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Feasibility analysis a hybrid system PV/Wind Turbine/Battery assisted by a diesel generator in southwest of Algeria

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ABSTRACT/RESUME

Abstract: *Hybrid energy technology can efficiently cope with the energy needed in rural farming areas. The present paper provides a simulation for Photovoltaic's panel/ Wind Turbine/battery assisted by a diesel generator for alimentation a farm and irrigation it in Adrar city. This case study is an agricultural land consisting of three houses. An evaluation analysis was carried out to assess the performance of the hybrid system to meet the electrical requirements without resorting to the grid. The best configuration of Integrated clean and sustainable energy systems with minimum gross net present costs and energy cost levelization (is a mix of 22400 W Photovoltaics energy, 13700 W converter, 17000 W diesel engine with 43 batteries (12 V, 200 Ah). The performance of Photovoltaic system and diesel engine are 91.8 % and 8.2%, respectively. The results show that the maximal energy consumption in the month of July with 14.25 kW, and the minimal in the month of November with 5.01 kW. Also, the simulation results show that the proportion of the Photovoltaic generator's average power output to the system's average load is 91.8 percent at the site, so the site is highly suitable for the operation of a system for power generation without a grid. The findings suggest that the Net Present Cost (NPC) and the levelized cost of energy (COE) of the optimum Integrated Renewable Energy System (IRES) are 91 183.16 € and 0.303 € per kWh, respectively.*

I. Introduction

Energies consumption is increasing at an ever increasing rate and cannot be fully met by conventional energy systems, due to its limited supply. With the depletion of fossil fuels and increased energy demand, renewable energy generation (RES) has attracted worldwide attention [1-2]. Algeria has a common geographical area, which makes it one of the best areas to invest in renewable energies, due to the presence of a vast field of solar energy [3], as well as the appropriate wind speeds for the use of both solar panels and wind energy [4]. Most of the researcher has described the optimization analysis of hybrid energy system, According to their needs and interactive elements, like PV-wind-diesel [5-9], solar-wind-hydrogen [10-12], PV-gas turbine [13-14]. Mokhtara et al [15], presented an alternative methodology for the optimal design of hybrid PV / WT / energy storage and diesel generator backup, for the supply of electricity to oil and gas drilling camps in Adrar, southwest of Algeria.

The multi-criteria decision-making method of the analytical hierarchy process (AHP) has been used to select between renewable technologies and to determine optimal HRES. The results confirm that the hybrid energy system with battery storage is the best configuration for both scenarios. a model for calculating the optimal amount of transmission, wind, and solar capacity in the grid's different regions developed by Deetjen et al. [16], to determine the optimum transmission, wind and solar scale of a PV power system in Germany. The results indicated that the storage, PV and wind measurements were 27.0 GW, 26.6 GW and 11.1 GW, respectively. The results confirm that these methods and model can be used by any grid with an aim for renewable energy capacity expansion.

Ismail et al. [17], presented an operational utilization of excess energy in unconnected area hybrid scheme based on PV-Wind by offering a new design for reducing the cost of energy. A sizing approach combined with an energy management strategy-based economic predictive control to build a reliable off-grid PV-wind-battery system at the lowest price was suggested by Rullo et al. [18].

The sizing of a system to be created in any site is a very important step. So that the energy produced by this system is sufficient to cover the load demand in electrical energy. On the other hand, there will be no wasted energy and therefore additional costs.

This whole process requires knowledge of the energy potential of the region, and therefore the installation of the appropriate productive elements.

Based on the documentary study, there are many programs that are interested in the study of the sizing of systems. Like sizing tools RET Screen and PV/SOL typically reduce the options available for power sources, system architecture, and dispatch strategies.

Simulation tools such as HOMER and Hybrid to allow all analyzes to be carried out in detail. Both also allow the inclusion of wind turbines in system analyzes. But only HOMER can compare systems that combine DC and AC currents.

The main objective of this study is to evaluate the performance of a hybrid PV-wind- Batteries with backup system in this isolated area by providing data and the best configuration to save energy by using this hybrid system, in addition to that, to compare several configurations in terms of fossil fuel consumption and carbon dioxide production, as well as saving money and energy.

