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# IMPACT STUDY OF THE SOLAR ENERGY ON THE ENERGY PERFORMANCES OF THE RURAL HOUSING IN ALGERIA

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## ABSTRACT

The building sector, which ranks first in terms of electricity consumption for fossil fuels, is a key sector, since it allows an influence on both demands with application of the energy efficiency measures and supply with integration of renewable sources like solar panel. Especially in Algeria which represent an inexhaustible tank of solar energy. This paper presents an energy behavior study of a rural housing in three areas in Algeria. First, we evaluated the energy needs for heating and cooling of a High Environmental Quality housing which is taken as a reference house. The performances of the reference housing are compared to those obtained for a traditional one which has the same dimensional characteristics. The results showed a positive effect of the energy efficiency measures on the energy needs reduction. A parametric study is carried out to optimize the reference housing design for each area using TRNSYS: Thermal insulation, window's glazing type and wall thermal mass. These optimal parameters could reduce again the annual energy needs. Second, a grid connected PV system is proposed to be integrated on the reference housing roof. The simulation of its electrical performances is done using Homer environment for the same areas and shows very satisfactory results.

**Keywords:** HEQ building, Energy efficiency measures, Energy needs, Optimization, Photovoltaic solar energy.

## 1. INTRODUCTION

Due to the recent increase in the total energy demand in the coming years, especially in the rural building, several high energy performance building concepts have been proposed [1]. In Algeria, building sector account for more than 40 % of the total energy consumption which is in clear growth for several reasons. For example, the demographic growth rate, low price of conventional energies, etc [2]. Compared to the traditional building and by applying the improvement techniques of construction (bioclimatic design), it is possible to reduce the energy consumption. Else, from renewable energy, the housing may usually produce electrical energy by the PV array on its roof. [3].

There are several studies which are interested in the building and its energy demand. Juanjuan Li et al [4] analyzed the energy building consumption according to different energy saving methods in hot–humid areas of China. Üllar Alev et al [5] analyzed renovation alternatives to improve energy performance of historic rural houses in three countries in Baltic Sea region. Francesca Stazi et al [6] identified an optimal combination of energy retrofitting on the building. A. bensenouci et al [7] developed an existing building model in Montreal using DOE-2E software. This model serves to evaluate the energy used of building. The results are validated via the energy actually consumed by the building. A study of the sensitive parameters is taken to illustrate the elements proves very fruitful on the energetic plan. Jukka Heinonen et al [8] analyzed holistically the residential energy consumption patterns and the overall housing energy requirements of urban and rural households in Finland. Adi Ainurzaman Jamaludin et al [9] analyzed the energy performance of four residential colleges which are low-rise multiresidential building. Mario Cucumo et al [10] analyzed the performances of building equipped with low-emissivity glazed components. Rohit Sen et al [11] used the Homer software to find the best combination of renewable energy technology (RET) in a given village location that can meet the electricity demand.

This paper presents a comparative study of the energy behavior (thermal and electrical) between the reference building (REF) and a traditional one (TRAD) in three regions of Algerian South. A parametric study is carried out to optimize the REF for each region using TRNSYS software (Version: 16.01.0003). Else, the electrical performances of the photovoltaic system connected to the electrical grid (proposed on the REF building roof) are calculated using HOMER, 268 beta, a free professional software.

## 2. SITUATION OF BUILDING SECTOR IN ALGERIA

### 2.1 Current state

In countries where the price of energy is subsidize like Algeria, households are not motivated by the pursuit of improving the energy efficiency of their home, energy costs remain low. According to a study carried out by Carole-Anne Sénit [12] on the building energy efficiency of the countries of southern and eastern Mediterranean Sea, the public policies as regards building are in full expansion in Algeria. The building deficit is estimated at 1.2 million units (vast construction programs are launched). In such context of scarcity of housing and emergency, the authorities are more sensitive to the interests of speed than that of energy efficiency, which once again overcomes the energy demand in this sector [13]. So the concepts of energy efficiency take then more than ever all their meanings.

