STEPS DESIGN OF A SOLAR STATION (THE SOLAR PUMPING)

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ABSTRACT

In our days, it seems to us that nobody can suspect it on the importance of water and energy for the human needs. With technological advances, the energy need does not cease increasing. This problem of energy is even more sensitive in the isolated sites where the use of the traditional resources proves often very expensive. Indeed, several constraints, like the transport of fuel and the routine maintenances of the diesel engines, return the search for an essential alternative energy source for this type of sites. it summer necessary to seek other resources of energy of replacement. Renewable energies, like photovoltaic energy, wind or hydraulic, represent a replacement solution par excellence and they are used more and more in our days more especially as the national territory has one of the solar layers highest with the world. The duration of insolation can reach the 3900 hours per annum on the Sahara. The energy acquired daily on a horizontal surface of 1 m2 is about 5 kWh, that is to say meadows of 2263 kWh/m2/an in the south of the country. The photovoltaic energy utilization for pumping of water is well adapted for more the share of the arid and semi-arid areas because of the existence in these areas of an underground hydraulic potential not very major. Another very important coincidence supports the use of this type of energy for the water pumping is that the demand for water, especially in agriculture, reached its maximum in hot weather and dryness where it is precisely the moment when one has access to the maximum of solar energy. This work is for the goal to see an outline on the general composition of a photovoltaic system of pumping, as well as the theoretical elements making it possible to dimension the current pumping stations.

Keywords:Water, Energies Renewable, photovoltaic pumping, requirement out of water, Agriculture.

1 INTRODUCTION

Irrigation by small scale pump is one of the most interesting uses of solar energy. Indeed, the maximum intensity of solar radiation is generally the most important period of pumping water needs. On the other hand the fact that this energy is available just at the point of use, the farmer is released from fuel supply problems, or the existence of electricity transmission lines easily accessible. At present, the main obstacles to the use of solar pumps larger scale, are their high cost and too recent nature of this technology. The development of sufficiently reliable solar pump and a reasonable cost - which would be very likely in a few years - could give a coup to agriculture in the Third World.

Pumping in the Saharan regions is the only solution for irrigation of agricultural land and drinking water. Following the experience gained on the ground and various studies conducted, irrigation photovoltaic pumping systems is the best way for rapid development of agriculture in the Saharan regions. Particular attention should be given to this strategic project and considered it for several reasons among them:

• Wealth of the water area at shallow depths (Pm 15 m); Very large area of land that can be exploited and stability of the population in remote areas.

The flow supplied by a pump is the amount of water it displaces during a given time interval. Solar pump, the flow is often in m3 per day.

Calculation of general pressure losses
Calculating the linear pressure loss, that corresponding to the general flow in a rectilinear conduit is given by the following general formula:

• Dp = linear pressure loss in Pal = pressure loss coefficient (dimensionless number), p = density of water in kg / m3, V = flow velocity in m / s, D = hydraulic diameter tube in m, L = length of tube in m
The general load losses depend on the following elements:

• The pressure drop is logically directly proportional to the length of the pipeline: it increases when the line length increases.

• When the diameter decreases, the loss increases considerably. The liquid is more difficulty thus flow friction increases to the same rate.

• As the flow increases (higher speed) plus the friction forces increase for the same diameter.
The total head Hmt:
• It is the pressure difference in meters of water column between the suction and discharge ports. This height can be calculated as follows:
Hmt = Hg + Pc (1)
with:

• Hmt: Geometric height between the sheet of water pumped (dynamic level) and plan to use (see Figure 1). It is calculated by the following formula:

- H_g= A + B + C (2)

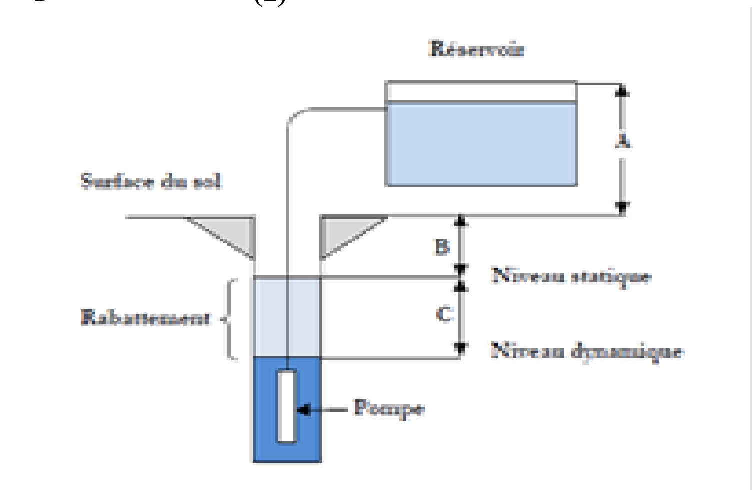

Figure 1 .Hauteur gauge total.

