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## Hybrid System and Environmental Evaluation Case House In South of Algeria

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### Abstract

Global environmental concerns and the escalating demand for energy, coupled with steady progress in renewable energy technologies, are opening up new opportunities for utilization of renewable energy resources. Hybrid energy (solar and wind) are the most abundant, inexhaustible and clean of all the renewable energy resources till date. Hybrid power generation system combines a renewable energy source (PV in this case) with other forms of generation, usually a conventional generator powered by diesel or even another renewable form of energy like wind. Such hybrid systems serve to reduce the consumption of non renewable fuel, we analyze long-term data of solar radiation and wind speed, spanning a period of 23 years, of the town of Adrar located in south of Algeria to evaluate technical-economic feasibility of using a hybrid system. The aim is to answer at load demand of a typical residential house with the annual electric energy demand of 8000kWh, an average calculated according to a study made by the Algerian government and to limit carbon emissions. Simulation results using the Hybrid Optimization Model for Electric Renewable (HOMER) software is proposed. The optimization modelling demonstrates that 100% of power demand can be supplied by hybrid configuration composed of 3 kW PV and 2 wind turbine of 2.6 KW and 18 batteries with no diesel generator. The Hybrid penetration PV and wind and the cost of generating energy from the renewable energy are analyzed. The cost of generating energy from system has been found 1.07 \$/kWh. It is shown that with the proposed

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hybrid system, approximately 5,2 tons/year of the carbon emissions entering the atmosphere can be reduced for one house only.

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## Introduction

Algeria's electricity demand is growing at a rapid, 7% annual rate and will, according to SONELGAZ, Company of Electricity and Gas require significant additional capacity possibly 8900MW by 2007 [1]. In 2010, Algeria's natural gas is the largest source of electricity production as it accounts for almost 98% of total electricity with remaining 1% came from small hydroelectric plants [2]. With this growth in electric demand the Algerian government has realized the importance of renewable energy. It has been realized that the renewable energy projects such as solar, biomass, photovoltaic, geothermal and wind, could be used as tools for the management of reserves and sustainable development of desert communities [3]. In this regard Algeria has huge plan to develop wind energy, solar energy or hybrid system. Several papers have been written on renewable energy in the Algeria's southern territories. Nowadays, renewable energy has become essential due to the greenhouse effect as well as the rising of energy demand. One of the renewable energy technologies that are being widely employed is the solar photovoltaic and wind energy. These two sources of renewable energy options are being used by a number of countries having a monthly average daily solar radiation level in the range of 3–6 KWh/m<sup>2</sup> and wind speed more than 6m/s like the case of Adrar. The dispersion of the villages in south Algeria and the increase in the rate of consumption of electrical energy constitute one of the major problems encountered by the company of electricity in Algeria. In order to overcome these two constraints, it is desirable to explore all the possible avenues for the generation of more energy [3]. One of the options to solve this energy shortage problem is the exploitation of the renewable energy sources [4]. In Algeria, in general, and in the province of Adrar, in particular, there is a record elevated level of solar radiation and wind speed. The solar radiation intensity of some provinces of the geographically diverse south and north are presented in table 1. However, as case study, this work concentrates on the province of Adrar. For all the examined areas, measurements of solar radiation and wind speed in the long time were used.

Table 1. Daily solar radiation for several cities in Algeria (average 22 years)

Town	Solar radiation (KWh/m <sup>2</sup> )	Duration of sunshine (hours) per day
Adrar	5.87	12.13
Alger	4.78	12.16
Bechar	5.38	12.12
Oran	4.80	12.15
Mostaganem	4.80	12.15
Tamnerasset	5.61	12.10
Tindouf	5.88	12.14
Tebessa	4.65	12.15

## 1. Geographical Position

The province of Adrar bordering the Sahara is located in the southwest of Algeria with a surface of 427368km<sup>2</sup>, constitutes 18% of the entire surface of Algeria fig1. Having a high solar potential, the annual solar energy in Adrar exceeds the 2700 KWh/m<sup>2</sup> [5-6-7]. Moreover, Adrar, due to its geographical distribution characterized by a large surface counts several thousands of the consumers remotely located on the many small oases in the Sahara, the shelters, the stations of telecommunication [6].

