Performancesof Photovoltaic-Diesel-Batteryhybrid power system for supplyan agricultural farmin dry Areas

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Abstract:The aim of this work is the simulation of the performance of a hybrid system to supply electricity a Saharan farm. This hybrid system is composed of a photovoltaic generator and a diesel generator. The system usesbatteriesto storeelectrical energy. The applicationwas made fora farmlocated inGhardaïa, insouthern of Algeria.
The simulation performance has been achieved through use the software Homer. Analysis of the results demonstrated the reliability of the hybrid system to satisfy the required load.

Keywords:Photovoltaic, Hybrid, Farm, Simulation, Renewable energy, Performance.

I. INTRODUCTION

Electrical energy is a necessary factor in developing sector of agronomy. The use of electrical machines in this sector increases the demand for electricity, which encourages the orientation to the use of another source to improve energy efficiency on farms. The energy policy of Algeriaorient to renewable energy use, which reduces the burning of fossil fuels and CO_2 emissions therefore emission, which is the main cause of global warming. This should land climate change and many countries if measures are taken. [1]

The Sahara of Algerian enjoys the favor of the use of solar energy conditions. Solar power their ability to operate its direct conversion into electrical energy using photovoltaic (PV) to electrify farms. The PV system necessary to equip with storage batteries that store electricity and return it on time.However, in an installation for PV generator [2]. Research has shown that the direct coupling of a PV array and battery is the easiest to achieve, but it cannot provide good performance and cost a lot [3], having batteries that is a member critical, it should not be too heavy or too exhausted. [4] The diesel generator is widely available in many common powers with the PV system as an extra source for charging batteries

For this the focus of our work focuses on the simulation performance of this hybrid system using the software for the purpose Homer operates solar energy to meet the electrical needs of a crop farm.

II. MODELING THE HYBRID PV SYSTEM

The mini-plant hybrid comprises a PV generator with a converter, and storage batteries.It also uses a generator Diesel as a source of extra to charge the batteries.Modelling system components enables we give its performance.

A. Modélisation de la température ambiante

The PV generator is the main source of energy in the PV-diesel-battery system.Calculation of daily production (E_{pv})depends on solar light (G), the temperature of the solar cells (T_j) and the operating point of the system.

$$T_j = T_a + G * \left(\frac{NOCT-20}{800}\right) \quad (1)$$

Where T_a is the ambient temperature, NOCT is nominal operating cell temperature.
According to [5] - [6] NOCT is the temperature of the cell in determining the PV module sowing the conditions wherein the illumination is 800 W / m^2, and the temperature of 20 °C.

B. Modeling of PV generator

The PV module consists of several cells that convert solar energy into electrical energy. In this work based for current-voltage characteristics (I-V) of PV cell consists of a diode Fig. 1.

The program of software allows us to calculate the cell temperature from the global irradiation on an inclined plane and the ambient temperature value match. Thus the maximum power (P_{m}) delivered by the PV module.

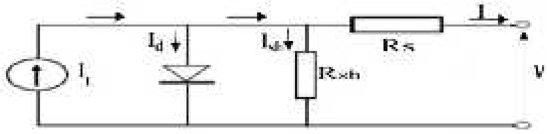

Fig.1:Electrical equivalent circuit of a solar cell.

The PV modules are grouped in series or in parallel due to increase the current and voltage of the PV generator to satisfy the need for the given load. The number of module connected in series (N_s) and the parallel (N_p) allows us the determined voltage and the current of the PV array by calculating the following equations:

$$V_G = N_s * V_M \quad (2)$$

$$I_G = N_p * I_M \quad (3)$$

Where V_G and $I_G$are the voltage and current of the PV generator, V_M and I_M are the voltage and current of the PV module respectively.
The power output PV generator (P_{G}) calculated by [8]:

$$P_G=P_M *N_s*N_p \quad (4)$$

With P_M is the power of a PV module.

C. Battery state of charge

The energy stored in the batteries in time period (t) Time slices during the charging period is calculated by [5]:

$$E_{Bc}\ t = E_{Bc}\ t-1 * 1-n_s + \left[\frac{E_{pv}(t)-E_l\ t}{n_{cnv}}\right] * n_{batt} \quad (5)$$

The energy stored in batteries during the discharge energy is:

$$E_{Bd}(t) = E_{Bd}(t-1) * (1-n_s) + \left[\frac{E_{pv}(t)-E_l\ t}{n_{cnv}}\right] \quad (6)$$

Where E_{Bc} (t) and E_{Bc} (t-1) are stored in the batteries for two successive time energy, n_s is the coefficient for which the batteries self discharges, $n_{cnv}$is the coefficient of converter and n_{batt} effective is charging batteries ranging from 0.65 to 0.85.

