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Power Photovoltaic Generation System Interconnected to Grid for an apartment in Algiers City

Billel BOUMAARAF*[1] Khaled TOUAFEK[2] Salah AIT-CHEIKH[1] Rafik LAHLOUR[3]

[1] *Département d'électronique, Ecole Nationale Polytechnique, Algiers, Algeria*

[2] *Unité de Recherche Appliquée en Energies Renouvelables, URAER, Centre de Développement des Energies Renouvelables, CDER, 47133 Ghardaïa, Algeria*

[3] *Département de physique, Université de Constantine1, Constantine, Algeria*

**boumaarafbillel@gmail.com*

Abstract**—solar energy is anticipated to play a major role in electricity generation in Algeria. This source of energy is considered as an opportunity and a lever of economic especially when the citizen produces its needs in electricity by himself and participates in the development of its country indirectly. In this paper, a study of power needs of an apartment F4. A number of panels and battery required are calculated, Their performances are evaluated and compared through theoretical analysis and digital simulation; HOMER software was employed to study the power generation of the system connecting in the grid This study allows us to estimate in the future in the case of connected grid the surplus from a city of Algiers.**

Keywords—solar radiation; solar cell; PV; Inverter; Battery; Grid;

I. INTRODUCTION

Since the past few decades, electricity demand in the world has been increasing drastically due to human population growth. As a matter of fact, most of electricity demand is supplied by electricity generated from fossil fuels However, the use of fossil fuels in generation causes CO2 emissions which effect the environment negatively.

The utilisation of solar energy to produce electricity has become increasingly attractive worldwide [1].Algeria has created an ambitious program to develop solar energy this program leans on a strategy focused on developing and expanding the use of inexhaustible resources. Specially now a days with low cost of barrel of petroleum [2]. The choice to use solar energy is strengthened by its geographical location. Indeed, Algeria has one of the largest solar resources in the World. Sunshine duration exceeds 2000 hours annually and can reach 3900 hours (Highlands and Sahara).

The daily power received on a horizontal surface of 1 m² in Algeria is about 5kWh on most of territory 1700 kWh/m²/year at North and 2263 kWh/m²/year at South [3]. The aim of this work is to simulate a PV/Battery and the energy performance of grid-connected PV system under the climate condition of Algiers city. This system supplies an apartment electricity load with backup electricity network. Fig.1 shows Average annual global radiation received on a horizontal surface area.

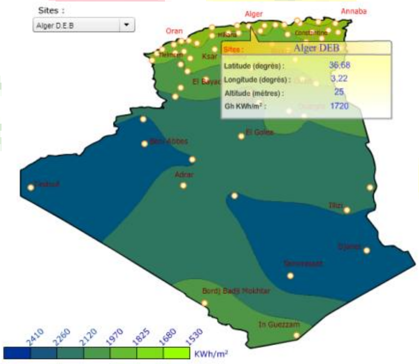

Fig. 1. Variation of solar radiation in function of time

II. PRESNTATION OF THE SITE

The city of Algiers is the capital of Algeria located in the North of the country; it occupies a strategic position due to its geographical location.

A. Daily solar radiation

The test day is 14/05/2016, the variation of the overall radiation of this day is shown in Fig. 2

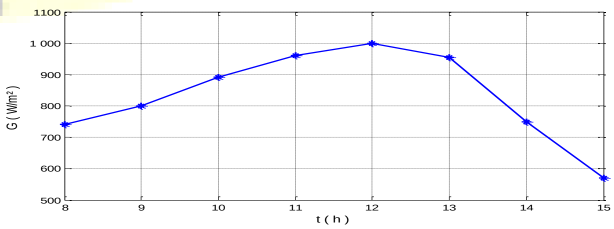

Fig. 2. Variation of solar radiation in function of time

We can notice that the power reaches 1000 W / m² at 12: 00, it is a sunny day.

B. Monthly Solar radiation

According to the Renewable Energy Development Centre (CDER),fig.3 shows the monthly average solar radiation of Algiers city [3].