II. Dynamic liquid metering system

A dynamic liquid metering system is defined as a system connected to the calculator, the correction device or the conversion device, which converts, during the measurement, the characteristic quantities of the liquid. The Selection of the study area and availability of renewable sources; estimate of the energy demands permitted in the study area by the minimum desirable load, as discussed below:

II.1. Area selection

Tsabit is the farmers' area; it belongs to the state of Adrar.

Adrar is located in the central part of the Algerian Sahara; it covers an area of 427,968 km^2, occupied by 336,046 inhabitants. It is bounded to the northwest by the wilaya of Bechar, to the east by the wilaya of Ghardaïa and Tamanrasset, to the west by the wilaya of Tindouf, to the southwest by Mauritania and Mali to the south. This wilaya, with an average altitude of 222 m, is made up of three large regions: Gourara, Touat and Tidikelt. It extends between geographic coordinates, longitudes between 0 ° 30 'and 0 ° 30' in the West, latitudes between 26 ° 30 'and 28 ° 30' in the North. [19] The climate of the commune of Adrar is of continental desert type and the rainfall is extremely low and even insignificant in the city of Adrar. Adrar city is located in the south west of Algeria was selected for the case study by [20-21].

Our study consists of a large farm that contains a family house of three rooms and a general pump that extracts water from a depth of 50 meters used for irrigation for 8 hours per day.

Figure.1, illustrate schematic configuration proposed in this work, system includes from two renewable sources (PV and wind system) which are connected with a backup source (diesel generator and batteries), the converter for connecting the DC / AC bus is included in the hybrid system. Table.1 shows the Description of technical data of hybrid system.

II.2. Flowchart of HOMER Pro

The basic steps in the form of a flowchart for developing our model by using the HOMER Pro is shown in figure 2. According to the flowchart, the various components of modeling, as well as their subcomponents, have been addressed in a step-by-step. The flowchart's solid lines represent the main steps in designing and implementing the model, while the dotted lines represent the different choices for the given parameter.

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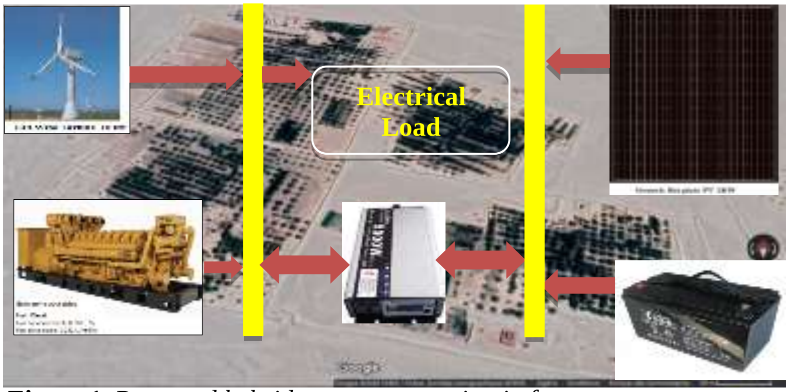

Figure 1. *Proposed hybrid system connection in farm area.*

Table 1. *The technical data devices description*

PV array parameter		Diesel generator	
Technology	Condor polycrystalline	Capital cost	300 €/kW
Capital cost	1100 €/Kw	Power	1400 kW
Efficiency	13%	Life time	15000 Hours

Wind turbine		Battery	
Technology	ENERCON E44	Capital cost	300 €
Capital cost	170 000 €	Capacity	1kWh LA
Power	10 kW	Nominal voltage	12V
Life time	20 years	Life time	10 years