Algeria wants to fill its delay as regards energy efficiency in housing by launching several programs and actions of information, sensitization, measurement, promotion. Eco Bat is one of these programs. It consist the realization of 600 High Environmental Quality (HEQ) houses in all the Algerian climatic zones [13, 2].

## 3. ENERGY BEHAVIOR OF RESIDENTIAL BUILDING IN ALGERIAN SOUTH

This part presents the Method used in this study; the results are exposed and discussed.

### 3.1 Method and data

First, all the necessary inputs data are presented: the climatic context and the rural building specifications. Second the calculation conditions under the used software are quoted.

Climate context: This study is carried out for possible establishments of the considered rural building in three regions of Algerian South. The solar resource used for the selected areas at the locations given above was taken from Meteonorm V7.0.22.8. The solar radiation is important throughout the year. For each area, the monthly received energy on horizontal surface exceeds 6kWh/m$^2$/day throughout the period of April until August. Therefore a considerable amount of PV power can be obtained in all these regions (See Figure 1).

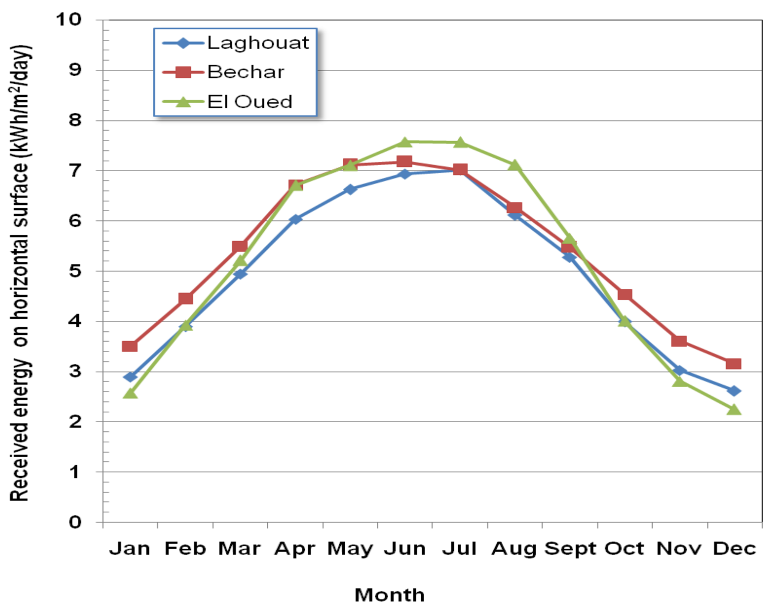


**Figure 1.** Monthly global solar on horizontal surface for the selected areas

Description of the building under study: two buildings are considered for this study, REF building and TRAD one. Thus, we had considered that these two building are occupied by a family of 5 persons, the average number of occupants of an Algerian family [13]. An occupancy schedule is defined by holding account that the father works and the mom is a housewife, two children are student and a pupil for a standard weekday. The REF building (see Figure 2) refers to the pilot project which was built in the framework of the MED–ENEC project. An HEQ rural housing with a surface of 90 m$^2$ approximately, the building is located in Souidania, Algiers. The house contains seven parts, namely, two rooms, living room, kitchen, bathroom, and corridor. Their height is approximately 2.74 m. Its technical characteristics are as follow (see Table 1):

- Walls with stabilized earth blocs.
- PVC doubles glazed windows (4/6/4)
- Thermal insulation of external walls and floors.
- The house has a compact shape and is oriented along the E-W axis [2].

