of season and market day. The daily average number of

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cows from January through December recorded in the market for 2016 is presented in Table 1. The market gained its popularity because of its vicinity to the Nigeria-Cameroon boarder. By virtue of its closeness to the boarder, cattle marketers find it easy to transport their cattle from the neighbouring countries, precisely Cameroon and the Chad republic to the market. The market is also one of the major cattle markets where marketers buy cows for onward transportation to the South-east, South-west and South-south of Nigeria. One of the major challenges faced by the cattle marketers with their cows is inadequate water supply as they solely rely on water tanker and trucks pushers for their water supplies. Therefore, as the market grows the water shortage will tend to increase which means a reliable and sustainable means of getting adequate water for the cattle is imperative.

Table 1: Average Daily Cows and their Water Requirementin Mubi Cattle Market (2015-2016)

Month	(No. of Cows/Day)	Daily Water Requirement (L/Day)
January	518	38850
February	783	58725
March	799	59925
April	876	65700
May	968	72600
June	1024	76800
July	1109	83175
August	1211	90825
September	1017	76275
October	848	63600
November	546	40950
December	582	43650
Average	856.75	64256.25

Description of the Solar-Powered Water Pumping System

Apart from the well itself, the solar water pumping system composed of two primary components, the PV panels and the pump. A good match between the pump, PV array, and the system parameters is necessary to achieve

efficient operation. The PV array converts the solar radiation to direct current which is to be used to operate the pump. The pump is used to move water from the borehole. The cattle watering system has a small pipe work from the water storage to the watering troughs. Small distribution is also required since there is more than one watering trough to avoid cattle congestion when drinking water from the troughs.

Principle of Operation of the System

In this system, the PV panels converts energy from sunlight and generates DC electricity which is then directed through a controller to the pump/motor in what is termed a direct-coupled system. The pump/motor combination moves water from the borehole through a pipe to a storage tank that feeds trough-drinkers. This direct-coupled system is intended to operate only during the day when sunlight is present, thus eliminating the expense and complexity of batteries. In this system, extra water should be pumped into a storage tank which can be used at night or on cloudy days. Fig. 1 shows a direct-coupled solar pumping system.

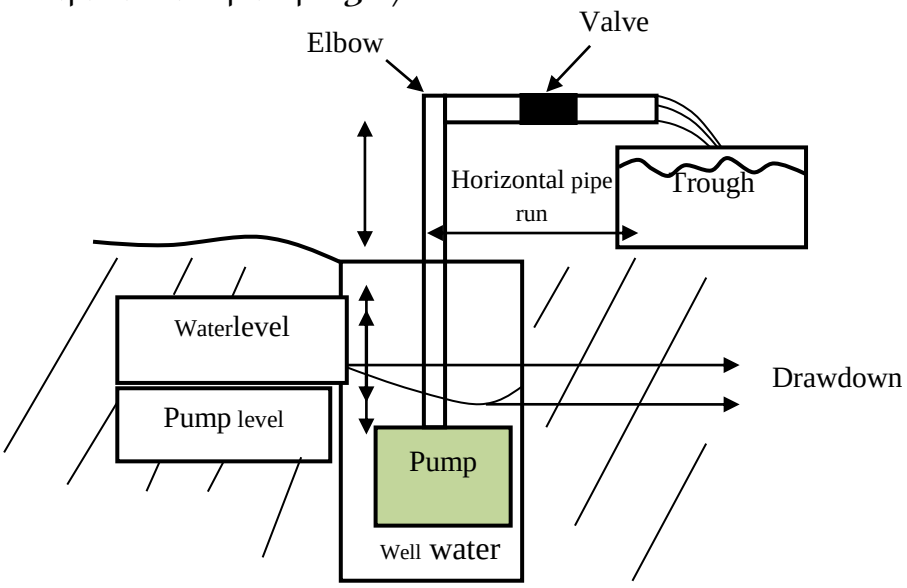

Fig. 1 Direct-Coupled Solar Pumping System

METHODOLOGY

The cattle water requirement is an important criterion for designing a solar-powered water pumping system. To determine the water requirement, information about the number of cows in the cattle market was obtained for

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two years (2015 – 2016). Since study shows that an average cow drinks about 75 litres a day [3], therefore the average hourly water requirement for January through December was determined and presented in Table 2. The information from Table 2 is then used to determine the average daily water requirement. Since many cows are to drink from this source, a jack pump with a 75-volt dc motor is used. The array is to be connected to the motor through the maximum power point tracker. A generator can be connected to the motor if a major failure occurs so the system sizing is considered noncritical. The pump stroke is approximately 14 inches at 30 strokes per minutes under full sun. Worksheets are then used to determine the pertinent parameters such as the array size, the design current, pumped water, pumping rate, etc. The schematic diagram of the system is shown in fig.2.