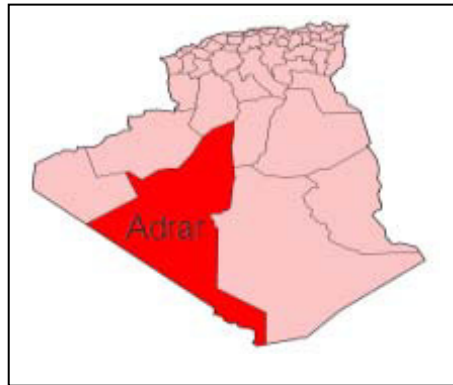


Fig. 1. Geographical position of Adrar

## 2. Climate and instrumentation

The climatic conditions impose the availability and the importance of solar energy of a site with respect to another, Adrar is far from the capital at almost 1600km. It is located in a desert environment. Two distinct seasons characterized this area: one very hot season from April to August and another temperate season from December to March. The present study uses the data recorded with the solar radiation and weather station of NASA [2]. The latitude of the site is of 27.53, longitude is -0.17, and the altitude of the site is 263 M.

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## 3. Data of Solar and Wind Energy

### 3.1 Solar

HOMER is sophisticated software which facilitates the systems design of autonomous or hybrid power supply and connected to the networks [2]. Many work and publications were born out using this software [24-33]. This investigation highlights the impact of the penetration of the photovoltaic system on the

energy production, cost of energy, number of the operational hours and on the produced surplus of various photovoltaic, wind or hybrid configurations

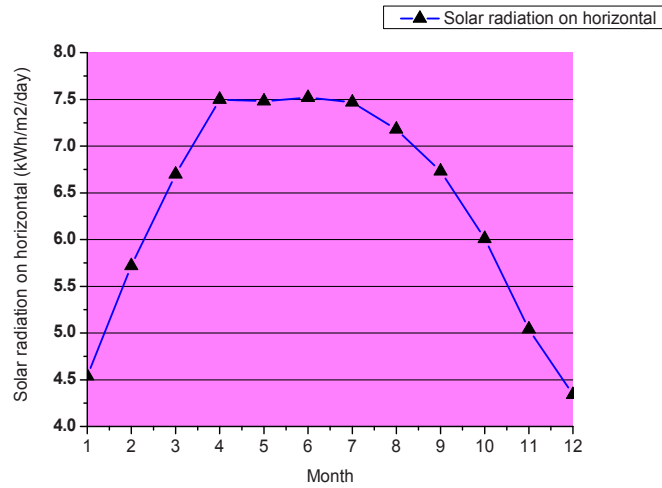


Fig 2 Average solar radiation data of case study location.

Monthly average values of solar data related to the case study location are shown in Fig 2. As can be seen from this fig 3, the solar radiation in Adrar reaches its minimum of 4.34kWh/m²/day in December and its maximum of 7.52 kWh/m²/day in June. So, the average of daily radiation in the whole year is 6.35 kWh/m²/day;

The monthly average daylight Hours (hours) are shown in fig3, the daily hours in Adrar reaches its minimum of 10h/day in December and its maximum of 13.3 /day in June. So, the average of daily hours in the whole year is 10.9 h.

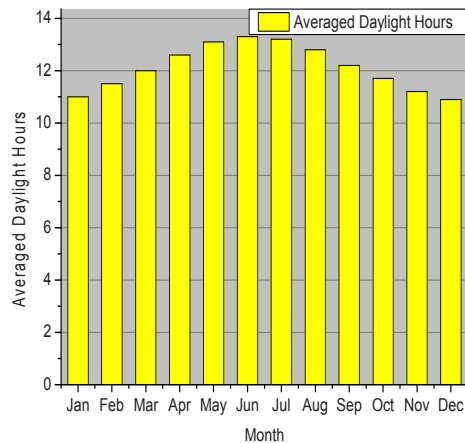


Fig 3. The monthly averaged daylight hours.

### 3.2 Wind

In this study, wind speed data of Adrar site have been used. Although HOMER has the capability to generate synthetic wind data if four parameters “Weibull k value, autocorrelation factor, diurnal pattern strength and the hour of peak wind speed” are defined by the user [16]. Adrar is characterized with an average wind speed of 5.53 m/s at 50 m elevation, 6.14m/s at 100m and 6,52m/s at 150m, In this, there are some wind turbine working at very low speed. The lowest monthly wind speed is in September and the highest one in January. Fig 4 depicts the changes of wind speed from January1983 to June 2005 at 50 m, 100m and 150 m elevations at Adrar site.