**Figure 2.** The reference building's photo

The traditional building corresponds to any construction which not calling to the bioclimatic techniques. The materials which compose both of REF and TRAD housing differentiate them [2] (see Table 1)

**Table 1.** Thermal parameters of both reference and traditional buildings

| Type | Building element | Materials and structure | T (m) | h ($W/m^2K$) |
|---|---|---|---|---|
| REF building | Roof | 0.03m of Mortar+0.16m of EP+0.08m of Heavy concrete + 0.04m of plaster | 0.31 | 0.22 |
| | External wall | 0.14m of SEB+0.09m of EP +0.29 m of Stabilized earth blocks | 0.52 | 0.35 |
| | Interior wall1 | 0.14m of SEB | 0.14 | 3.43 |
| | Interior wall2 | 0.29m of SEB | 0.29 | 2.37 |
| | Ground | 0.05m of Heavy concrete +0.06m of EP +0.15m of Heavy concrete+0.03m of Mortar + sand +0.02m of tiles | 0.31 | 0.54 |
| | Window | double glazed window | - | 2.95 |
| TRAD building | Roof | 0.03m of Mortar+0.12m of Heavy concrete +0.04m of plaster | 0.19 | 2.64 |
| | External wall | 0.02m interior gypsum plaster+0.20m cinderblock +0.02m stucco cement | 0.24 | 2.30 |
| | Interior wall | 0.02m interior gypsum plaster+0.1m cinderblock+0.02m interior gypsum plaster | 0.14 | 2.67 |
| | Ground | 0.15m Heavy concrete+ 0.03 m of (Mortar+sand) + 0.02m of tiles | 0.20 | 3.41 |
| | Window | Simple glazed window | - | 5.74 |

According to APRUE, it is proved that the electric household appliances are at the origin of the continuous rise of the electricity consumption in the rural housing [14]. Among many actions that reduce electrical energy consumption in rural building, we opted to change the conventional equipments by the efficient equipments. So, an electric assessment of consumption is estimated using the conventional equipments for a standard day. Then, we propose another electric assessment of consumption using efficient appliances to show the benefit of the energy efficiency (see table 2). A daily profile of consumption is elaborated for the REF building while being based on the new electric consumption 2.48kWh/day.

**Table 2.** Electric characteristics of conventional and efficient equipments

| Zone | Device type | Power (W) | | Watt-hour/Day | |
|---|---|---|---|---|---|
| | | Conventional | Efficient | Conventional | Efficient |
| Room1 | Light | 75 | 15 | 225 | 45 |
| | Iron | 1025 | 800 | 512 | 400 |
| Room2 | Light | 75 | 15 | 225 | 45 |
| | Laptop | 144 | 144 | 289 | 289 |
| Living room | Light | 75 | 15 | 375 | 75 |
| | Tele 55cm | 65 | 55 | 390 | 330 |
| | Demo | 25 | 25 | 150 | 150 |
| Kitchen | Light | 75 | 15 | 300 | 60 |
| | Washer | 1500 | 1000 | 750 | 500 |
| | Ref | 100 | 40 | 1000 | 400 |
| | Radio | 30 | 30 | 60 | 60 |
| | Robot | 250 | 250 | 35 | 35 |
| Bath room | Light | 75 | 15 | 150 | 30 |
| Toilet | Light | 75 | 15 | 75 | 15 |
| Corridor | Light | 75 | 15 | 225 | 45 |
| Total | | 3664 | 2449 | 4761 | 2479 |

Table 2 shows a reduction of 50% of the electric energy needs (from 4761 to 2479 Wh/day).

Calculation condition of thermal performances: To simulate the thermal performances we choose to work on TRNSYS software using a developed program on it. In that program we need to define the housing in TRNBUILD and to introduce the weather files (Typical Meteorological Year Files TMY2). In TRNBUILD, we first create the different housings zones. For each zone, we have to specify the zone volume, the dimensional and technical characteristics of walls, roof, floor, and windows which are quoted in Table 1. Then we define the setting temperatures for heating (19°C) and cooling (27°C) and the schedules of occupancy for all zones.

A parametric study is carried out to determine the optimal energy efficiency measures of RFH in each studied region through three cases and a basic case. From all cases, we choose the optimal parameters for each area. Table 3, show the specific parameters of each case.

