River Water Pumping by Solar Energy Project for Pauk Myaing Village, Tadau Township, Mandalay Division

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Abstract- In this paper, a stand-alone solar water pumping system is designed for rural area at dry region of Myanmar. This system is designed for any water pump type which has a 5 horse power, AC permanent magnet motor and a single-state surface pump. This paper gives many options to users not only on pump but other system component such as inverter, charge controller and solar module. The Experiences gained during implementation stage of 3248W solar pumping system project is shared.In this research, the PV water pumping system considered for supplying water from Ayeyarwaddy river for a village named Pauk Myaing with 200 households. The capacity of water requirement is 162 m3 per day for 1000 people and cattle. In this section estimate the total amount of power required by 200 families is 3284 W and it will consume about (average) five hours per day and seven days in a week. The user can select system component according to their availability of such items on the market.The main aims are the potential for optical concentration to reduce the cost of solar water pumping system has been noted a number of times and the computed coats of the more cost-effective configurations of solar pumping systems, if produced in quantity appear competitive with current and projected costs of photovoltaic systems. The objectives are to have ready technology in the future, to provide irrigation by using direct solar energy and to reduce the cost solar water pumping system has been noted a number of times.The PV pumping system can be designed to a very small water pumping requirement for drinking water to large water volume requirement for irrigation purpose. The small scale PV water pumping system for 1000 people (200 families) is design. The water demand is 42840 gallons per day in summer and the capacity of water requirement is 162 m3 per day.

Index Terms – River water pumping, solar energy, rural area, dry zone.

I. INTRODUCTION

Solar water pumping systems are a practical and affordable solution used to solve water shortage problems. Due to rolling blackout and the constantly rising cost of fuel, pumping of water from surface water and groundwater wells has become extremely difficult for farmers and other water users. Solar powered systems are proven as an affordable alternative pumping system for rural area (drinking water, planting water and other use) individual farmers and enterprises.

Solar water pumping systems use photovoltaic (PV) cells to power DC pumps. DC pumps require considerably lower power than conventional AC pumps and provide greater efficiency. Solar systems only operate during daylight hours and the water pumped out must be stored in a storage tank for use 24 hours per day, to ensure constant availability of water. The tank capacity should be designed to allow for rainy or cloudy days (no sun days) when pumping will be limited. The size and dimensions of the storage tank is determined based on the required number of days storage. If large storage tanks are impractical, back up batteries or a petrol generator can also be incorporated in the design to allow for prolonged periods of no sun days that will eventually empty the water storage tank.

Each component must be carefully matched, and proper planning is essential – so the final system will be efficient and reliable system and can function for many years to come. In this project, direct solar water pumping system is used therefore battery system is not required.

II. SOLAR ENERGY FOR WATER PUMPING

A solar cell or photovoltaic cell is a device that converts light energy into electrical energy. Sometimes the term solar cell is reserved for devices intended specifically to capture energy from sunlight by the photovoltaic effect, while the term photovoltaic cell is used when the light source is unspecified.

Generally, solar energy is utilized in two ways, solar thermal and solar electric development. A small stand-alone type solar PV power system can provide power to a rural house for lighting, fans, TV, a small refrigerator and water pumping. Apart from this household application, PV power water pumping system are being installed to provide portable water and for low consumption irrigation purpose. Pumping water is a universal need around the world and the use of photovoltaic power is increasing for such application. PV power pumping systems offer simplicity, reliability, and low maintenance for a broad range of applications between hand pumps and large generator driven irrigation pumps. Both AC and DC motors with rotary and displacement pumps are being used with PV power.

Brushless DC motors are now available and provide low maintenance on shallow submersible pumps. The PV arrays are often mounted on passive trackers to increase the pumping time and production of water. The design of photovoltaic water pumping systems, firstly because water pumping is a major application for photovoltaic and secondly because the design of each system is considerable more complicated than most applications, owing to the large range of water source types consumer requirement and system configurations. In the simplest photovoltaic water pumping systems, the solar panels are directly connected to a DC motor that drives the water pump. For this project, AC motor is used for water pumping system.

Solar powered pumps can provide an equal volume of water per day without the high and inefficient energy demands of a large capacity AC pump. Instead of pumping a large volume of water in a short time and turning off, the solar pump works slowly and efficiently all day.

Solar energy has two other big advantages. Firstly, unlike fossil fuel and nuclear power; it is an environmentally clean source of energy. Secondarily, it is free and available in adequate quantities in almost all part of the world.

