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Photovoltaic (PV) System Connected to the Grid without Battery Storage as a Solution to Electricity Problems in Burkina Faso

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Abstract:This work presents a key solution to the electricity problem faced by many African countries by inserting systems (PV) connected to the network without storing batteries. African networks are typically characterized by low installed power. In this study we suggest the use of a PV system connected to the network without storage of the batteries as a solution to the problems.The simulation shows that this proposed system allows to meet the energy demand of the consumer; To reduce its electricity bills and to reduce the load on the electricity grid.

Keywords: Problem, PV, African Networks, Power, Consumer, Electricity, Grid.

Introduction

In recent years the problem of electricity in Africa particularly in West Africa becomes increasingly disquieting. Faced with the incapacity of the local powers installed which does not satisfy the demand, some countries of this zone like Burkina imported a large quantity of electrical energy from the neighboring countries to satisfy its demand [1-3].For example, Burkina imported in 2015 443 GWh; Which represent approximately 31% of the total energy injected into the grid [4]. This part imported from production is generally a source of instability because all the countries of West Africa are experiencing some instability. Moreover, the energy losses on the distribution network are very enormous.

For example, in 2015, it was noted that these losses were estimated at 114 GWh [4]. This situation represents a real handicap for the economic and social development of this country. It therefore becomes very imperative to find a solution that can reduce the load of the network in order to stabilize it.

In addition, the cost reduction of photovoltaic (PV) and technical advances in electronics conversion devices and power semiconductors make PV an asset to many African countries, especially those with a permanent sunshine throughout the year such as Burkina Faso [5-8].

In this paper, we propose a PV system connected to the grid without storage as a solution.

This system will function by injecting the surplus to the grid. We conceive to power consumer electrical loads and the power grid is considered a secondary source of supply and storage.

The work is presented in two (2) sections: Section 1 describes the methods and materials used and Section 2 presents the results and analysis.

I°) Materials and methods

1°) Data Series

For our study we collected from ten (10) consumers of the low voltage (LV) network of the city of Ouagadougou in Burkina Faso, the average of their load profile of July. Of these 10 consumptions four (04) are subscribed to the counter of 5 A and 06 are on 3 A.The daily sunshine and temperature data were obtained from the photovoltaic power station installed at the Ministry of the Environment in Burkina Faso [9].

2°)Choice of PV system

PV systems connected to the grid can be classified into two groups [1-3]:

- ✓ PV systems connected to the grid with storage (SCGS);
- ✓ PV systems connected to the grid without storage (SCGWS).

Work has already been done with the SCGS as a solution to the problems of electricity for a country where the interruption rate is very high mainly due to the load shedding [1-2,10].

In this paper we propose SCGWS as a solution because when the proliferation of PV systems becomes important, the network will be less overload and the balance between production and consumption could be reached which will reduce the load shedding.

Currently, there are two types of SCGWS:

- ✓ PV systems with total injection of production: all the energy produced by the PV system is sold to the network distributor, the load is exclusively powered by the network;
- ✓ PV systems with injection of surplus production: The energy produced by the PV system is directly consumed by the loads. The possible surplus of production over the instantaneous consumption is sold through distributor network.
  Net energy = Energy purchased -Energy sold.
  Net energy can be positive or negative.

The surplus injection PV system has been used in this paper as it seems more suitable for consumers on the LV network.

The LV network study is typical of the Burkinabe national network (nominal voltage Un = 220 V and frequency f = 50 Hz).

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The table below gives the maximum PV power to be installed for each counter.

Counter	3 A	5 A	10 A
Maximum counter power(W) P =U*I*cos φ	530	880	1760
Maximum PV system power (W) P=U*I	660	1100	2200

For our study, we will install a PV system of 600 W for consumers whose counter has 3 A and 1000 W for the 5 A (in standard conditions of irradiance G = 1000 W / m2 and T = 25 ° C).
To simulate the operation of the network, we implemented the system under Simulink / Simpower.