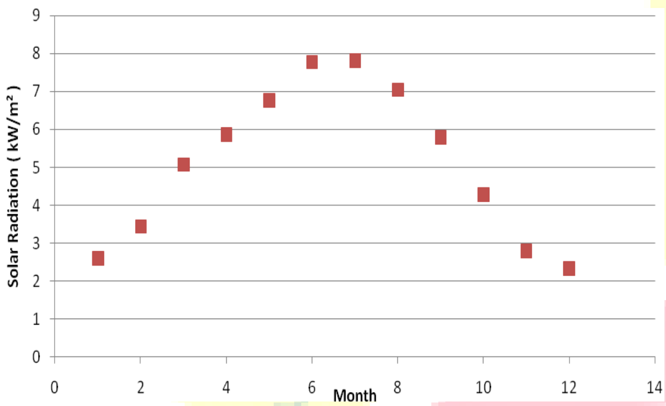

Fig. 3. Monthly solar radiation data

We note that the solar radiation is between 2.32 kWh/m² and 7.77 kWh/m². The average solar radiation over the year 5.10 kWh/ m²/day. Solar irradiance is high (above the average)from April to September, with a peak in the month of July, while solar radiation is low in January, February, march, October, November, and December.

III. System components

A. Electrical model of the panels

This model is the most classical one found in the literature [4][5][6]. As shown in Fig. 4, the equivalent circuit model of a solar cell consists of a current generator (I_{ph}) and a single diode representing the PN junction plus series (Rs) and parallel resistances (Rsh) representing the Joule losses.

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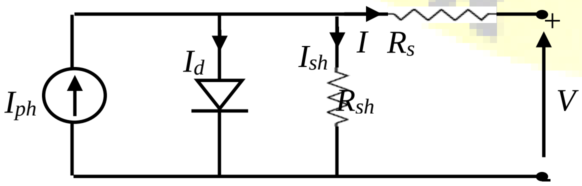

Fig. 4. Equivalent electrical circuit of a cell

Each panel group consists of a series/parallels association of elementary cells.

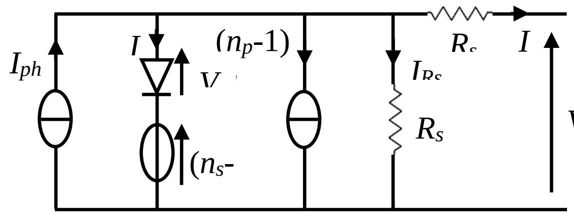

Fig. 5. Equivalent electrical circuit of a panel group

The characteristic equation for panel group GPV, is deduced from the equivalent electrical diagram (Fig. 5), can then be derived:

$$I_G = I_{phG} - I_{dG} - I_{shG} \tag{1}$$

The expression of the current generated by a photovoltaic cell is given by the following equation :

$$I_G = n_p I_{ph} - n_p I_{sc}\left(exp\left(\frac{q(V+IR_s)}{n_s nkT}\right)-1\right) - \frac{(V+IR_s)}{R_{sh}} \tag{2}$$

With:

$$I_{sc} = I_{scref}.(T/T_0)^3.\exp(-\frac{E_g}{kT}) \tag{3}$$

I_{sc}: Current of saturation of the diode.
I_{ph}: Photocurrent generated by insolation (A)
R_s: series resistor (Ω)
R_{sh}: parallel resistor (Ω)
T: Temperature (Kelvin)
T_0: Ambient temperature (T_0=25°C)
k: Boltzmann's constant (1,38.10-23 J/K).
q: elementary charge (1,6.10-19 C).
E_g: gap energy (Eg=1.12 eV).
n: Ideality factor of the diode
n_s: Number of cells series branches
n_p: Number of parallel branches

Fig. 6 shows the (I-V) and (P-V) characteristics obtained in standard conditions (T=25°C and E=1000W/m2), A brief summary on the data of PV is presented in table1.