**Table 3.** Specification of the different cases of the parametric study

| | Description | Configurations |
|---|---|---|
| Basic case | - | REF construction characteristics described in Table 1 |
| Case1 | Effect of TINW and window glazing type | For a simple glazing type, the thickness of TINW is varied from 0m to 0.15m and 0.25m |
| | | For a double glazing type, the thickness of TINW is varied from 0m to 0.15m and 0.25m |
| | | For a triple glazing type, the thickness of TINW is varied from 0m to 0.15m and 0.25m |
| Case2 | Effect of TINR and TINF | For a thickness of TINF of 0m , the thickness of TINR is varied from 0m to 0.2m and 0.3m |
| | | For a thickness of TINF of 0.1m , the thickness of TINR is varied from 0m to 0.2m and 0.3m |
| | | For a thickness of TINF of 0.2m , the thickness of TINR is varied from 0m to 0.2m and 0.3m |
| Case3 | Effect of thermal mass | Different thicknesses of thermal mass are considered ranging from 0.05 m, 0.14 m, 0.3 m and 0.35 m. |

Calculation condition of electrical performances: The combination of the component of our system under HOMER software, namely, solar PV system, inverter, and the grid, is illustrated by the following Figure 3.

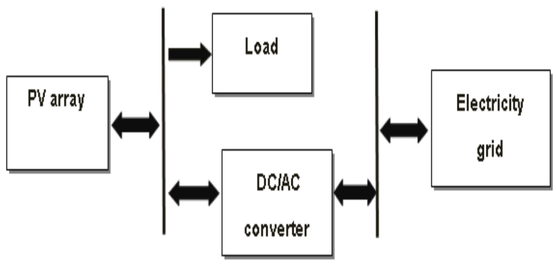


**Figure 3.** Design of the proposed PV system

The input data to be introduced in each component of our system are as follows: the standard daily profile of electric consumption which is indicated before in Table 2, and the monthly global horizontal radiation of each region which is illustrated before in Figure1. Thus, the peak power of the PV system which is estimated equal to 660 Wp. The capital cost values: 1.14 $/W for the solar PV, 0.43 $/W for the inverter, and 0.052 $/W for the grid, local cost of electricity. The costs used are local costs of Algerian market actualized in 2015 [15].

### 3.2 Analysis of the thermal energy demand

This part consist the evaluation of the reference rural housing needs for heating and cooling for three selected areas of Algeria in order to show the climatic and construction effects. The monthly energy needs of the reference housing for the selected areas are shown in Figure 4.

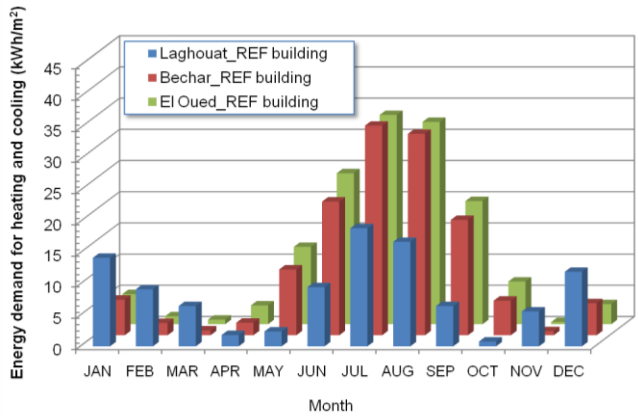


**Figure 4.** Heating and cooling energy needs of REF building in the studied regions

This figure shows that For Bechar and El Oued, the energy needs for cooling are very high especially for El Oued from the month of May until the month of September. This period is very hot in these two areas where the horizontal global solar almost exceeds 7kWh/m²/day. During which the average annual temperature exceeds 22°C in El Oued, 20°C in Bechar. For the other months of year, the energy needs for heating are low especially for El Oued. Generally the energy needs for cooling and heating for these two areas are too close because they belong to the same climatic zone, the Saharan zone. For Laghouat, the energy needs for cooling and heating are important especially for cooling. This is directly related to the climate context of this area with a hot long summer and a short cold winter. The energy demand depends on the climatic conditions.