The estimate of the battery state of charge (SOC) is complicated [9], it depends on battery power during charging and discharging (E_{Bd}).The choice of minimum energy (SOC_{min}) to keep the batteries is based on cost and the lifetime of the PV hybrid system. And the SOC schedule time slot t is calculated by:

$$SOC(t) = \frac{E_{Bd}(t)}{C_{bat}*V_{nb}} \quad (7)$$

Where C_{bat} and V_{nb} are the capacity and battery bank voltage respectively.

III. SIZING THE HYBRID PV SYSTEM

Homer (The hydrideoptimization model for electric renewable) is developed by(National renewable electric laboratory) Laboratory of Energy of the United States of America Department. This is a simulation tool, design and optimization of PV hybrid systems / Wind / Diesel. Homer simplifies the task of evaluating the design of autonomous and non-autonomous systems for various applications and can make the simulation on an hourly basis thousands of system configurations and allows you to find the best combination of system components economically.

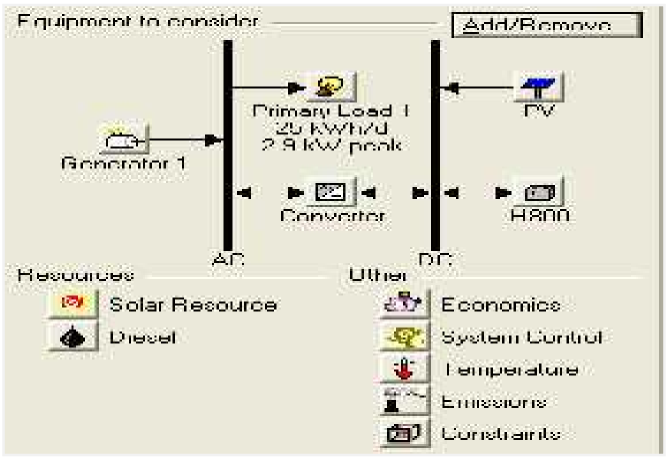

Fig. 2: PV-Diesel-Battery system configuration in Homer software.

Shows in Fig. 2.the components of hybrid PV-Diesel-battery systemconfigured by Homer software.

A. Présentation de site

The agricultural farm is located in El-Gurrara which 150 km away from the capital of the province of Ghardaia having latitude 32° North, longitude 4° and altitude of 450 m. For the final design of the PV generator, it is based on the most favorable terms [10], that is to say, we must choose the most favorable due to the higher daily capacity or months of existence of a source of appoint PV-battery system is the generator.

B. Load profile of the daily consumption.

For our study we chose a farm with a profile of energy consumed daily schedule is given in Fig. 3.

Consumption is important in the morning, between 4 and 6 o'clock, and from 8 to 10 am and in the afternoon between17 and 18 o'clock because of the use of milking machine and high power machines such as the mixer and the crusher for food preparation. Evening, consumption is mainly due to the lighting of the farm and local workers.

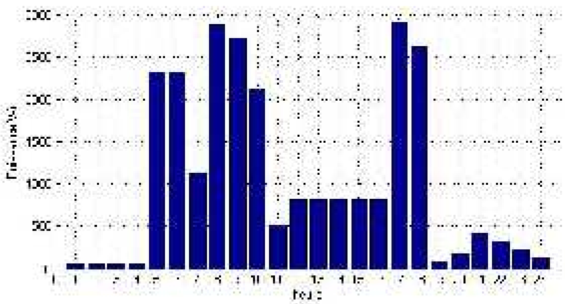

Fig. 3 Le profil de charge de la consommation journalière

C. Choice of PV module

In our work, the design of the system is based on data from the PV module type UDTS-50 whose electrical characteristics are presented in Table.1 the UDTS-50 solar module consists of 36 solar cells square monocrystalline silicon, 10 cm side, connected in series (Table. I).

TABLE I
CHARACTERISTICS OF SOLAR MODULE UDTS-50.