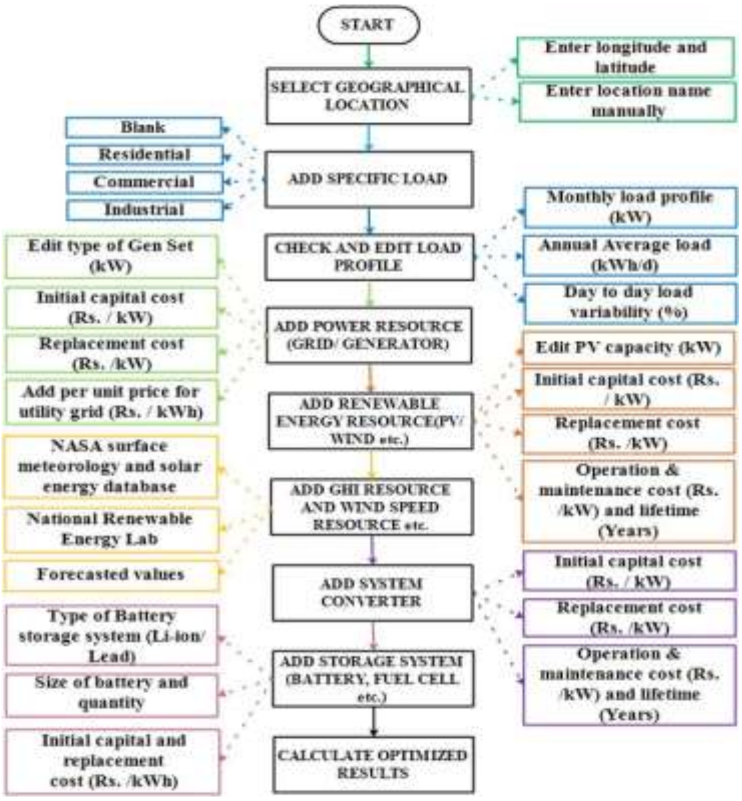

Figure 2. *Flowchart of HOMER Pro software [22].*

II.3. Estimation of Energy Demand

The Energy demand projected in this study, Regardless of the production of electricity in Adrar state; thus energy consumption increases with respect to the summer period. Based on the energy requirements of this research, the main base-data is gathered from the location of the farm by registering a group consisting of three main sections represented in the consumption of water pumping operation and the use of air conditioners in lighting homes and entertainment in summer and winter as shown in Figure 3.

II.4. Estimation of renewable energies sources

There is a large potential availability of sources of alternative energy, such as wind and solar, in the southwest of Algeria. The solar irradiation quality and the annual wind speed and direction data of the Tsabit location were collected from the latitude and longitudes of the study area. (28° 21' 7.452" N and 0° 13' 1.956" W). To find out the normal solar irradiation, HOMER Pro program is being used; average wind velocity; and optimum sizing dimensioning across these latitudes and longitudes.

II.4.1. Monthly solar irradiance

Figure 4, shows the annual daily available solar irradiation reported at the Adrar location. The highest solar irradiation was found in June at 7.34 kWh / m2 / day, while the lowest was found in December at 3.794 kWh / m2 / day.

II.4.2. Monthly wind velocity

As seen in Figure 5, the annual average wind speed available at the Adrar location and its value is found at 3 m / s.

III. Hybrid farm sizing

III.1. Wind energy system

Wind speed at the location and turbine specifications control the wind turbine’s energy performance is calculated by the equation. (1) [23].

$$P_e(v) = \begin{cases} 0, & v < 3 \\ 0.007(v-6)^2 + 0.06(v-6) + 0.13, & 3 \le v < 8.5 \\ -0.005(v-14)^2 + 0.04(v-14) + 0.68, & 8.5 \le v < 20 \\ 0.0008(v-22.4)^2 + 0.02(v-22.4) + 0.68, & 20 \le v \le 25 \\ 0, & v > 25 \end{cases} \quad (1)$$

Where: $P_e(v)$ is the generator's electric energy output at a v (m / s) wind level.

III.2. Solar photovoltaic system

The photovoltaic influences are a way of converting the power that is created by the sun in the structure of rays for electrical energy (DC), a semiconducting device called a solar cell is used to produce the electricity [24-25]. the following expression is correlated with the output voltage and the load current [26]:

$$I_{PV} = I_L - I_D$$

$$= I_L - I_0 \left[exp\left(\frac{U_{PV} + I_{PV} R_S}{\alpha} \right) - 1 \right] \quad (2)$$

Where: $I_L[A]$: Photovoltaic current,
$I_0[A]$: Saturation current,
$I_{PV}[A]$: Load current,
$U_{PV}[V]$: Output voltage,
$R_S[\Omega]$: Series resistance,
$\alpha[V]$: Thermal saturation factor

For a PV module with N_S series connected cells and N_P parallel linked cells, the current-voltage characteristic is given by:

$$I_{PV} = I_L - I_D$$

$$= N_P I_L - N_P I_0 \left[exp\left(\frac{\frac{U_{PV}}{N_S} + \frac{I_{PV} R_S}{N_P}}{\alpha} \right) - 1 \right] \quad (3)$$