Thus, the energy needs of the rural housing are compared to those obtained for a traditional housing to show the efficiency measures effect on the energy needs. The monthly needs for heating and cooling of the two housings are shown in Figure5.

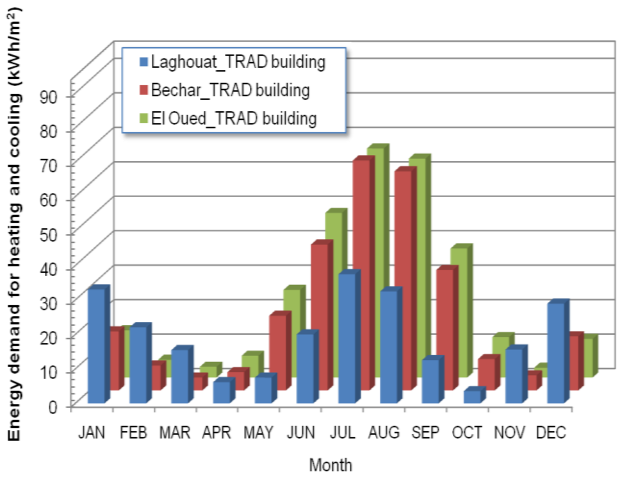


**Figure 5.** Heating and cooling energy needs of TRAD building in the studied regions

This Figure shows that a large difference is marked between the energy needs of the REF building compared to the traditional one. The energy needs for heating and cooling of the traditional housing is very high compared to those obtained for the reference housing. An important conclusion can be drawn, by applying the energy efficiency measures we can reduce the energy needs of the rural housing by up to 50% in Algeria. The energy needs are reduced by 56% in Laghouat against 53% in Bechar and 52% in El oued.

As it is indicated before, a parametric study is carried out to optimize the reference housing for the selected areas. The following Table 4a-4b respectively gives the results of the different cases of the parametric study (energy needs for heating and cooling in all the case's configurations).

**Table 4a.** Annual energy demand for heating and cooling in the case 1 for the region of Laghouat, Bechar, and El Oued

| Configurations | | Laghouat | Bechar | El Oued |
|---|---|---|---|---|
| | | ∑ (kWh) | ∑ (kWh) | ∑ (kWh) |
| Basic case | REF conditions | 7070 | 9400 | 9699 |
| Case1 | 0 m TINW | 11529 | 12632 | 12792 |
| Simple glazing | 0.15m TINW | 7548 | 9736 | 10019 |
| | 0.25m TINW | 7345 | 9596 | 9884 |
| Double glazing | 0 m TINW | 10430 | 11692 | 11839 |
| | 0.15m TINW | 6461 | 8771 | 9061 |
| | 0.25m TINW | 6268 | 8649 | 8937 |
| Triple glazing | 0 m TINW | 10470 | 11807 | 11985 |
| | 0.15m TINW | 6527 | 8948 | 9252 |
| | 0.25m TINW | 6335 | 8820 | 9130 |

Where: ∑ is the total of the energy demand for heating and cooling.

**Table 4b.** Annual energy demand for Heating and Cooling of the case 2 and 3 in the regions of Laghouat, Bechar, and El Oued