G [W/m^2]	T[°C]	I_{cc} [A]	V_{co} [V]	I_m [A]	V_m[V]	P_m [W]	n_m	FF
1000	25	3.21	21.30	2.95	16.10	47.5	0.11	0.72

D. Use and storage of PV energy

The PV energy is used through a converter, or stored in the batteries when it is in excess. The converter has a role to transform the electric battery power to 220VAC, and its input voltage is 48V.

E. Meteorologycaldata

Ghardaia has a very important solar potential in Algeria. Its location gives it an important energy wealth as its insolation fraction frequently reaches values that exceed 75%, while the daily global radiation received on a horizontal plane is about 6000 Wh/ m² annual on average [11].

We represent in Fig. 4 monthly changes of sunlight horizontally and angle that is equal to 32 °. We have the month of June is more favorable with 6984 Wh/m^2 [12].

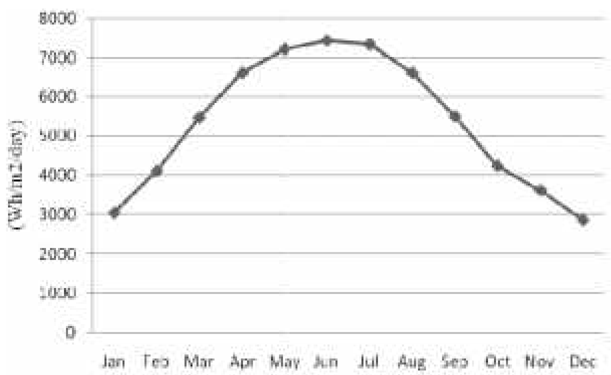

Fig. 4: The average monthly of global irradiation on the horizontal plane.

IV. RESULTS AND DISCUSSIONS

Homer software we can give results about, the size of system PV hybrid, his configuration, and energy produced by PV hybrid system.

A. Sizing the components of hybrid PV system

From the Fig. 5, Homer class as the hybrid PV system with the best combination of energy cost (COE) of $ 0.602 / kWh, fuel consumption 2858 l / year allows the use of the generator operation of order of 1,950 hours per year, and system components that are obtained in the results of design where the size of the PV array under Homer is the same as was sized to the site.

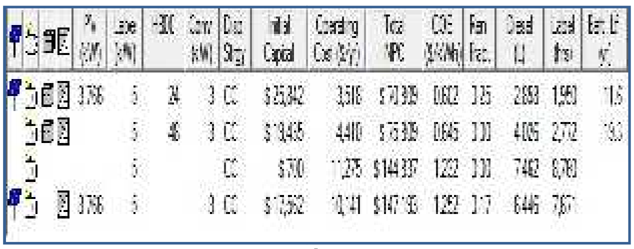

Fig. 5: Results per category.

The size of the PV generator with storage is shown in Table 2. The PV array required to meet a load of 25.2kW/day power 3.76 kWc. It consists of 81 modules in 3 strings, 27 modules by string (Table. II).

TABLEAU II
RESULT OFTHE SYSTEM SIZING.

Load (kW)	Solar energies (hour)	Size PV array (kWc)	Battery capacity (Ah)	Module PV	Batteries
25.2	6.9	3.76	820	27×3	24

B. Results the simulation of the system

Fig. 6 shows the daily of monthly load average and the average daily PV power output delivered by the system to supply the load for each month of the year.

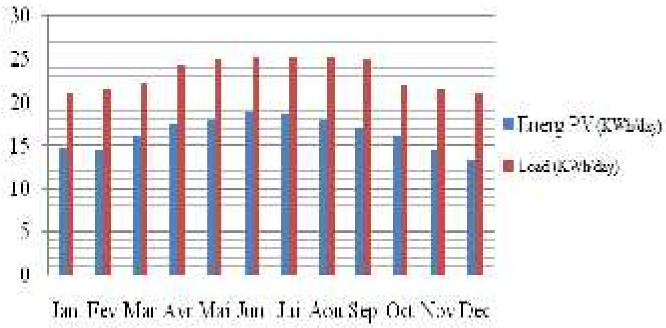

Fig. 6:Monthly of average electric PV product and load.

According to this figure obtained representing the variation of output of the PV array from the load. It is recorded that the latter is fixed vis-a-vis the change in output of the PV generator which varies between 13kWh/day at least in the month of December and 19kWh/day maximum in April.