3°) LV network model in Simulink/Simpower

The representation of the study LV network is given in figure 1. This diagram is composed of several blocks: the two bocs data Load and data PV allow to insert respectively the data of the load and the field PV; The Measurement block is used to perform all possible calculations we need on the network, namely network voltage, net power, and so on.

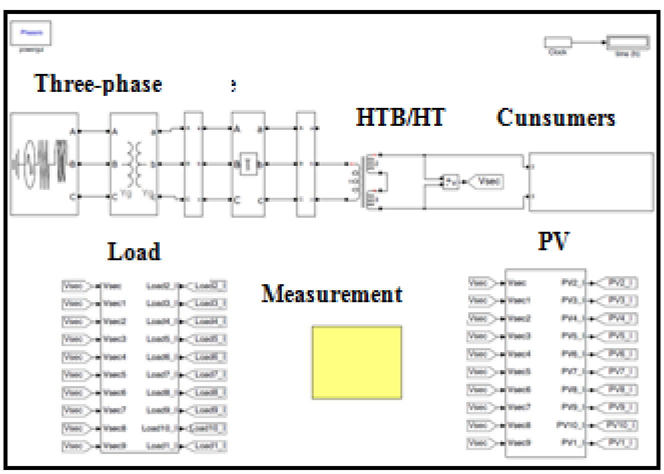

Figure 1: LV network model in Simulink/Simpower

Figure 2 and 3 respectively show simplified models of the load and the PV system. We used the simplified models for the program to be fast because the simulation time is very large t = 86400 s.

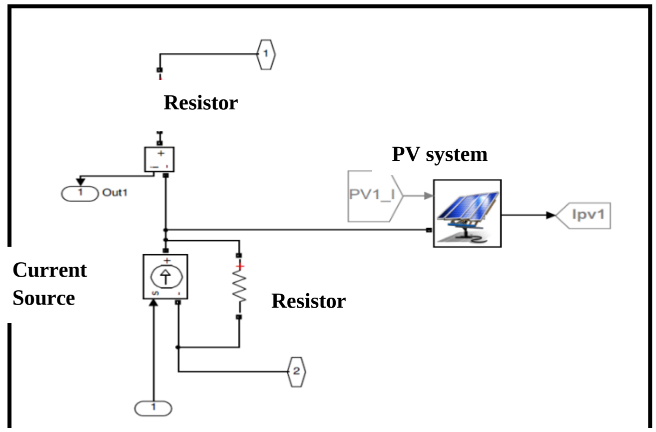

Figure 2:Load model schema in Simulink/Simpower

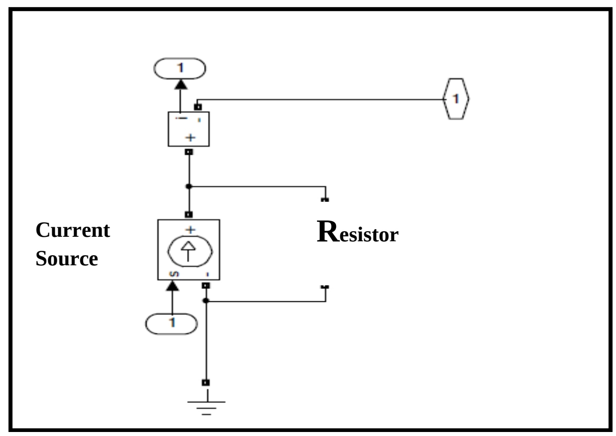

Figure 3:PV system model schema in Simulink/Simpower

II°) Results and discussions

Simulations allow to obtain the load profile 10 when the PV system is connected.
To see the influence of the integration of PV systems, we plotted the load curves (in black), the daily production of the PV systems(in black dash) and the net power(in red) of the production on the same curves. The result is given in Figure 4a.
It is observed that for all the counters, the power of the load is in accordance with the power subscribed for each counter, that is to say 530 W and 880 W respectively for the counters of 3 A and 5 A.
It can also be seen that the net power (in red) in Figure 4a decreases considerably until it reaches negative values for all consumers. This effect is especially noticed between 10h and 16h, and the peak is reached at 12 for all consumers.
It is justified by the presence of the PV system whose production grows considerably between 9h and 10h.