| Configurations | | Laghouat | Bechar | El Oued |
|---|---|---|---|---|
| | | ∑ (kWh) | ∑ (kWh) | ∑ (kWh) |
| Case2 | | | | |
| 0 m TINF | 0 m TINR | 12486 | 12574 | 12417 |
| | 0.20 m TINR | 6065 | 6464 | 6555 |
| | 0.30 m TINR | 5918 | 6328 | 6424 |
| 0.10 m TINF | 0 m TINR | 13579 | 15482 | 15529 |
| | 0.20 m TINR | 7167 | 9782 | 10114 |
| | 0.30 m TINR | 7024 | 9662 | 10002 |
| 0.20 m TINF | 0 m TINR | 13739 | 15846 | 15908 |
| | 0.20 m TINR | 7374 | 10242 | 10605 |
| | 0.30 m TINR | 7232 | 10128 | 10494 |
| Case3 Thermal mass | 0.05 m | 7165 | 9467 | 9759 |
| | 0.14 m | 7129 | 9437 | 9734 |
| | 0.30 m | 7066 | 9398 | 0.6 |
| | 0.35 m | 7044 | 9385 | 9685 |
| Optimal parameters | | 6147 | 7824.6 | 8134 |

The Table 4a let us to make the following remarks:

**Case 1:**

When the thermal insulation of windows is not improved while the thermal insulation property of walls is absent, the energy need for heating and cooling is very important in all the selected areas. For the wall insulation thickness of 0.15m, the energy need for heating and cooling is reduced by 34%, 23%, and 22% in Laghouat, Bechar, and El Oued respectively. By increasing the thermal insulation thickness of walls to 0.25 m, the reduction ratio will be about 36% in Laghouat, 24% and 23% in Bechar and El Oued respectively.

When the thermal insulation of window is fixed to 2 $W/m^2k$, the energy needs decrease compared to case1 in spite of the absence of thermal insulation of walls. By increasing the wall thermal insulation thickness to 0.15 m, the reduction ratio will be about 38%, 25%, and 23% for Laghouat, Bechar and El Oued respectively. For the wall insulation thickness of 0.25 m, the energy need for heating and cooling is reduced by 40%, 26%, and 24% for Laghouat, Bechar, and El Oued respectively.

For a heat transfer coefficient of window equal to 1.43 $W/m^2k$ (double glazing), the reduction ratios are better than to these obtained a simple glazing and too close for a triple glazing for the same insulation thicknesses of walls. The reduction ratio are as follow: 38%, 39% for Laghouat, 24%, 25% in Bechar, and 23%, 24% in El Oued respectively for a thicknesses of 0.15m, and 0.25m.

The remarks above let us to say that:

The double low-e glazing type of window is the most helpful for all the selected areas to reduce the energy needs.

The appropriate thickness of the thermal insulation of exterior walls for the area of Laghouat is between 0.15 m and 0.25 m. For the area of Bechar and El Oued, the thickness of 0.15 m is the best.

The Table 4b makes possible to take the following remarks:

**Case 2:**

When the thermal insulation property of roof and low floor are absent, the energy need for heating and cooling is very great for all the selected areas. This means that the thermal insulation of roof and low floor must be considered.

When the thermal insulation property of low floor is absent while the thermal insulation thickness of roof is equal to 0.20 m, the energy needs are reduced by 51%, 49% znd by 47% in the region of Laghouat, Bechar and El Oued respectively. When the thickness of the roof insulation is equal to 0.30 m, the reduction is about 53% in Laghouat, 50% and 48% in the regions of Bechar and El Oued respectively.

When the thermal insulation property of roof is absent while the thermal floor insulation thickness of low is varied from 0.10 m to 0.20 m respectively, the energy needs decreases from 13579 kWh to 13739 kWh in Laghouat, from 15482 kWh to 15846 kWh in Bechar, from 15529 kWh to 15908 kWh in El Oued.

When the insulation thickness of the low floor is fixed to 0.10 m while the insulation thickness of the roof is varied from 0.20 m to 0.30 m respectively, the reduction ratio decrease to 47%, and 48% in Laghouat respectively, to 37%, and 38% in Bechar respectively and to 35%, 36% in El Oued respectively. This means that the insulation thickness of low floor must be not important.