Table 2.Water Requirement (2015 – 2016)

Month	Daily Water Requirement (L/Day)	Hourly Water Requirement (L/HR)
January	38850	1618.75
February	58725	2446.88
March	59925	2496.88
April	65700	2737.50
May	72600	3025.00
June	76800	3200.00
July	83175	3465.63
August	90825	3784.38
September	76275	3178.13
October	63600	2650.00
November	40950	1706.25
December	43650	1818.75
Average	**64256.25**	**2677.35**

Worksheet 1: Determination of the Water Pumping Load

Source Capacity (L/HR)		Water Required Per Day (L/DAY)	Pumping Time Factor		Peak Sun (HRS/DAY)		Pumping Rate	
Large		64256.25	÷	1.2	÷	5.4	=	9916.09

Static Level (m)	Drawdown Level (m)		Static Lift (m)		Discharge Head (m)		Static Head (m)		Allowance for Friction (m)		Static Head (m)		Total Dynamic Head (m)	
10	+	6	+	1	+	0	=	17	×	0.03	+	17	=	17.51

Water Required per Day (L/DAY)	Total Dynamic Head (m)		Conversion Factor		Hydraulic Energy (WH/DAY)		Pump System Efficiency (Decimal)		Array Energy (WH/DAY)		Nominal System Voltage (V)		Amp-Hour Load (AH/DAY)	
64256.25	×	17.51	÷	365	=	3082.54	÷	0.25	=	12330.16	÷	12	=	1027.51

Water Pump and Motor Information	
Make/Model	Solar jack SDS-D-224
Pump type	Diaphragm
Motor type	1/10 hp DC
Input voltage (AC/DC)	12V DC
Optimum current	2.7
Pump system efficiency	0.25

Amp-Hour Load (AH/DAY)	Wire Loss Factor (Decimal)		Battery Efficiency Factor (Decimal)		Corrected Amp-Hour Load (AH/DAY)	
1027.51	÷	0.99	÷	1.0	=	1037.89

Worksheet 2: Design Current and Array Tilt

Corrected Amp-Hour Load (AH/DAY)	Peak Sun (HRS/DAY)		Design Current (A)			Tilt Angle
1037.89	÷	5.4	=	192.2		10.5°

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Worksheet 3: Determination of System Array Size

Design Current (A)	Module Derate Factor (Decimal)	Derated Design Current (A)	Rated Module Current (A)	Modules in Parallel			
192.2	÷ 0.9	= 213.6	÷ 3	= 71			

	Nominal Battery Voltage (V)	Batteries in Series	Voltage Required for Load (V)	Highest Temperature Module Voltage (V)	Modules in Series	Modules in Parallel	Total Modules
1.20	× 12	× -	= 14.4	÷ 13	= 1	× 17	= 17

PV Module Information					
Make/Model	Siemens M75	Nominal Volt	12		
Length	48″	Width	13″	Thickness	2″
Weight	11.6 pounds	Bypass Diode	Y/N√		
Voltage (V)	At STC	Open circuit	At Highest Expected Temperature		
Current (A)	At STC	Short Circuit			

Modules in Parallel	Rated Module Current (A)	Rated Array Current(A)
	× 3.0	= 51
	Module sc Current (A)	Array sc Current (A)
	× 3.4	= 57.8
Modules in Series	Rated Module Voltage (V)	Rated Array Voltage(V)
	× 15.9	= 15.9
	Open cct Module Voltage (V)	Array Open cct Voltage(V)
	× 19.8	= 19.8