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The negative part of the Pnet, corresponds to the excess power, it will return to the LV network to other nearby users.

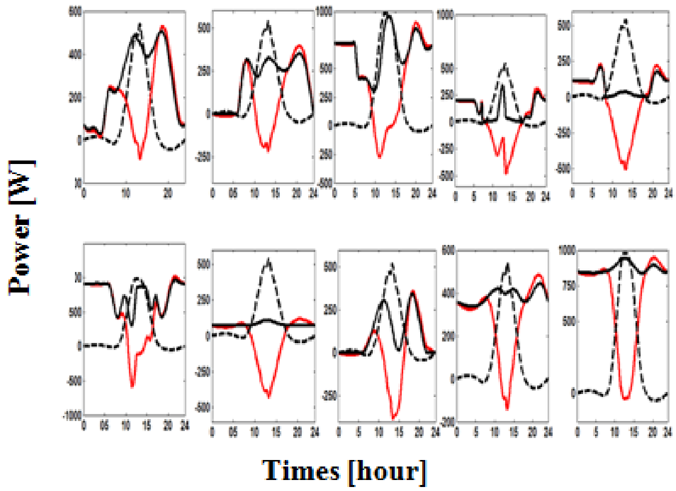

Figure 4a: Load profile with PV system

The influence of the insertion of the PV systems on the HTB / HTA station is shown in Figure 4b. We note that the power demand (Pd) of the HTB / HTA station decreases considerably between 10 h and 16 h.

At this time, it is also noted that the total production of the PV (PPV) system far exceeds the demand for power. This surplus could be redistributed to other distribution centers.

Thus, with the integration of PV systems in consumers, the distribution network will no longer have to worry about the increase in the number of consumers because each would become producers, this could reduce the energy losses on the network from the transport and distribution.

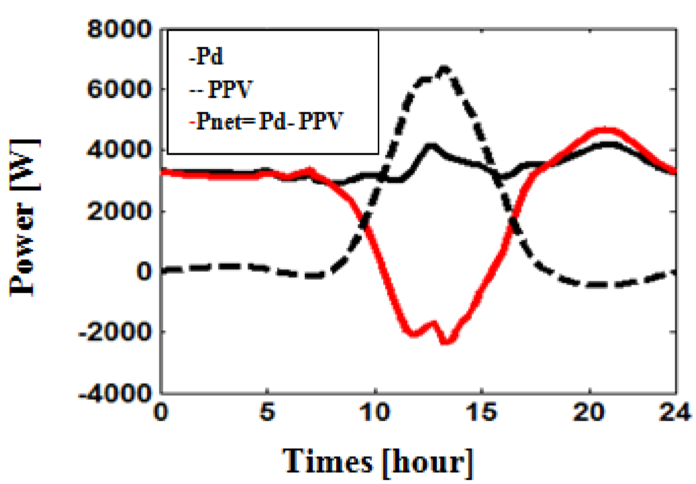

Figure 4b:Total load profile with PV system

In Figure 5a we have a representation of the energy consumed before and after the insertion of the PV system.

Before insertion of the PV system is noted that consumers C_1, C_2, C_3, C_4, C_5, C_6, C_7, C_8, C_9 and C_{10} have used 7 kWh respectively, 4 .5 kWh, 15 kWh, 2.5 kWh, 2 kWh, 17 kWh, 2.01 kWh, 2.6 kWh, 8 kWh and 19 kWh.

