Photovoltaic/Wind Hybrid System Power Stations to Produce Electricity in Adrar Region

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***Abstract*—This current work, which is implemented on hybrid power stations to produce electricity and use it to cover the increasing demand for electricity in public lighting projects, so that this study is carried out in the Adrar region. To achieve this goal, in the first part, we introduced the components of the hybrid photovoltaic system with wind generators to produce electricity with renewable energy sources that are not harmful to the ocean. After that, we simulated the system using the homer pro program, which allows us to take a comprehensive view in terms of the natural data, the capacity and cost of energy production, as well as the characteristics of each component that enters into the composition of the hybrid system. Production capacity and cost are discussed. The results obtained in the framework of this study showed that this Adrar region is considered an energy treasure as it contains very significant climatic data that can be used in converting solar energy and wind energy into electrical energy. Also, the Homer program confirmed to us through simulation results that the system the considered hybrid is successful.**

Keywords—control, modelling, vector, Homer, solar, PV, wind, hybrid system, Adrar

I. Introduction

Most remote areas use diesel generators as their main source of electricity generation. Fuel prices increase with distance. Extensive research has been conducted on the design, optimization, control and operation of hybrid renewable energy systems.[1]

A hybrid power system is made up of various components. When designing a hybrid power system, factors such as component sizes, system configurations, suitability of various renewable energy resources in that region, the hybrid system will help the decision maker determine the most suitable solutions. cost-effective hybrid system to meet the electrical loads for which it is being designed. This research presents a designed case study where Algeria is chosen.

A hybrid power system (HES) is an electrical power generation system that contains two or more different power sources. SEH typically combines two complementary technologies, one or more non-renewable energy sources with at least one renewable energy source.[2]

In this paper we present the photovoltaic-wind hybrid system power stations to produce electricity and use it to cover the increasing demand for electricity in public lighting projects, so that this study is carried out in the Adrar region.

II. Descriptions of the Photovoltaic-Wind Hybrid System

First, The photovoltaic generator is mainly composed of photovoltaic cells. Electricity is produced when exposed to solar radiation. It is a safe and environmentally friendly way to generate energy.A wind turbine can be defined as a system made up of elements capable of converting part of the kinetic energy of the wind into mechanical energy and then into electrical energy.

It consists of photovoltaic generator and wind turbine :

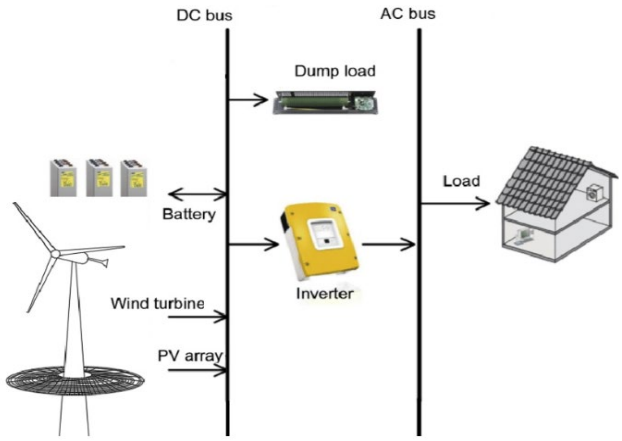

Fig. 1. Schematic of the proposed solar PV-wind hybrid system

A. Regulation system

The regulations should take into account the fact that these are two flows of a different nature. Photovoltaic is fairly constant and low-threshold. The force of the wind is very variable. Thus, the regulation system will be responsible for operating the generator system at an optimum point to charge the batteries.

Storage typically uses batteries. There are other, but not very useful, forms of storage, such as hydrogen storage, water pumping, and flywheels. transformers are used to convert direct current to alternating current and vice versa. In SEH, there are three types of transformers (rectifiers, inverter and chopper).[3, 4].

B. Description of the "ADRAR" study area

Adrar region extends over the northern part of southwestern Algeria, thus covering an area of 427,968 km^2 or 17.97 % of the national territory (see Figure 2). Generally occupied by the Sahara, Adrar is sparsely populated with a population density of 0.75 inhabitants/km^2.