When the insulation thickness of the low floor is fixed to 0.20 m while the insulation thickness of the roof is of 0.20 m, the energy needs reduced by 46% in the area of Laghouat, 35% and 33% in Bechar and El Oued respectively. For the same thickness of the low floor and a thickness of the roof of 0.30 m, the needs reduced by 47% in Laghouat, by 36% and 34% in the areas of Bechar and El Oued. These reduction ratios are decreased a little compared to those achieved for the low floor insulation thickness of 0.10 m. What means that the thickness of the low floor insulation must be lower than 0.10 m especially for the areas of Bechar and El Oued

**Case 3:**

The monthly needs for heating and cooling decreases a little with the increase of the thermal mass until the thickness of 0.30 m where the energy needs stays almost the same for all the selected areas.

From each case, we select the optimal parameter for which the energy needs are minimal. This case gives the combination of all the optimal parameters, see Table 5.

**Table 5.** The optimal parameters and the annual energy demand of each optimal parameter in each region

| | Laghouat | | Bechar | | El Oued | |
|---|---|---|---|---|---|---|
| | Otimal parameter | Energy demand (kWh) | Otimal parameter | Energy demand (kWh) | Otimal parameter | Energy demand (kWh) |
| TINW | 20 cm | 6660 | 15 cm | 9202 | 0.15m | 9509 |
| Window's glazing | Double low-e,Ar | 6343 | Double low e,Ar | 8781 | Double low-e,Ar | 9061 |
| TINR | 0.25m | 6153 | 0.25m | 8618 | 0.20m | 8978 |
| TINF | 0.06m | 6153 | 0.03 m | 7825 | 0.03m | 8134 |
| Thermal mass | 0.32m | 6147 | 0.29m | 7825 | 0.29m | 8134 |

This table shows that the use of optimal parameters can be generates again an annual energy needs reduction of 13%, 17%, and 16% in Laghouat, Bechar, and El Oued respectively. So we have a total reduction ratio of 69% for Laghouat, of 70% for Bechar and 68% for El Oued.

### 3.2 Analysis of the electrical performances

In this part, we evaluate the electrical performances of a photovoltaic system connected to the grid which is proposed on REF housing roof. This system is used to supply with electricity the electric household appliances and office automation except heating and cooling requirements.

The simulation is done by using the Homer models micro-power systems with single or multiple power sources for three selected regions. For our case, as it is indicated before, we employed like source of energy the photovoltaic solar panels and the electric supply network.

An optimal configuration is matched by the simulation, thus indicates a generator and an inverter of 660 W for all the selected areas. In such system connected to the network, the account of energy is bidirectional, it is carried out for energy injected and energy tapped of the electrical supply network [16-17].

The simulation results of the electrical energy performances are very satisfactory. The energy balance obtained (see Table 6), show that an excess of electricity is produced for all the selected regions.

**Table 6.** Optimal least cost grid connected PV system for the case study

| | Laghoaut | Bechar | El Oued |
|---|---|---|---|
| Production (kWh) | | | |
| PV array | 1064 | 1158 | 1097 |
| Grid purchases | 511 | 485 | 508 |
| Total | 1575 | 1643 | 1605 |
| Consumption (kWh) | | | |
| AC primary load | 894 | 894 | 894 |
| Grid sales | 573 | 633 | 601 |
| Total | 1467 | 1527 | 1495 |

The table above gives the rate of the total energy produced annually by the PV array. The rates are about 68%, 70%, and 68% respectively for Laghouat, Bechar and El Oued. Thus, the rate of the total energy purchased annually from the grid in these regions is equal to 32%, 30% and 32% respectively. The sum of the energy produced annually by each component (the PV array and the grid) is about 1575 kWh/yr, 1643 kWh/yr, and 1605 kWh/yr for Laghouat, Bechar, and El Oued respectively.

In the other hand, the rate of the total energy serving the AC primary load annually is about 60% approximately in all the areas. Thus the ratio of the total energy sold to the grid annually is equal to 40% approximately in the same regions. The sum of the energy consumed annually of these components is equal to 1467 kWh/yr, 1527 kWh/yr, and 1495 kWh/yr in Laghouat, Bechar, and El Oued respectively.