III. COMPONENTS OF THE SYSTEM

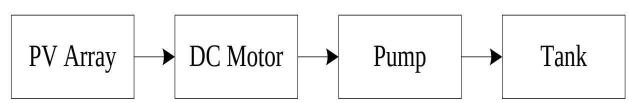
In this typical solar pumping system, the following items are included

- Photovoltaic Array
- Charge Controller
- Power conditioning for the adaptation of the photovoltaic generator to the other system components. This is a DC to AC inverter.
- Electric motor
- Pump
- Pipe, valves and fitting
- Water storage tank

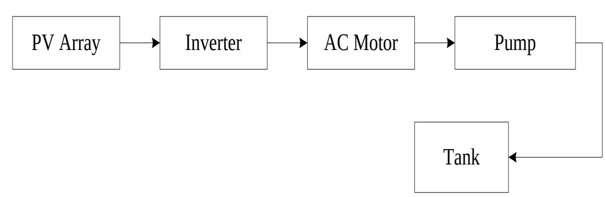
Two different systems configurations are currently been studied:

System1: PV array is directly coupled to a DC motor and a pump.

System2: PV array coupled to an inverter which is then coupled to AC motor and a pump.



(a)



(b)

Figure 1 (a) DC Motor Driven System(b)AC Motor Driven System

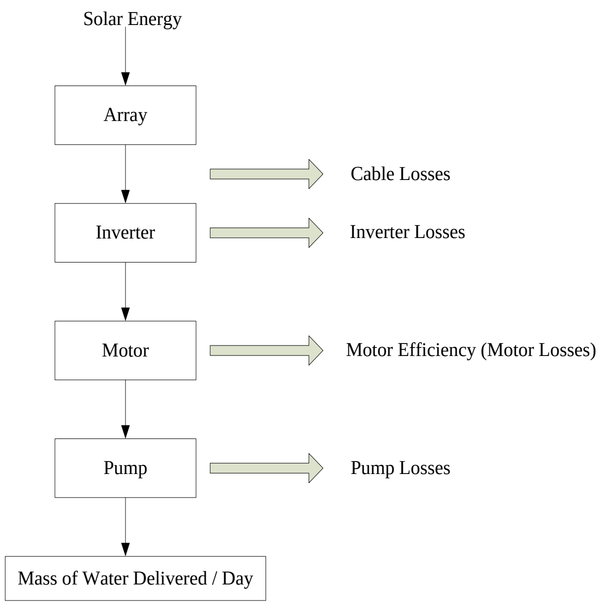


Figure 2 Typical Pump Installation Pump-set and Water Storage Tank

IV. LOCATION FOR PV PUMPING SYSTEM

In most locations in the Union of Myanmar winter produces the least sunlight because of shorter days and increased cloud cover, as well as the sun's lower position in the sky. Usually, one work with yearly average, June and July average when isolation is highest, and December and January average when isolation is lowest. When selecting a site for the solar power panels to pick a spot that are clear of shade from a minimum of 10 (am) to 2 (pm).

Even a limb from a deciduous tree will substantially reduce power output. Since Pauk Myaing is a land of plentiful sunshine, solar energy is available around the country. Pauk Myaing is situated, riverside of Ayeyarwaddy, in the middle part of the Mandalay Division; it enjoys abundant sunshine all year around. The main business of this village is agriculture and dairy cattle husbandry.

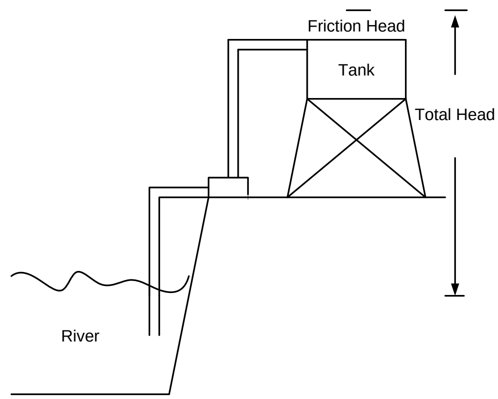


Figure 2 Typical Solar Pumping System

The sun path of the Mandalay is shown in Figure 3. These data were obtained from the NASA Langley Research Center Atmospheric Science Data Center.