It represents the Fig.7 the daily distributions of the incident solar radiation on an inclined plane and photovoltaic power produced.

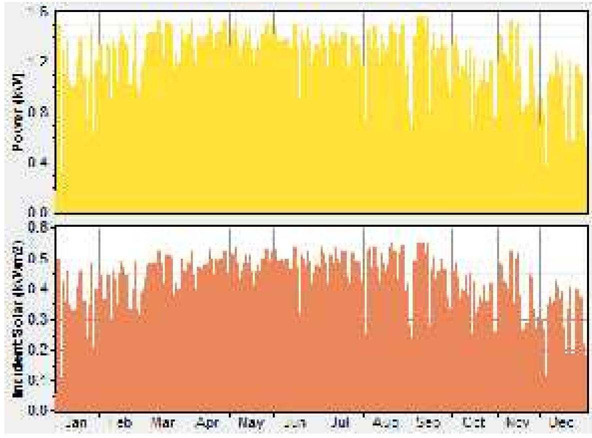

Fig. 7: Daily electric PV output and solar irradiation correspondent.

This figure that there is a perfect correlation between the incoming solar radiation on the plan of the PV array and photovoltaic power produced byhim.

Fig. 8 shows the hourly evolution of photovoltaic capacity, state of charge of the battery and the profile of the load for a typical day, the least favorable (December 21st) .The photovoltaic field generate electricity from 5h30 to 18o'clock for that day. These hours correspond the times of sunrise and sunset of the site.

The PV array is able to meet the load during these hours to charge the battery takes over at night.

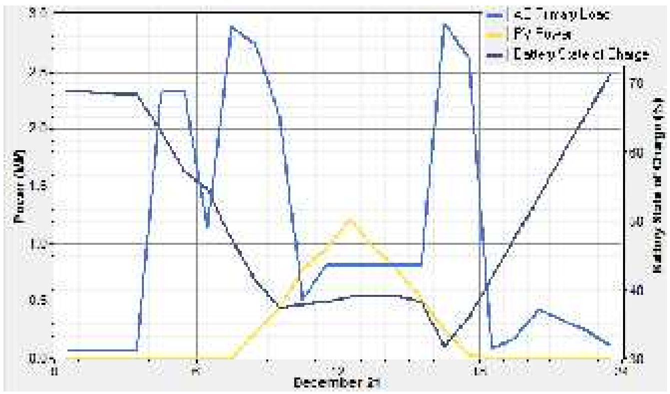

Fig. 8:The hourly energy balance December21st.

Fig. 9 shows the evolution of the state of charge of the battery over time.This figure is seen from the batteries can undergo depth of discharge during the winter or summer up to 60%.

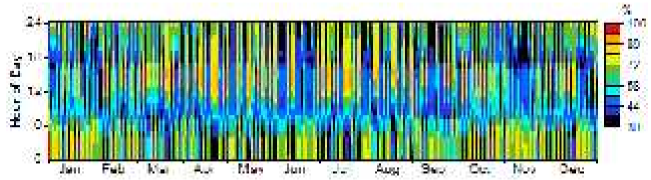

Fig. 9: Battery State of charge

Fig.10 shows the power delivered by the generator diesel per time period during the year.

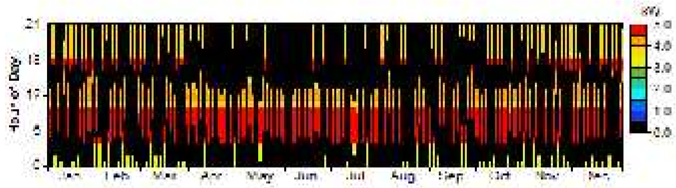

Fig. 10: Generator output

It indicates that the power produced is high during the winter months (Nov-Jan) compared to other months. This is a feature because the demand for electricity is high during these months and radiations are unfavorable compared to the summer months.

V. CONCLUSION

Our study presented the simulation of the performances of a hybrid PV system to supply anagricultural farm. Uses the Homer software allows us calculate energy PV power of a module, and array generator assembly. So to calculate the state of charge of the batteries.

The determined that the PV hybrid system simulation allows us to cover the need of load for electrics energy to supply agricultural farm in the El-Gurraraarea.

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