In Algeria a very high solar potential, because the average energy received annually on its surface is 170,000 TWh, and the average annual radiation exceeds 2000 hours to reach 3500 hours of sunshine in the desert, which is very rich and represents 86% of Algerian territory. This is shown in the table below.

Fig. 2. Adrar region in Algeria [3].

We note from table 1 the Adrar region receives a very significant amount of solar radiation. In addition to the vastness of its area and the average annual brightness period, it is considered a national treasure that can be used in the production of electrical or thermal energy.

Table 1: Solar energy potential in Algeria by region.[4]

Region	coastal region	High plateaus	Sahara
Area	**4**	**10**	**86**
Average sunshine duration (hours/year)	**2650**	**3000**	**3500**
Average energy received (kwh/m2/year)	**1700**	**1900**	**2650**

The northern Mediterranean was characterized by coasts and mountainous relief, represented by two chains of the Tillian Atlas and the Saharan Atlas, interspersed with scattered plains and high plateaus with a continental climate and the presence of micro-climates in the coastal sites of Oran, Béjaïa, Annaba and on the high plateaus of Tiaret and in the area bordered by Bejaia to the north and Biskra to the south. The South is also characterized by a désertclimat at times.[5]

Southern Algeria is characterized by a higher wind speed than the north, especially the southwest and the Adrar region.

III. HYBRID ELECTRIC STATION FOR PUBLIC LIGHTING

The HOMER Energy (Hybrid Optimization Model for Electric Renewables) was developed in 1993 by the National Energy Research Center for rural electrification programs. It represents a global standard for the development and creation of grid-tied or stand-alone micro-grids.[6--9]

Initlly, this software allows the management of simulators in order to improve the system and then finally to carry out an in-depth study on these improved systems. The solution obtained by HOMER is the lowest cost between different combinations of renewable energy systems, fossil fuels or hybrid systems comprising two or more energy sources. It is useful for village power plants, camps, military bases and even individual residences, whether connected to the grid or not.

ugh this research, we will study a public lighting project for the road linking the commune of Tamantit and the commune of Awlad Ibrahim, about 8 km long, which consumed 350 cans by a distance (20 meters) between each, at from a power station operating in a hybrid system (wind/photovoltaic). To cover the road choose by a public lighting network with LED lamps, we found that the lighting and requires an electrical power of 67.5 kilowatts. So we thought of saving this energy by building a hybrid power plant. We need:

Lighting need:
50W LED projector with a luminous flux of 16500LM and a Luminous efficiency: 110 LM/W.

Fig. 3. 150W LED projector used

Need for electricity production:

- Four wind turbines, each with a production capacity of 10 kilowatts.
- Photovoltaic generators with a production capacity of 30 kilowatts (94 PV units of 325).
- Diesel generator to power the system in the absence of sun or wind.

A set of batteries to store the surplus in production and keep it until the moment of need (the absence of the sun).
A converter to transfer the current (DC to AC or vice versa) or increase the same type of current.
By the increment of the component president with the table below, the software HOMER PRO must make the simulation of system hybrid studied parallel to the schema of figure (4).

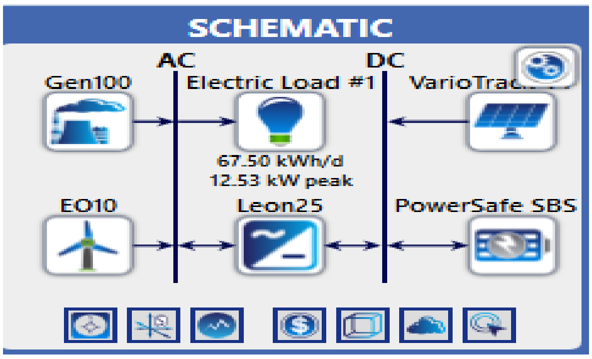

Fig. 4. Diagram of the hybrid system simulated by HOMER PRO

IV. ANALYSIS OF SIMULATION RESULTS

When you click on the "calculate" icon, the HOMER imitates all the possible configurations of the hybrid system. And it displays the table of results, figure (5). Along with this table, the Homer displays a series of configurations which determine the probability feasible of this system. They are ranked in order (from top to bottom) from maximum profit to minimum profit.