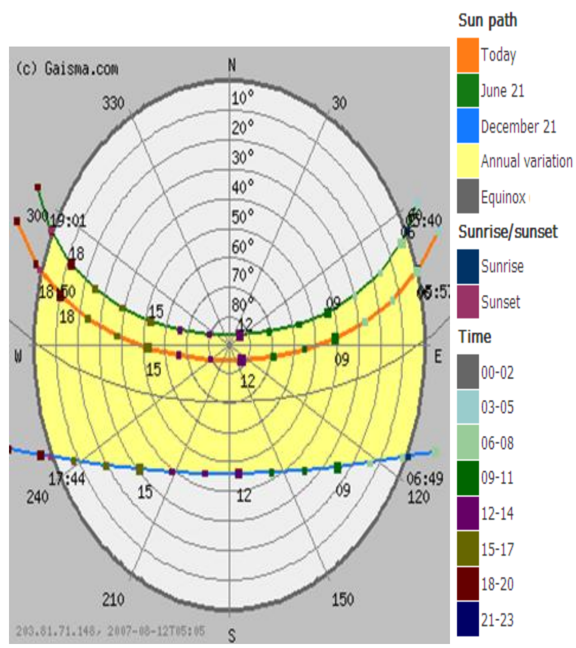


Figure 3 Mandalay, Myanmar – Sun Path Diagram

V. DAILY AMOUNT OF WATER REQUIREMENT

Domestic water requirements vary markedly in response to the actual quantity of water available. Some local knowledge of the population and their way of life is therefore an essential requirement in estimating the water demand for a village. For first rough estimation of the energy demand one may consider a yearly sum of the required "final consumer energy". In a photovoltaic pumping system this is the hydraulic energy needed to pump the required water quantity.

Table 1. Monthly Averaged Radiation, Temperature of Mandalay

Month	Radiation ($kwh/m^3/day$)	Temperature High/Low ˚F
JAN	4.5	85/58
FEB	5.65	91/62
MAR	6.06	98/69
APR	6.33	102/76
MAY	5.97	99/78
JUN	5.45	95/79
JUL	4.88	95/79
AUG	4.64	93/78
SEP	4.70	93/78
OCT	4.34	92/75
NOV	4.07	88/68
DEC	3.99	84/60

The following table show values for the typical daily water consumption in rural regions, which may taken as a basis for the calculation of the energy demand, which has to be covered by the photovoltaic power system.

Generally, it can say that there are four persons and some plants in a family. This table assumes a family of five, with each person requiring 90 liters of water per day. Therefore the normal consumption of a family can be calculated by:

Table 2. Daily Amount of Water Requirement For Human

No	Per person	Gal/day	Lit/day
1	To survive	1.1	5
2	Minimum consumption	6.5	30
3	normal consumption	8.8	40

The following equations are used to design for river water pumping by solar energy system.

Daily electrical energy demand

$$= \frac{\text{Peak daily hydraulic power output}}{\eta_{\text{motor-pump}}} \quad (1)$$

Table 3. Daily Amount of Water Requirement For Animal

No	Per Family	Gal/day	Lit/day
1	Cattle	10	45
2	Sheep and goat	1.1	5
3	Horse	10	45

Table 4. Daily Amount Of Water Requirement For A Family

No	Per Family	Gal/day	Lit/day
1	Four persons	95.2	360.37
2	Plant watering of a garden	23.8	90.09
3	Animals	23.8	90.09

$$H_{total} = H_{s+}H_{d+} H_f \quad (2)$$

Where,

H_s = The static head

H_d = The drawdown

H_f = The friction losses

$$GPM=\frac{\text{gallons per day}\times 1\text{ hour}}{\text{peak sun hours per day}\times 60\text{ minute}} \quad (3)$$

Hydraulic energy, $E=\frac{QH}{365}$ (4)

Where,

Q = Volume of water lifted

H = Total head

Energy output for photovoltaic panel

$$=\frac{\text{Peak daily hydraulic power output}}{\eta_{cable}\times\eta_{motor\text{-}pump}\times\eta_{inv}} \quad (5)$$

Total Wp of PV capacity needed

$$=\frac{\text{Total PV energy need}}{3.43} \quad (6)$$

$$\text{Number of module}=\frac{\text{Total Wp of PV capacity needed}}{\text{Rated output of module}} \quad (7)$$

$$\text{Number of series module}=\frac{\text{System nomonal voltage}}{\text{Vmpp}\times\text{derting factor}} \quad (8)$$