For exposing well the results obtained by the simulation, we exported the monthly average electric production of PV and Grid for the selected areas (see Figure 6).

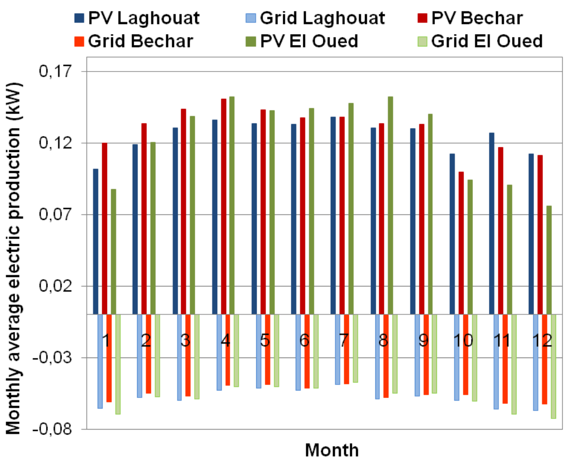


**Figure 6.** The monthly average electric production from PV and Grid for the selected areas

This Figure shows that the monthly average electric production of PV is very high compared to the average electric power tapped from the grid in all the selected regions. During the very hot months of year in the selected regions, the monthly PV production is too higher than the monthly electric power tapped from the grid. This means that the majority of the consumed electric power is ensured by the PV and the recourse to the network is carried out only for the needs during the night. For the rest of year, due to the insufficient PV production, the majority of the consumed electric power is tapped from the grid.

## 4. CONCLUSION

There is a significant influence on the energy performances of a rural building by means of bioclimatic rules and solar photovoltaic technology. In this paper, the energy performances of a reference house (Pilot project of Algiers) is analyzed and compared to these obtained for a traditional building in three regions of Algerian South, namely, Laghouat, Bechar, and El Oued. The two houses have the same dimensional characteristics. As REF building is optimized for the climate of Algiers, a parametric study is carried out to optimize its energy efficiency measures for the climate of each region. The results show a reduction rate of more than 56% at Laghoaut, 53% at Bechar and 52% at El Oued. The combination of the determined optimal parameters reduces again the annual energy demand for heating and cooling by 13% for the climate of Laghouat, 17% for Bechar and 16% for El Oued. So, the global reduction rate will be equal to 69%, 70%, and 68% in the same regions and in the same order respectively. What means that a very significant and very motivating reduction of the energy needs are achieved.

In the other hand, the replacement of the conventional appliances used in the traditional building by the efficient equipments show a reduction of more than 50% of consumed daily electrical energy. Then, a grid connected PV system is proposed on the roof of the REF building. The simulation of its electrical performances in Homer software indicates a positive energy balance of 62kWh/yr, 148kWh/yr and 93kWh/yr in the regions of Laghouat, Bechar, and El Oued respectively. What means that the amount of the electric energy produced via the PV solar is sufficient to cover the needs of the building to supply its electric appliances on electricity except heating and cooling in all the selected regions. Else, an excess of electricity is produced and can be sold to the network supply and represents energy and an economic profit. Without forgetting that the supply network which often knows cuts of electricity in Algeria can be relieved. In addition to, the environmental burden of building sector can be reduced (a clean energy is used).

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## NOMENCLATURE

| | |
|---|---|
| AC | alternating current (A) |
| DC | direct current (A) |
| EP | expanded polystyrene |
| h | heat transfer coefficient (W/m$^2$k) |
| HEQ | high environmental quality |
| Med-Enec | energy efficiency in construction sector in mediterranean |
| SEB | stabilized earth blocks |
| TINF | thermal insulation of floor |
| TINR | thermal insulation of roof |
| TINW | thermal insulation of walls |
| T | thickness (m) |