III.3. Converting system

In order to sustain energy, transfer from various IRES power sources to electrical load by transferring electrical energy from one type to another (DC to AC), the power converter is very important. The energies generated in the battery bank by the wind turbine, solar PV are in DC form. So even though, electricity produced by electricity is in the form of AC. The transformer is both an inverter (DC-AC) and an inverter (AC-DC) combination. [8]

III.4. Storage system

This system is very important for energy conservation during the production period from renewable energies and it is used in the event of stopping production, whether at night although solar radiation is unavailable, or in a period when the wind is non-existent and the weather is cloudy, and the case when there is pic consumption.

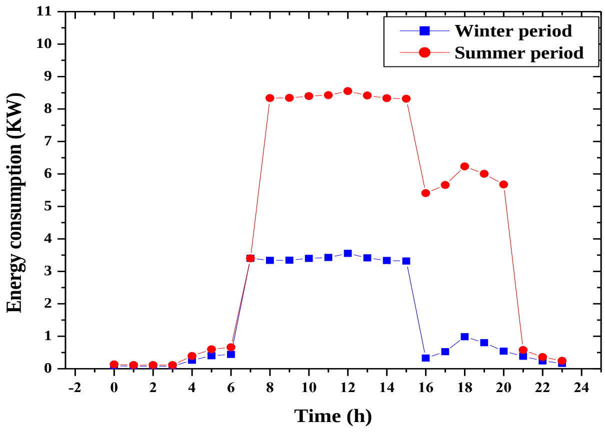

Figure 3. *Hourly load profiles within the summer and winter periods.*

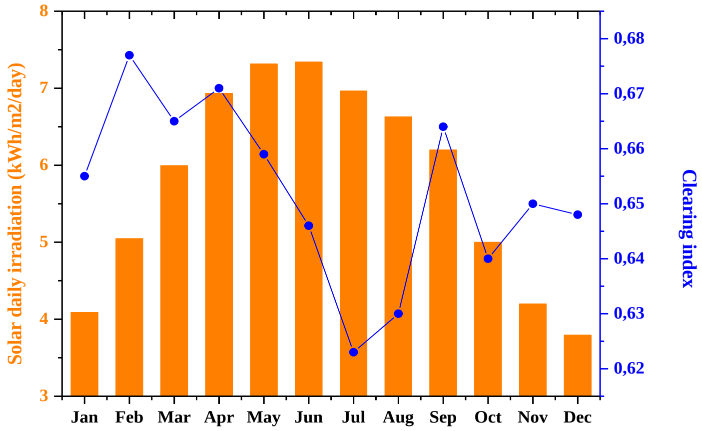

Figure 4. *Monthly solar radiation in Adrar Area.*

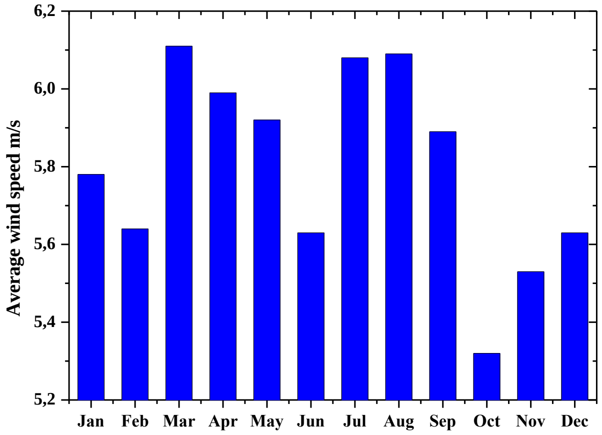

Figure 5. *Monthly average wind speed.*

III.5. Load demand Profile

Load demand profile is represented by the energy required to operate the appliances, equipment of lighting, water pumps, refrigeration, and air conditioning systems is considered on this farm. The table 2. Illustrate the load profile for each equipment.

IV. Results and discussions

In this section, after selecting each of the solar panels, wind turbine, batteries storage system and the diesel engine as backup system. HOMER Pro, on the basis of the strategy for optimization methodology, the details of the hybrid power system are discussed on the basis of the optimum system scale, economic performance and energy.