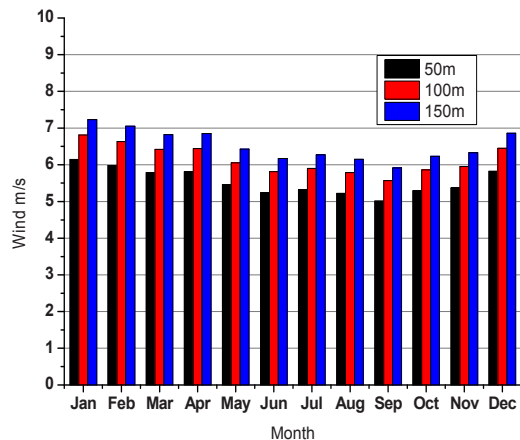


Fig.4. Average wind speed at Adrar site

#### 4. Software Homer and Strategy of Hybrid System

Homer is software of modelling of energy for the systems of renewable energies and a powerful tool for the design and the analysis of the hybrid feeding systems, which contain a mixture of traditional generators, the cogeneration, the wind, the photovoltaic solar, the hydroelectricity, the batteries, the combustible batteries, the hydraulic power, the biomass and other inputs. For the environments except network, HOMER helps to determine how the variable resources such as the wind and solar energy can be integrated in an optimal way in the hybrid systems. The aim is to compare the results and to obtain a realistic projection with their capital and the operating costs [2].

Our load was fixed at 8000 KWh with a variation installations of power statement of 1kW, 2KW, 3KW, 4 KW and 6KW, the variation of the inverter is of 1KW, 2KW, and 4KW and 2 wind turbine. For the batteries the number was selected according to the data of sunning and the power of each battery and the days defined as black days or without sunning.

Homer analyzes all the probabilities of optimization of the system by giving all the proposals available to carry out the optimal realization with a better output and a minimum of cost. Influences temperature on the output and order MPPT is also integrated in the calculation of optimal result, a comparison will be made on application as of these orders and their influences on the final output. The power of our system will be defined based on our request for load and the elements which we have included in optimization in relation to the data weather of province of Adrar.

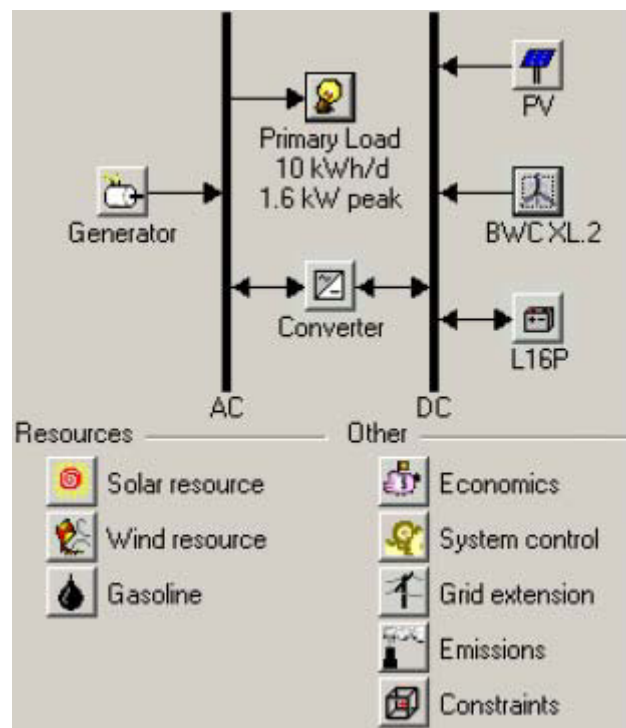


Fig.5. configuration of hybrid system

The process of optimization makes it possible to determine the best configuration possible of the system, optimal and satisfy the constraints specified at low cost in order to decide the composition of the elements than the system must contain. The objective of the process of optimization is to determine the optimal value of each variable of decision (Size of statement, PV, wind turbine batteries, inverter and others) in our study fig 5.

## 5. Result

The simulation of the hybrid system made up of the various combinations supplemented by the base weather. The most important parameters to explore through our case study are the capacity of the photovoltaic to be installed and the awaited production, the power of inverter and the capacity in the batteries. An important consideration of any power generating system is load. As a case study and as a representation of typical house, the measured annual average energy consumption (based on 1 years of data) with air-conditioned in the summer has been considered as yearly load 8000 kWh in the present study.