Worksheet 4: Pumped Water and Pumping Rate

Modules in Parallel	Rated Module Current	Nominal System Voltage (V)	Pump System Efficiency (Decimal	Conversion Factor	Peak Sun (HRS/DAY)	Module Derate Factor (Decimal)	Total Dynamic Head (m)	Pumped Water (L/DAY)

	(A)			)												
17	×	3.0	×	12	×	0.25	×	367	×	5.4	×	0.9	÷	17.51	=	15585.03

Pumped Water (L/DAY)	Pumping Time Factor		Peak Sun (HRS/DAY)		Pumping Rate (L/HR)	
15585.03	÷	1.2	÷	5.4	=	2405.1

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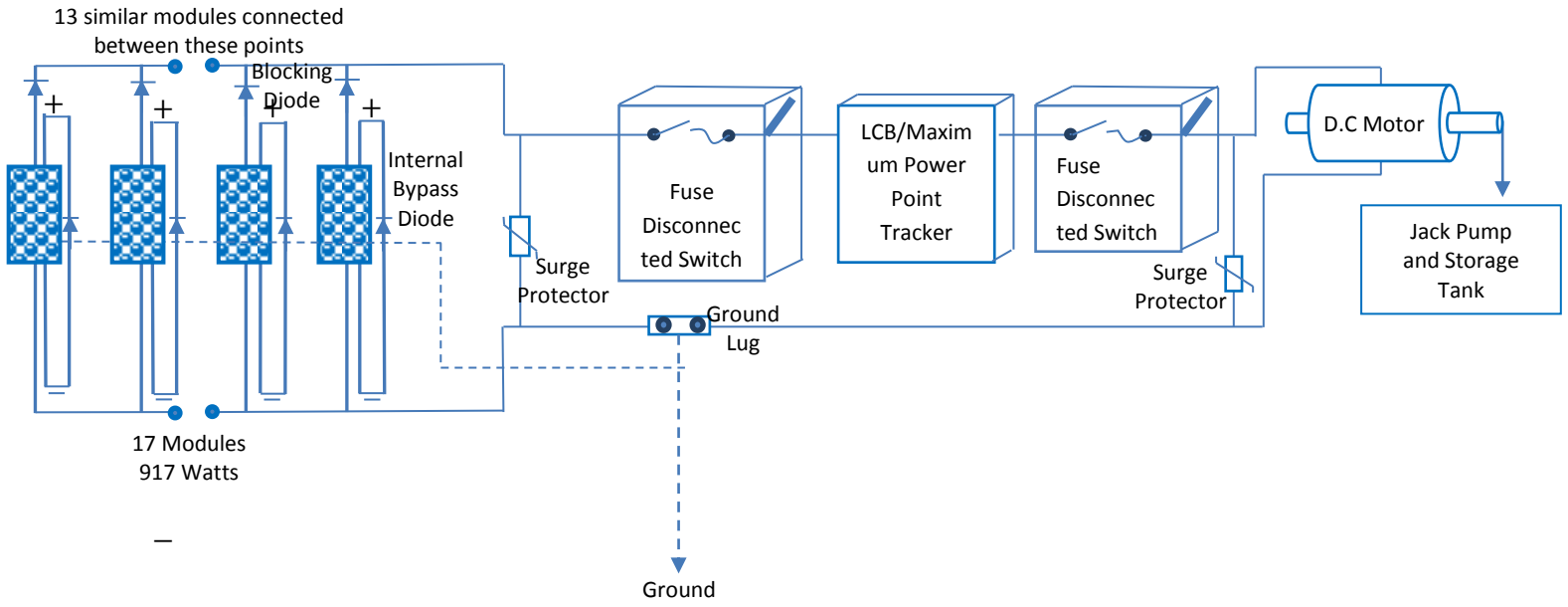

Fig. 2 Schematic Diagram of the Solar Water Pumping System

CONCLUSION

The solar-powered water pumping for cattle watering for Mubi cattle market was designed. The designed which was based on the average daily water requirement using worksheet shows that the water pumping rate is 2405.1litres per hour. This however can be achieved using 17 modules of 917 watts. Therefore, the use of photovoltaic-powered water pumping system is attractive and can go a long way in ameliorating the shortage of water problem faced by the cattle market.

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