IV.1. Analysis of the optimum size for the integrated system

The contribution of the individual wind turbine, PV, battery, diesel generator and DC-AC system components shows the influence of the optimization architecture in this proposed scheme. The highest use of wind, PV and batteries is used to cover the need for loads of 64.35 KW. To find the optimum setup, the HOMER program simulates 9071 options, 7069 of which were feasible and 2002 were not feasible due to power limitations. The method of optimization is based on the existing net cost. Some of the best potential configurations of an optimized hybrid renewable energy system are described in Table 2. The combination of 22.4 kW solar photovoltaics, 13.7 kW transformer, 17 KW diesel generator and 43 batteries (200 Ah, 12 V) backup energy storage is the most feasible IRES configuration with minimal NPC and COE.

IV.2. Analytical study of the system

The method of optimization is based on net present expense, which is the cumulative cost of capital, O&M cost, cost of replacement and cost of salvage of all elements of the integrated device over the life of the project. The optimum IRES of the NPC and COE are 91 183.16 € and 0.303 € per kWh, respectively. The economic report of this hybrid structure is noted in Figure 06. The net current cost collapse study of the best hybrid energy system as seen in Table 3. It should be remembered that the overall cost of the PV system is highest which accounts for about 52.7 percent of the system's total net current cost, followed by the battery bank with 27.6 percent, 10.91 percent diesel generator and 8.78 percent converter.

IV.3. Hourly consumption in rural farm

For 12 months, the hourly utilization of this farm was estimated. It observed that low winter consumption and high summer consumption were low in the summer season. From the Figure 7, we observed the maximal energy consumption in the month of July with 14.25 KW, and the minimal in the month of November with 5.01 KW. The Figure 5, shows that large energy is consumed in the summer period between cooling and pumping water from the 50 m depth of the earth and this is due to the need of the farmer for water and thermal comfort in his house during summer period and that is because the farmers are located in a dry and hot area. Otherwise, in the winter period, when energy needs decrease by 50 percent.

IV.4. Comparison between consumption and solar photovoltaic production

We notice from the Figure 8, that the solar energy covers the farm's energy needs most of the time except for the night periods and periods of great stress for energy. In these two exceptional cases, we use batteries and diesel generator system to cover the energy consumption needs. It is also noted that production via solar energy in this region is high throughout the year, in the winter period we do not need much energy consumed unlike summer.

IV.5. Hybrid system generators daily production

Figure 9, displays the figures for the everyday generation of electricity from two appliances and additional relevant hybrid device efficiency review via the solar panel system and the classic diesel engine system, which notes that solar energy is used on a daily basis and is an important element in the hybrid system, unlike the diesel engine that is used in the period of energy stress and in the case of panels not being able Solar cover from the required power. Therefore, the clean component of the grid accounts for 84% and 43% of overall annual electricity production is excess energy, according to simulation. The load following requirements is the generator dispatching technique used here; thus, the generator must be run in such a way that it generates only the necessary amount of power to cover the lack of energy that cannot be supplied to fulfill the load from the renewable systems or battery bank 91.8% and 8.2%, respectively, are the power variables of the PV system and diesel generator.

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Table 2. *Load demand profile*

Equipment	Summer	Winter	Time
01 Television + sat reserved	250 W	250 W	12 h
01 Pump water 50m depth	3000 W	3000 W	9 h
01 Air conditioner (18000BTU)	5000 W		8 h
01 Refrigerator 500 L	300 W	24 h	24 h
14 Bulb economic	700 W	700 W	12 h
Others	17000 W		12 h
Total	102,805 KW/Day	35 KW/Day	/

Table 3. *Different configuration of some of the viable combination of integrated hybrid energy systems*