Financing is provided in a structured power system and is in the range of ($82,992 with replacement, operation & maintenance and fuel costs of $7,549, $6,199 and $1,061 respectively, and finally the salvage value is $10,580.The total current cost (NPC) of annual revenue is PV $33,658, wind generator $4,000, batteries $7,125, Diesel generator $7,125. $31,855 and converter $10,581, depending on the minimum cost of the other components. The resulting improvement results in a total cost of $87,222.

A. By photovoltaic panels:

From the results shown in the figure (5), it can be seen from the table that the PV will operate at a force of 21.3%. With a daily production capacity of 153 kWh/d, and an annual production of 55,932 kWh/year.

Quantity	Value	Units
Rated Capacity	30.0	kW
Mean Output	6.38	kW
Mean Output	153	kWh/d
Capacity Factor	21.3	%
Total Production	55,932	kWh/yr

Quantity	Value	Units
Minimum Output	0	kW
Maximum Output	30.1	kW
PV Penetration	227	%
Hours of Operation	4,381	hrs/yr
Levelized Cost	0.0466	$/kWh

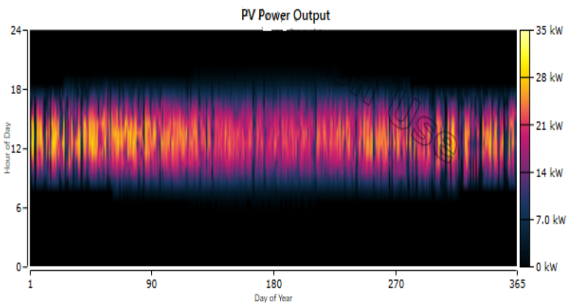

Fig. 5. PV output power

B. By wind generators:

We note that the wind turbines produce an electrical capacity of 29.3 kilowatts with an efficiency of 73.1%, and an operating time of 7,686 hrs/year, and an annual production of 256,267 kWh/year, figure (6).

Quantity	Value	Units
Total Rated Capacity	40.0	kW
Mean Output	29.3	kW
Capacity Factor	73.1	%
Total Production	256,267	kWh/yr

Quantity	Value	Units
Minimum Output	0	kW
Maximum Output	46.5	kW
Wind Penetration	1,040	%
Hours of Operation	7,686	hrs/yr
Levelized Cost	0.00121	$/kWh

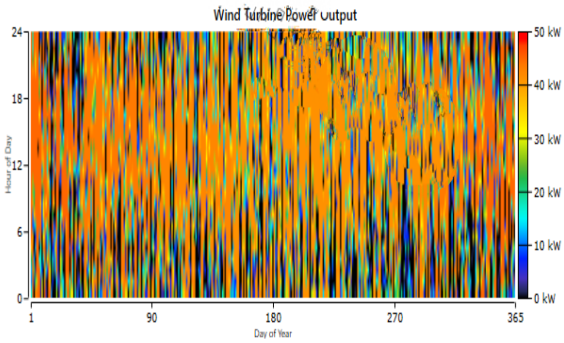

FiG. 6. jump power of wind generators

C. By diesel generator:

The diesel generator produces an output power of 0.0257% as shown in figure (9), the generator can reach a maximum power of 25 kW. .Fuel consumption 82.1 liters. The annual electricity supply is 225 kWh.