• Ns: The static level in a well or borehole is the distance between the ground and the pump before the water surface.
• Nd: The dynamic level of a well or borehole is the distance the soil and the surface of the water for pumping to a given flow rate. For the calculation of the HMT, the dynamic level is calculated for an average flow rate.
• Folding: The difference between the dynamic level and the static level.

• Maximum Drawdown: is the maximum acceptable drawdown before stopping the pump.
• Pc: Pressure losses produced by the friction of water on the walls of the pipes.
• They are expressed in meters of water and are a function of distance lines (D), their diameter and the pump capacity.

2. THE COMPONENTS OF A PV PUMPING SYSTEM

A solar pumping system usually consists of: [4]

- The photovoltaic generator, the electric pump unit, control electronics and control and the storage part,

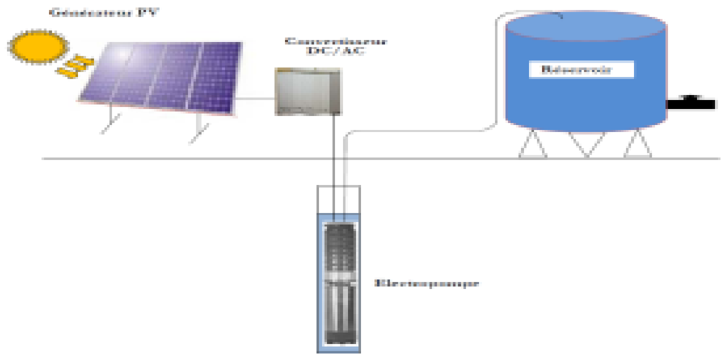

Figure 2. Simplified Block Diagram Pumping PV

2-1 The photovoltaic generator

For higher powers, it is necessary to combine serial and parallel multiple modules. In some applications, it is possible to use one or more modules of several tens of cells. For larger applications, the PV generators are grouped in a field of several modules (a few hundred).

The curve of I-V operating a seriated-parallel association of solar modules will have a similar evolution operating in the basic cell curve, but by changing the échèles on both axes. The performance of a PV generator are determined from these curves.

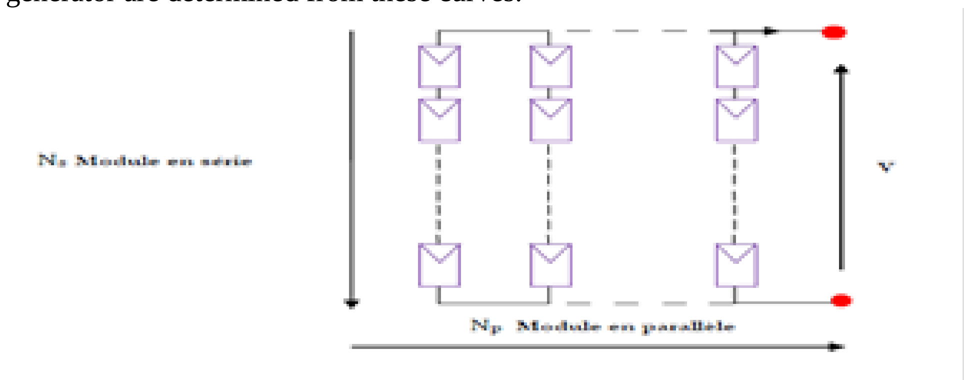

Figure 3. Module Ns Harness in series and in parallel Np

Using the equation below for a mixed group formed from a number

$$I = N_p . I_{ph} - N_p . I_0 \left[exp\left(\frac{N_s . V + \frac{I . N_s R_s}{N_p}}{n . N_s . V_T} \right) - 1 \right] - \frac{N_s . V + \frac{I . N_s R_s}{N_p}}{\frac{N_s R_p}{N_p}} \quad (3)$$

Ns Np module series and parallel module

2.2. The electric pump unit

A pump is a device for sucking and discharging a fluid. There are two main types of pumps: centrifugal pumps and positive displacement pumps. These are suitable for raising low water flows at high pressures. [2]

2.2. 1.La centrifugal pump

The centrifugal pump conveys the kinetic energy of the fluid motor by a rotational movement of paddle wheels or fins. The water returns to center of the pump will be pushed outward and upward through the centrifugal force of the blades.

2.2.1.1 Characteristics of a centrifugal pump

- Centrifugal pumps are widely used for applications with photovoltaic energy because the couple drive of the pump is zero at start
- The pump runs with very low sunshine, the motor can provide fast speed nearly constant
- Use for high flows.