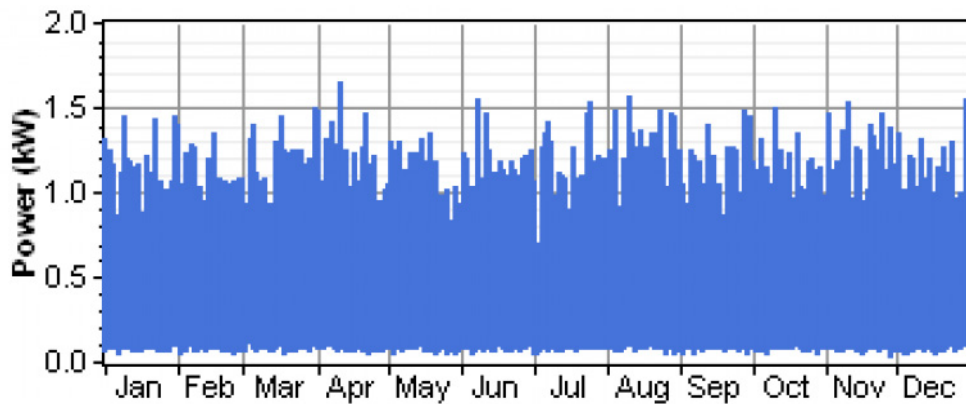


Fig 6 House power demand in one year

Our system as indicated in Fig 6 is made up of a field of solar panels of power of 3 KW., 02 inverters of capacity 4 KW, 2 wind turbine of 2.6 KW and a whole of 18 solar batteries as an optimal solution to our situation. In Fig 7 we show the production of our hybrid system

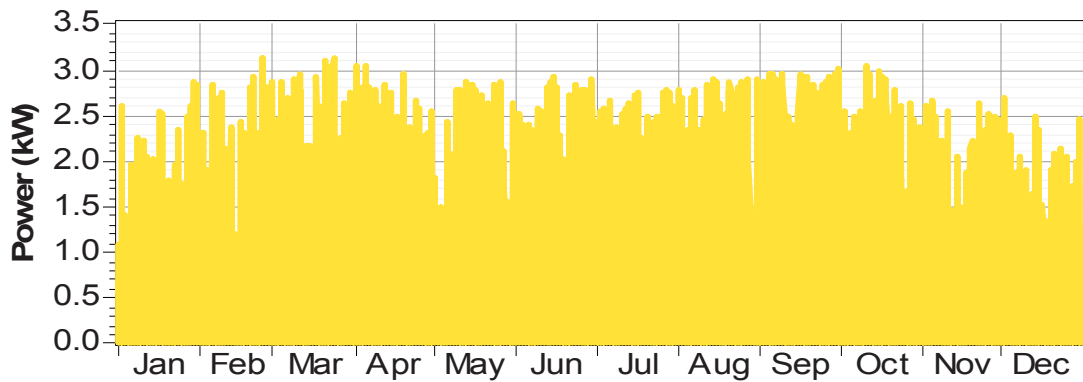


Fig 7 Power production of hybrid system

## 6. Discussions Result

Several Configurations were compared through this simulation, or an economic model of feasibility was identified basing on several introduced criteria. The level of irradiation is high during the months especially May-August compared to other months. The median value of the solar radiation daily annual in the site of Adrar is 5.87 KWh/m<sup>2</sup> and the wind works with a speed at 4 m/s. Our system statement enabled us to satisfy the total request for this typical house with 8400 KW of production per year. The total costs of installation of hybrid system and its follow-up in 25 years were estimated at 74572\$ (the choice of use of the Dollar currency instead of Algerian Dinar is with the variations of rate of exchange), the cost of kWh is 1.07 \$ KW. We took the rate of current exchange of December 12th, 2010 day which was 1\$= 76 DA [34], to have an idea of the price kWh is 81.32 DA.

## 7. Environmental Evaluation

The production argument of our Hybrid system has enabled us annually to eliminate the gas emissions with greenhouse effect in the atmosphere from 5200 kg CO<sub>2</sub>. What makes our house ecological at 100% as indicates in Table 2 by comparing it with a house which consumes traditional electricity.

Table 2. CO<sub>2</sub> removed from the atmosphere

Type of electricity	Consummation (KWh/year)	Emission year Kg	CO <sub>2</sub> /
Fossil	8000	5200	



The emissions of CO<sub>2</sub> avoided for our ecological house is an indicator of the quality, of which although the cost initial investment of our hybrid system is high compared to the traditional energy, but environmental protection has also a price. So, in the design of this house, the invoice will be much less expensive [35].

## **8. Conclusion and Recommendation**

Hybrid system indicate that the use of the system approximately 5,2 tons/year of the carbon emissions can be avoided entering the atmosphere for only one house. Taking into account of the fact that in Adrar there are more than 75000 houses, it easy to put out the benefits of uses in ecological house by hybrid system. The study indicates that Adrar, in particular, and Algeria in general and the Arab countries have an important photovoltaic potential for development of the residential applications, agriculture, food of the sites isolated and even a mean from investment to avoid after oil.

This work shows that the potential of solar energy and wind energy cannot be neglected. A fraction of the energy demand of Algeria can be exploited starting from hybrid system, PV system or wind system. The results of this study can be used for other sites having similar climatic conditions and load. Our future is in this renewable energy to create more and more jobs, richness and reduce pollution. This pushes us to examine the Algerian law to encourage the production of renewable energy at least 5% of the general production of Algerian electricity in the next few years [36].

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