Architecture						Cost				System	
PV (kW)	E44	Gen (kW)	1kWh LA	Converter (kW)	Dispat	COE (€)	NPC (€)	Operating (€/yr)	Initial capit (€)	Ren Frac (%)	Total Fuel (L/yr)
22,4		17,0	43	13,7	CC	0,300 €	91 183 €	3 439 €	46 729 €	84,2	1 228
55,6			71	15,8	CC	0,400 €	121 420 €	2 650 €	87 159 €	100	0
		17,0	18	2,67	CC	0,605 €	183 836 €	13 346 €	11 300 €	0	9 312
	1	17,0			CC	0,974 €	295 824 €	9 339 €	175 100 €	81,5	1 817
10,8	1	17,0	36	15,3	CC	1,02 €	308 223 €	8 185 €	202 417 €	98,9	92,4
36,7		17,0		7,23	CC	1,03 €	311 415 €	20 401 €	47 687 €	0	13 840
23,0	1	17,0		3,83	CC	1,05 €	319 307 €	9 107 €	201 573 €	85,6	1 453
		17,0			CC	1,09 €	329 557 €	25 098 €	5 100 €	0	17 806
49,0	1		72	15,0	CC	1,23 €	373 362 €	9 539 €	250 049 €	100	0
	3		108	15,3	CC	2,82 €	856 147 €	23 914 €	547 000 €	100	0
50,7	17			7,88	CC	14,75 €	4,48 €M	118 421 €	2,95 €M	100	0
	35				CC	29,93 €	9,09 €M	242 636 €	5,95 €M	100	0
	1	17,0	16	4,58	LF	0,948 €	287 855 €	8 245 €	181 274 €	92,4	707

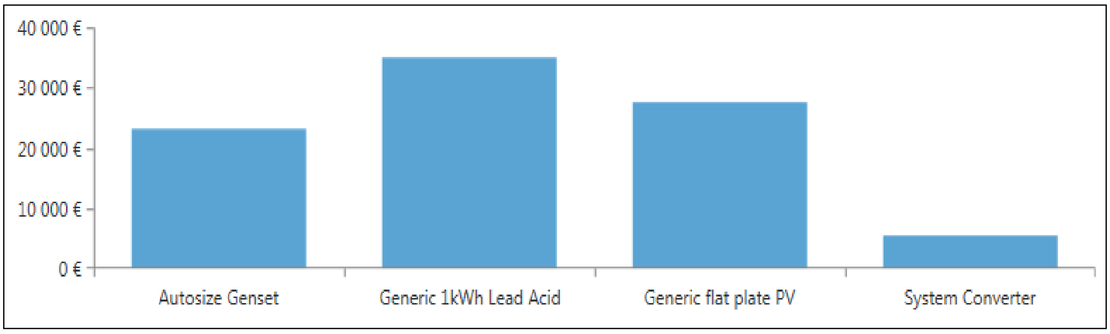

Figure 6. *Economic report of hybrid system components*

Table 4. *Net current cost breakdown study of the optimal integrated hybrid energy system.*

Components	Capital	Replacement	O&M	Fuel	Salvage	Total
Diesel generator	5 100,00 €	0,00 €	2 511,95 €	15 874,96 €	-445,94 €	23 040,97 €
1kWh Lead Acid	12 900,00 €	18 135,02 €	5 558,83 €	0,00 €	-1 487,69 €	35 106,16 €
Flat plate PV	24 627,47 €	0,00 €	2 894,29 €	0,00 €	0,00 €	27 521,76 €
System Converter	4 101,59 €	1 740,20 €	0,00 €	0,00 €	-327,52 €	5 514,27 €
System	46 729,06 €	19 875,21 €	10 965,07 €	15 874,96 €	-2 261,15 €	91 183,15 €