Number of parallel module

$$=\frac{\text{Total number module}}{\text{Number of series module}} \quad (9)$$

Rated array current = Number of parallel module x Impp(10)

$$\text{Friction Losses} = f\times\frac{L}{D}\times\frac{v2}{2g} \quad (11)$$

L = Length of pipe,
D = Diameter of pipe
f = factor,
v = Velocity,
g = gravity

Table 5:Design Data

No	Specification	Value	Unit
1.	Daily demand (gal/day), for 1000 people	42840	gal/day
2.	Peak Daily output energy	8.12	kWh/day
3.	Flow rate, Q (gpm)	142.8	gpm
4.	Total length of pipe	50	ft
5.	Total head requirement	40	ft
6.	Pump efficiency	50	%
7	Energy output of PV Panel	12.6578	kWh/day
8	Number of Module	9	nos
9	Inverter Rating	7.5	kW
10	Motor Rating	5	HP
11	Charge Controller rating	110	A
12	Cable size (Array-Inverter	25	(SWG)mm^2
13	Cable size (Inverter-Motor)	10	(SWG)mm^2

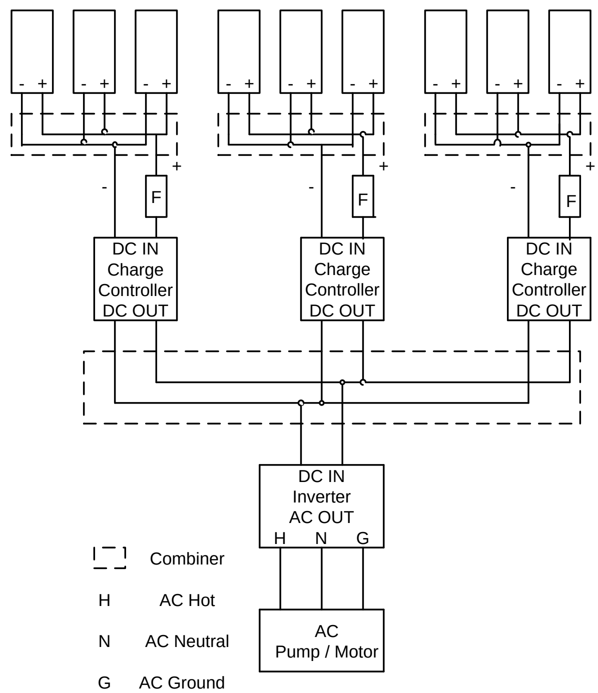


Figure 4 Wiring Diagram of AC water Pumping System

VI. CONCLUSION

The research area is situated on Pauk Myaing Village, Tadau Township, Mandalay Division, and the middle part of Myanmar. Results so far over a rainy season, worst month condition for Myanmar, are good. There's plenty of power available to supply the water pumping system when direct use from output of array converts by inverter. Although the rainy season, sun shining hours is less than the others, all the intended appliances work well as estimated. The charge controllers do a good job keeping the batteries charging. The data (voltage and current) collect, shows from the controller display, according to the weather conditions and how to change the provide power from panels arrays help to understand more in practice. This system will work well in during summer and winter because of sunshine hours is more than rainy seasons and estimate the system was sized as maximum in winter condition.

Pumping water is a universal need around the world and the use of photovoltaic power is increasing for such application. PV power pumping systems offer simplicity, reliability, and low maintenance for a broad range of applications between hand pumps and large generator driven irrigation pumps. Both AC and DC motors with rotary and displacement pumps are being used with PV power. The PV arrays are often mounted on passive trackers to increase the pumping time and production of water. The design of photovoltaic water pumping systems, firstly because water pumping is a major applications for photovoltaic and secondly because the design of each system is considerable more complicated than most applications, owing to the large range of water source types consumer requirement and system configurations.

In this design, 9 numbers of solar modules SCT300 are required. Each PV modules can produce 300 W (V = 35.3 V, A = 8.22 A). They are parallel connected (9 × 300 W) solar modules as three pairs, (3 × 300 W) panels connect in parallel as one pair or a set due to the charge controller, which is 15A. Four sets of solar arrays feed the charge controller each. So, in this design, number of three 15A charge controller is used. The load requires an AC voltage. Therefore, 7.5 kW inverter and 5hp single-phase AC motor are used. Inverter is used to convert the DC power supply by the PV generator or the storage battery into AC power. In this design, the water demand is 42840 gallons per day in summer and the water is store in a two numbers of 22500 gallon open metal tank on site.

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