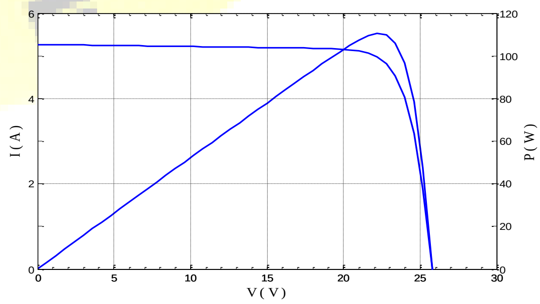

Fig. 6. (*I-V*) and (*P-V*) characteristics of a panel

Table 1

Lifetime (years)	25
Efficiency (%)	13
PV Size (kW)	20
Operating temperature (°C)	47

B. *Inverter*

The inverter size is related based on the PV size to maximize the quantity of energy which will be harvested by the inverter

from the PV arrays. A constant R is generally used to express the PV size compared to the inverter size, defined as:

$$R = \frac{size_{pv}}{size_{inverter}}$$

The inverter is frequently equal to or less than the PV size $(R \geq 1)$ because the PV does not always produce its full rated power. Most PV inverters cannot produce the reactive power. Following the new regulations adopted in the EU countries. Inverters will need to be able to supply the reactive power. In such a case, the PV inverters should be oversized in relation to the PV arrays in order to deliver the required reactive power without reducing active power production. It was also reported that oversized (30%) inverters is the optimal size at power factor of 1. [7]

A brief summary on the data of inverter is presented in table 2. The inverter life time was set at 15 years.

Table 2

Lifetime (years)	15
Efficiency (%)	90
Inverter Size (kW)	20

C. *Btteries*

The most common type of storage is chemical storage in the form of a battery. However, in some cases other forms of storage can be used like storage by capacitor.

The most used systems for photovoltaic batteries, electrochemical batteries are lead-acid batteries (Fig. 7) [8]. The data used for the storage system is given in Table 3.

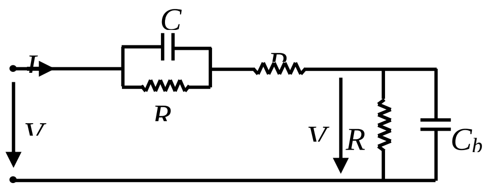

Fig. 7. equivalent model of lead-acid batterie .

The equivalent input impedance of a lead-acid battery is given by:

$$Z(s) = R_{bs} + R_{b1} \| C_{b1} + R_{bp} \| C_{bp} = R_{bs} + \frac{R_{b1}}{R_{b1}.C_{b1}s+1} + \frac{R_{bp}}{R_{bp}.C_{bp}s+1} \quad (4)$$

Table 3

Float life (years)	10
Efficiency (%)	80
Capacity (Ah)	10 842
Battery voltage (Volt)	12

IV. Generation of Hourly Electrical Load

A typical daily electrical load profile shown in Fig.8 for an apartment located in Algiers city, has a total surface of 120 m² it consist of 3 rooms, a living room, a kitchen, 2 bath room and a toilet.

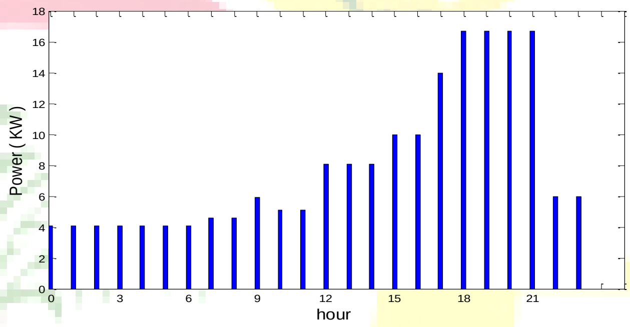

Fig. 8. daily electrical load profile

V. Results and Interpretations

The block diagram of the complete chain: PVG - converters - electrical network studied is given in fig.9. If the grid is disconnected the control circuits from the inverter open connection with the grid, the inverter is then supplied by the batteries to provide all the power necessary to the critical loads. [9].