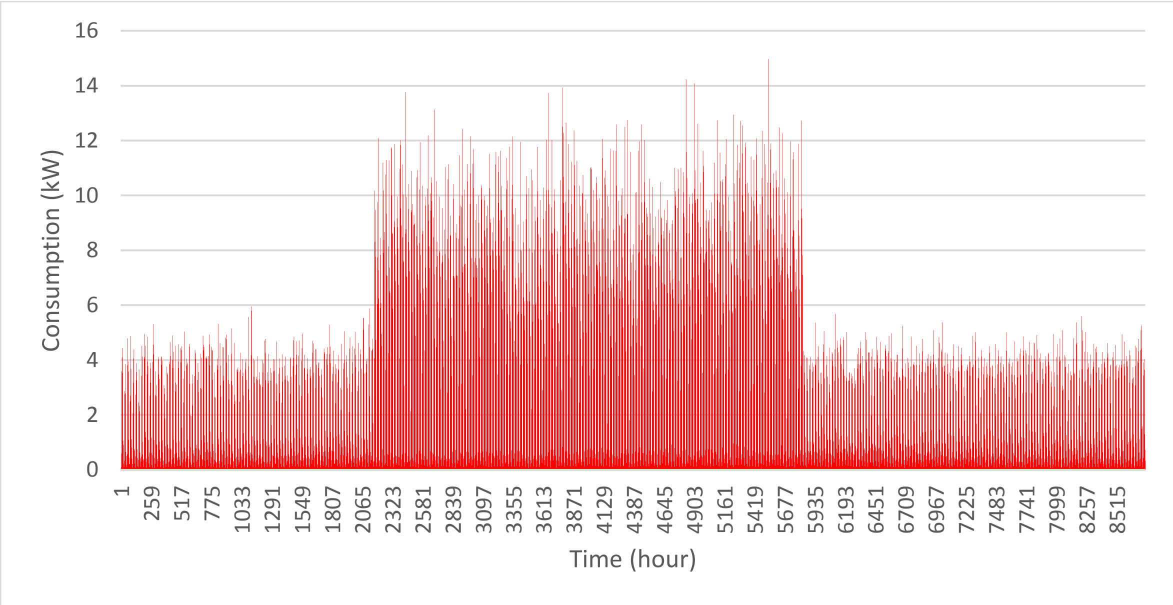

Figure.7. *Hourly consumption in rural village.*

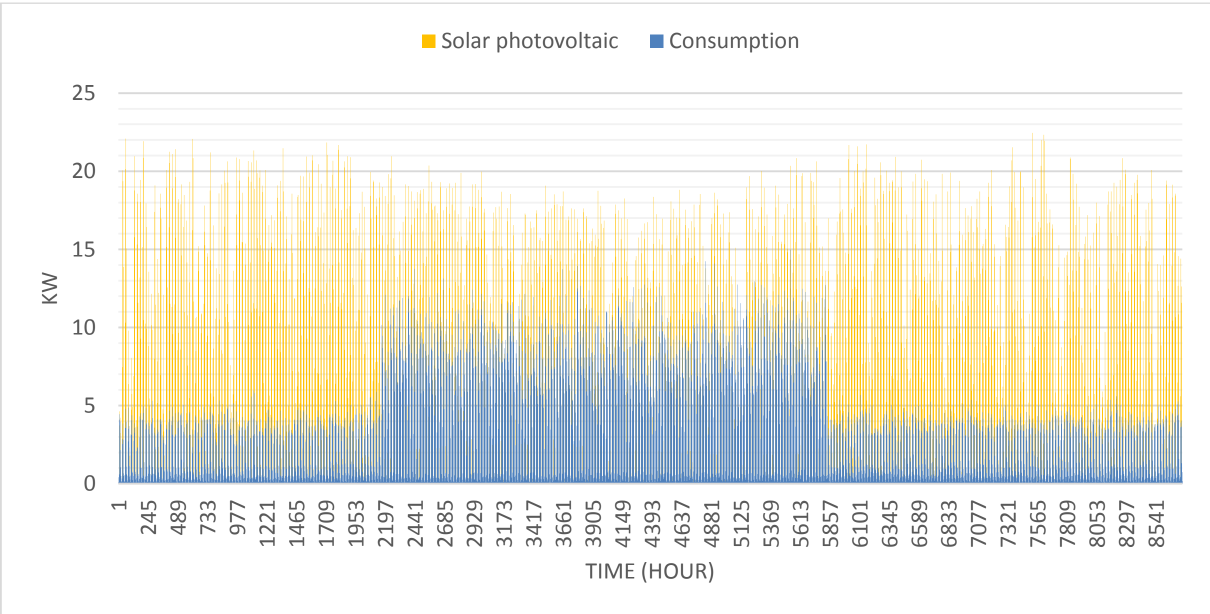

Figure 8. *Comparison between consumption and solar photovoltaic production*

IV.6. Monthly average battery discharge

During the morning period, the extra energy generated by the solar panels can be used, after fulfilling the load request, to charge the battery, until the batteries are charged. Although stored energy may be discharged, the battery releases energy to help cover load requirements when power generation is inadequate, before capacity is depleted. Then, it defines whether the battery is in charge or discharge mode, the discrepancy between the electricity needed for the load and the total power provided. The variations in sun energy irradiation output do not obey the demand time distribution. The association of battery storage facilities therefore includes power generation systems to smooth the mismatch in time allocation between load and solar power generation and to ensure system maintenance. The storage system is seen as a key cost factor in small-scale stand-alone power systems. It is noticeable from the Figure.10 that the consumption of the battery is more during the summer period than in the winter, and during sunset and sunrise periods, and this is clearly apparent.