Quantity	Value	Units
Hours of Operation	9.00	hrs/yr
Number of Starts	9.00	starts/yr
Operational Life	1,667	yr
Capacity Factor	0.0257	%
Fixed Generation Cost	7.47	$/hr
Marginal Generation Cost	0.253	$/kWh

Quantity	Value	Units
Electrical Production	225	kWh/yr
Mean Electrical Output	25.0	kW
Minimum Electrical Output	25.0	kW
Maximum Electrical Output	25.0	kW

Quantity	Value	Units
Fuel Consumption	82.1	L
Specific Fuel Consumption	0.365	L/kWh
Fuel Energy Input	808	kWh/yr
Mean Electrical Efficiency	27.8	%

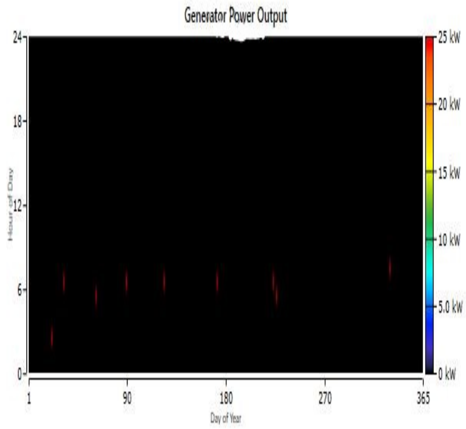

Fig. 7. Diesel generator power output

Noting that the diesel generator does not work all year round, so fuel consumption and gas emissions are low.

The architecture consists of 10 batteries, with a string size of 1.00 each battery, a series of 10 parallels and with a bus capacity of 12 V. The battery capacity is autonomous for 22.8 hours, nominal capacity of 91.6 kWh, 88,428 kWh battery life and long life up to 15 years, figure(6, 7).

Quantity	Value	Units
Batteries	10.0	qty.
String Size	1.00	batteries
Strings in Parallel	10.0	strings
Bus Voltage	12.0	V

Quantity	Value	Units
Autonomy	22.8	hr
Storage Wear Cost	0.0551	$/kWh
Nominal Capacity	91.6	kWh
Usable Nominal Capacity	64.1	kWh
Lifetime Throughput	88,428	kWh
Expected Life	15.0	yr

Quantity	Value	Units
Average Energy Cost	0	$/kWh
Energy In	5,986	kWh/yr
Energy Out	5,806	kWh/yr
Storage Depletion	0.000602	kWh/yr
Losses	180	kWh/yr
Annual Throughput	5,895	kWh/yr

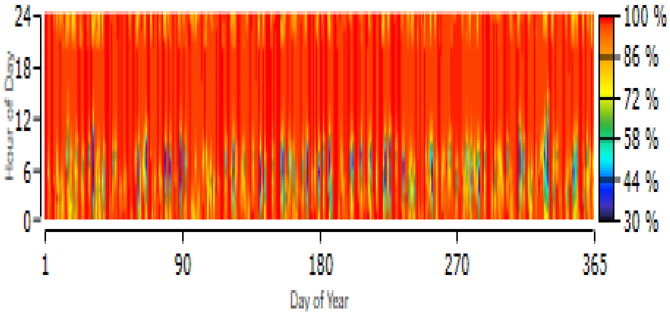

Fig. 8. Battery storage state of charge for one year.

The simulation results show that this system produces annual electrical energy of 312,424 kWh/year. In which the total energy produced from a wind generator (256,267 kWh/year), is greater than the energy generated from a PV generator (55,932 kWh/year), and the it is greater than the energy generated by Diesel generator (225 kWh/year) table (2).

Table 2: Electricity production and demand for photovoltaic-wind-diesel system

Production	kWh/yr	%
CanadianSolar MaxPower CS6X-325P	55,932	17.9
Generic 100kW Fixed Capacity Genset	225	0.0720
Eocycle EO10	256,267	82.0
Total	312,424	100

Consumption	kWh/yr	%
AC Primary Load	24,638	100
DC Primary Load	0	0
Deferrable Load	0	0
Total	24,638	100

V. CONCLUSION

In this study, we relied on the data provided by the Homer program (wind speed, temperature ... etc.) automatically. After determining the location in which the system should be applied, we came up with a set of solutions and suggestions for installing the hybrid system.

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