3. FULL SYSTEM DESIG

The different steps for the design of a pumping system are: Assessment of water needs, water power calculation necessary Determination of solar energy available and component selection.

3.1 Estimates of water requirements

For a tropical region, water requirements can be defined using the following values of the table [Humans: Person 5 to 10 liters / day minimum, normal living conditions 30 liters / day

Animals: Sheep and goats 5 liters / day Horse 40 liters / day Ane 20 liters / day, Camel 20 liters / day

Irrigation

Agriculture maraichère 60m3 / hectare / day, Rice 100 m3 / ha / day, cane sugar 65 m3 / ha / day, Cotton 55 m3 / ha / day

3.1. 1Calculation of daily hydraulic energy required

Once the necessary volume of water needs for each month of the year and the characteristics of the well defined, we can calculate hydropower daily and monthly average needed from the relationship

Eh = Ch. Hmt Q. (4)

with:

Eh: Hydropower kwh / d Ch: Constant hydraulic kg .s. h / m2 Q: Water volume (m3 / d) Hmt: Total height gauge (m), C = g. ρ / 3600 g: the gravity (9.81m / s2) and ρ: Density of water (1000kg / m3)

3.1. 2Calculation of daily electrical energy required

The energy required to raise a certain quantity of water to a certain height during a given day is calculated from the following equation:
Ee = Eh / ηmp xηond (5)

Where: Ee: Electric energy expressed in kWh / d Hmp: The performance of the pump unit, generally between 30% and 60%, Hond. The inverter efficiency.

3.2. Determination of the available solar energy

The design method used is based on the calculations of monthly daily average values of solar radiation available to the inclination β of the photovoltaic (PV) relative to the horizontal plane. This must be done to maximize the conversion of sunlight into electrical energy.

3.3. Size of the PV array

Two methods are used for sizing photovoltaic pumping systems: an analytical method and graphical method. These methods allow to design a photovoltaic pumping system to meet the water needs of a determined consumption.

3.3.1 Analytical method

Once known the daily volume Q (m 3 / day), the total head and the incident Hmt average irradiation in terms of generating the corresponding rated power of the photovoltaic generator Pc is calculated by the following expression [6] :
The power provided by the PV generator in the measurement standard conditions CSM

(Illuminance (1000w / m2) and the temperature 25 ° C).

Pc = ηg. A. G (6)

with:

Pc: The power output of the generator (w) under MSC (peak power).

Hg: The efficiency of the generator to the reference temperature (25 ° C).

A: The active area of the generator (m2).

G: The illumination in the MSC conditions.

The daily electrical energy is given by the equation:

Ee = ηpv. A. Gd ( ) (7)

ηpv: The average daily output of the generator in the operating conditions

Gd ( ): The average daily radiation incident on the level of modules inclination (kwh / m2 / d)

Hpv the yield is calculated by the following formula:

ηpv Fm = (1 - γ (T-Tr) ηg (8)

Or :

Fm: Coupling factor, defined as the ratio between the electrical energy generated under the conditions of operation and electric energy that would generate if the system working at maximum power point.

γ: cell temperature coefficient. γ assumes values between 0.004 and 0.005 / ° C for

modules in mono and poly crystalline silicon, and 0.001 and 0.002 for amorphous silicon modules.

T: average temperature of the cells during hours of ensoleillement.4

Calculation of power in watts peak, which should have the field.

Substituting equations (8) (7) (5) (6), we obtain the peak power of the generator:

3.3.2 Graphical method

The calculation of the power of the PV array can be done in two ways: either by analytic expressions as that given so high, or using the performance charts pumps supplied by the manufacturer that provides a function of irradiation overall Pc power required developed by the panels to operate the pump in this range of flow, and HMT. These are quite handy (see Figure 5) and summarize the performance of different pumps for the conditions of their use. [3]
The graphs:

These are graphic facilitating direct reading digital calculations. Graphics for spontaneously determine the result of calculations in a system of predefined lines and prepared beforehand. The graphs are operated by a direct reading without having to perform additional plots by reading data directly lying at the intersection of corresponding lines by reading the dot competing in relation to the needs of the speaker. The equipment manufacturers are developing such diagrams based on calculated or measured data. This kind of graphs shows the possible configuration of an electric pump. By way of example, Figure 6 shows the characteristics of the electric pump 3 SP14A-GRANDFOS given by the manufacture.