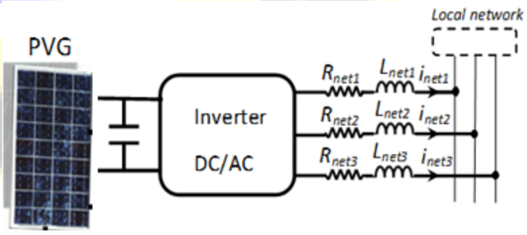

Fig. 9. Schematic diagram of the PV generation system

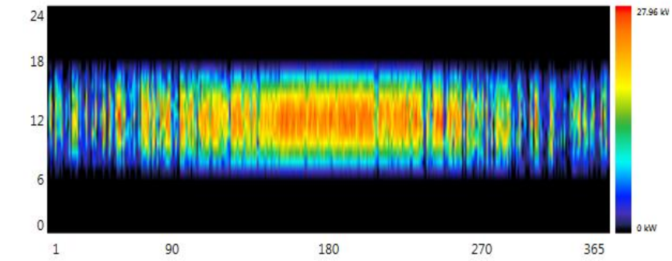

Fig. 10. Annual electric energy production by PV system

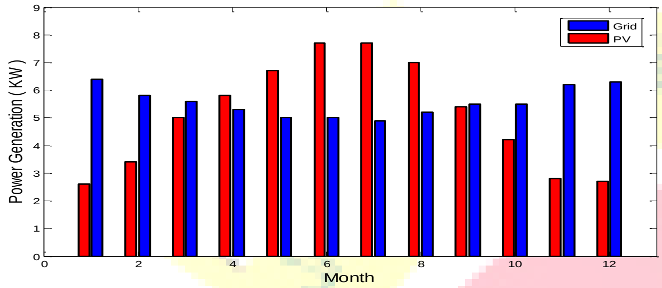

Fig. 11. Contribution of electrical energy production by PV/Grid substation

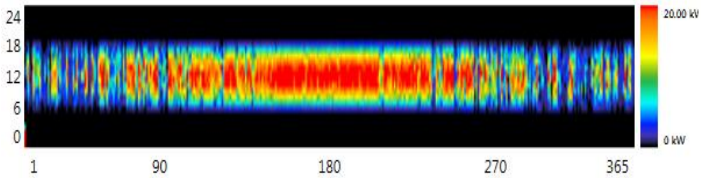

Fig. 12. Annual outpout power of Inverter

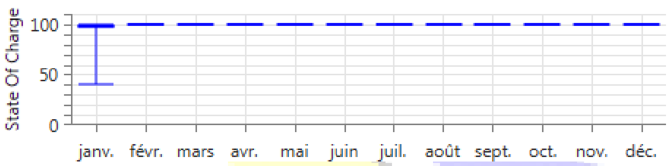

Fig. 13. Statistical result of battery system

In the month of April, May, June, July and August due to sunny day total energy purchased is very less because solar radiation is maximum (…) as compare to other months. in the month of January, February, March, September, October, November and December the generation of power through PV system is less so that energy purchased from grid in this month is high as compared to other months.

The inverter size depends in maximum DC input power and by consequence depends on solar radiation. The average of state of charge is a 100 % in all months of the year because the battery fields are dimensioned to generate the electricity in the case of non-grid generation and non-solar days.

VI. Conclusion

The proposed system is designed and optimized using HOMER software to supply energy to primary load and in case of base load excess energy generated by alternative source sold to the grid substation. The PV arrays produce direct current (DC) at a voltage, which depends on the specific design and the solar radiation.

The inverter size depends in maximum DC input power (i.e. size of the PV arrays in peak watt) as well as the maximum specified output power (i.e. the AC power provided to the grid). The and by consequence depends on solar radiation.

Battery storage system is also important which stored energy in case of low demand and excess generation of electricity in the aim to generate it in the case of non-grid generation and non-solar days.

VII. References

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