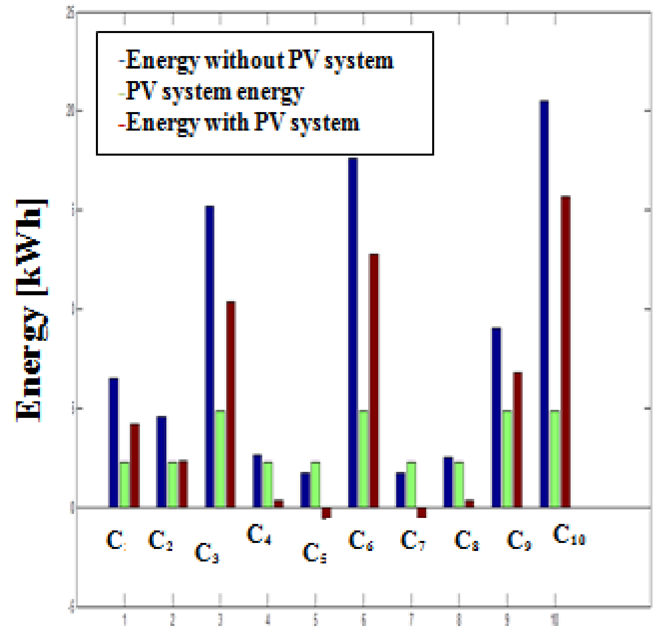

Figure 5a:Energy consumed with the PV system presence

After the insertion, the energy consumed by consumers C_1, C_2, C_3, C_4, C_5, C_6, C_7, C_8, C_9 and C_{10} respectively pass to the values 4.5 kWh, 2 kWh, 10 kWh, 12 kWh, -0.04 kWh, 1.1 kWh, 3 kWh and 14 kWh.The negative sign of the energies of C5 and C7 corresponds to an excess of energy which will be resold to the national network or reversed in the next invoice.

The reduction in the daily bill for each consumer is illustrated in Figure 5b.

It is noted that the bill will be reduced by 400, 250, 800, 200, 250, 700, 260, 260, 400 and 500 FCFA for the respective consumers C1, C2, C3, C4, C5, C6, C7, C8, C9 C10.

We have an average daily decrease of 400 FCFA.

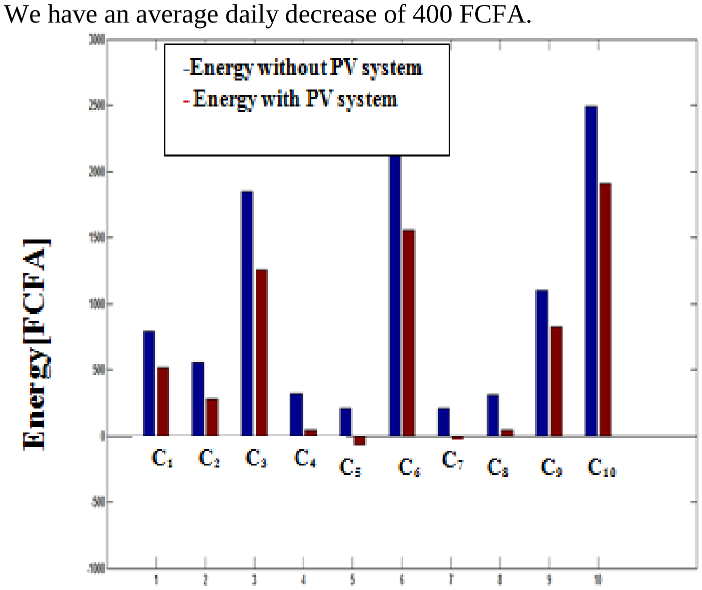

Figure 5b:Cost of consumption with PV system

Conclusion

In this paper, we present a key solution to the electricity problem encountered by some African countries, notably Burkina Faso.

To solve this problem, we must motivate consumers to install PV systems connected to the grid without battery storage.

The simulation of the PV systems connected to the LV network of 10 consumers revealed that this system makes it possible to meet the energy demand of the consumer; To reduce the load of the network and to ensure the reduction of its electricity bills.

For the future, we intend to improve the work by studying the influence of connected PV systems on the network when the penetration rate becomes significant.

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