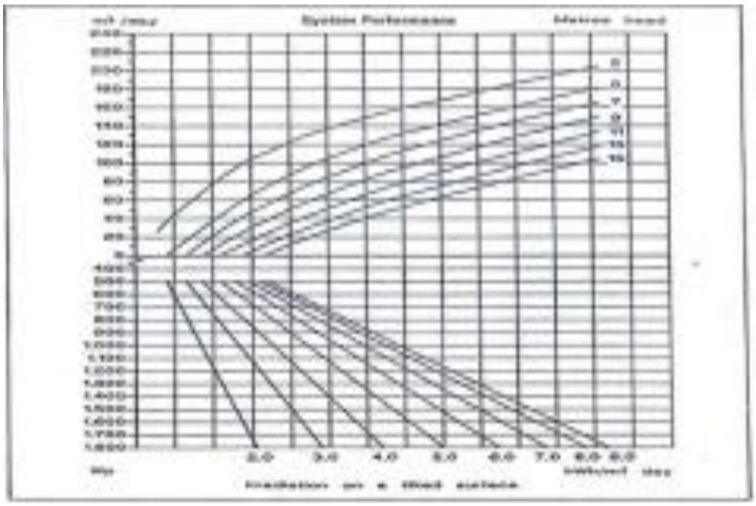

Figure .6. typical performance curve of pump conditions of use

3.4. Pump dimensioning

The choice of the pump is ba (10) sed on the following two factors:

• The discharge head and HMT The hourly flow rate Qh.

$$Q_h = \frac{Q[m^3/jour]}{h}$$

h: is the number of hours maximum sunshine in (1000w / m2)

3.4.1. Sizing solar pumping stations

To set the output power to operate the pump powered by solar panels, the minimum data are:

The geographical location to determine the overall solar radiation, the flow rate to determine the daily water needs during the maximum required period, the total head for measuring the static level, the maximum drawdown, the tank height and load losses due to the pipe.

We proceed as follows: [7]

Set monthly daily global irradiation in mh / m2 / d compared to the latitude of the work area, choose a pump depending on flow and total head (use the pump performance charts provided by

3.5. Pump dimensioning

The choice of the pump is based on the following two factors:
• The discharge head and HMT The hourly flow rate Qh.

$$Q_h = \frac{Q[m^3/jour]}{h} \qquad (10)$$

h: is the number of peak sunlight hours at (1000w / m2)

3.5.1. Sizing solar pumping stations

To set the output power to operate the pump powered by solar panels, the minimum data are:
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We proceed as follows: [7]

Set monthly daily global irradiation in mh / m2 / d compared to the latitude of the work area, choose a pump depending on flow and total head (use the pump performance charts provided by the manufacturer) Choose UPS for your pump (voltage and power) Determine Pc peak power required to operate the pump by the analytical method and graphical Choosing the type of solar panel (set nominal power Pn) Determine number of panels by the relation Pc / Pn, check the rated voltage for operation of the inverter (depending on model), determine the number of series / parallel module (form connection). [8]

CONCLUSION

In our literature review, two PV pumping techniques were presented: pumping over with sun and pumping drums. We showed interest pumping said "over the sun." We could also conclude that the photovoltaic pumping systems the most common, according to the state of the art, consist of a centrifugal pump with a tiny three-phase induction motor. The engine is powered by a photovoltaic generator without batteries, via a three-phase variable frequency inverter designed specifically for this application. We also gave important and necessary definitions for understanding the practical study presented in the following chapter.

REFERENCES

A.Labonne,«Alimentationd'une pompe à Burkina Faso »,2004.

A. Hadj Arab, M. Benghanem et A. Gharbi, « Dimensionnement de Systèmes de Pompage Photovoltaïque », Rev. Energ. Ren. Vol. 8 (2005) 19 – 26.

A. DJAFOUR, « Etude d'une station de pompage photovoltaïque dans une région saharienne », Thèse de magistère, université de Ouargla, 2000.

A. HADIDI « Synthèse Bibliographie sur le pompage solaire et la dimensionnement de la station de pompage photovoltaique» ,Rapport annuel , MAI 2016.

B. Molle, « Les stations de pompage individuelles pour l'irrigation », juin 1996.

B. Multon, H. B. Ahmed, N. Bernard, « Les moteurs électriques pour applications de grande série », Pierre-Emmanuel CAVAREC Antenne de Bretagne de l'École Normale Supérieure de Cachan, Revue 3EI juin 2000.

J. Royer, T. Djako, « Le pompage photovoltaïque», Manuel de cours à l'intention des ingénieurs et des techniciens, Université d'Ottawa, 2002.

S. LABED. « Le pompage photovoltaïque et le développement des régions sahariennes », Colloque International sur les Ressources en Eau Souterraines dans le Sahara (CIRESS) Ouargla - 12 et 13 décembre 2005.Pompage Photovoltaïque ''Rev.Energ. Ren. Vol. 8 (2005) 19-26.