IV.7. Diesel generator monthly fuel consumption

The diesel generator is used for the continuity of the power supply of different forms of hybrid power systems. In order to generate electric power to satisfy load requirements, it is a combination of diesel engine and synchronous generator. For a diesel engine to have the necessary output voltage at 50 Hz, the synchronous generator runs at a constant rpm. The fuel consumption of the diesel generator depends on the power output. Even if the electricity is not produced from it and still generates a large amount of pollutant gas, the generator also absorbs about 25 percent of the fuel at its full nominal capacity. From figure. 11, We have noticed that the use of the diesel engine in periods of extreme need for electricity and we noticed that its use is much in the summer period compared to the winter in which its use is almost non-existent, and this makes the fuel consumption high in the summer period.

V. Conclusion

HOMER Pro simulation software is used to simulate energy performance of hybrid system Pv-batteries- Diesel generator for a period of one year. This paper was concerned with the design of an independent off-grid system for use in farm in southern of Algeria. HOMER-Pro, the optimization method developed by NREL, is used to evaluate the best hybrid mixture possible and its implementations. The results of the simulation show that the proportion of the PV generator's average power output to the system's average load is 91.8 percent at the site, so the site is highly suitable for the operation of a system for power generation without a grid. The findings suggest that the NPC and COE of the optimum IRES are 91 183.16 € and 0.303 € per kWh, respectively. Moreover, the best hybrid energy system's net present expense collapses study. It should be remembered that the overall cost of the PV system is highest which accounts for about 52.7 percent of the system's total net current cost, followed by the battery bank with 27.6 percent, 10.91 percent diesel generator and 8.78 percent converter. This theoretical study demonstrated the effectiveness of solar panels to provide energy load to the farm with the use of the diesel engine and the batteries as auxiliary and secondary tools in the system, as well as the inefficiency of the wind turbine in producing energy in this region due to the lack of wind speed. In order to reduce the cost of these systems, the State must develop a strategy to organize and stimulate the renewable energy market (production of solar panels, wind turbines, inverters and generators, etc.). The implementation of these systems must be on the charge of the state, because, it is impossible for the average citizen to pay such bills. That is, instead of expanding the network, the state is responsible for the supply and installation of these hybrid systems with a symbolic contribution from citizens.

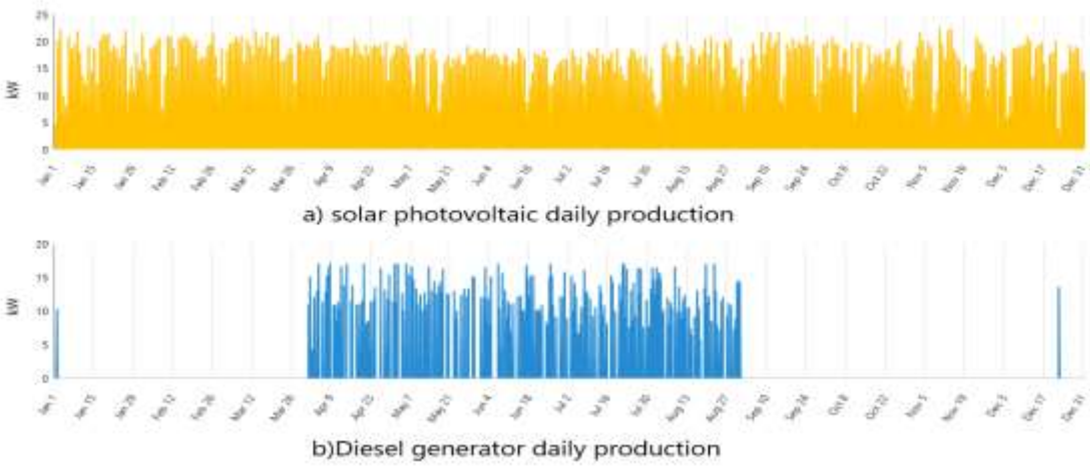

Figure 9. *hybrid system generators daily production*

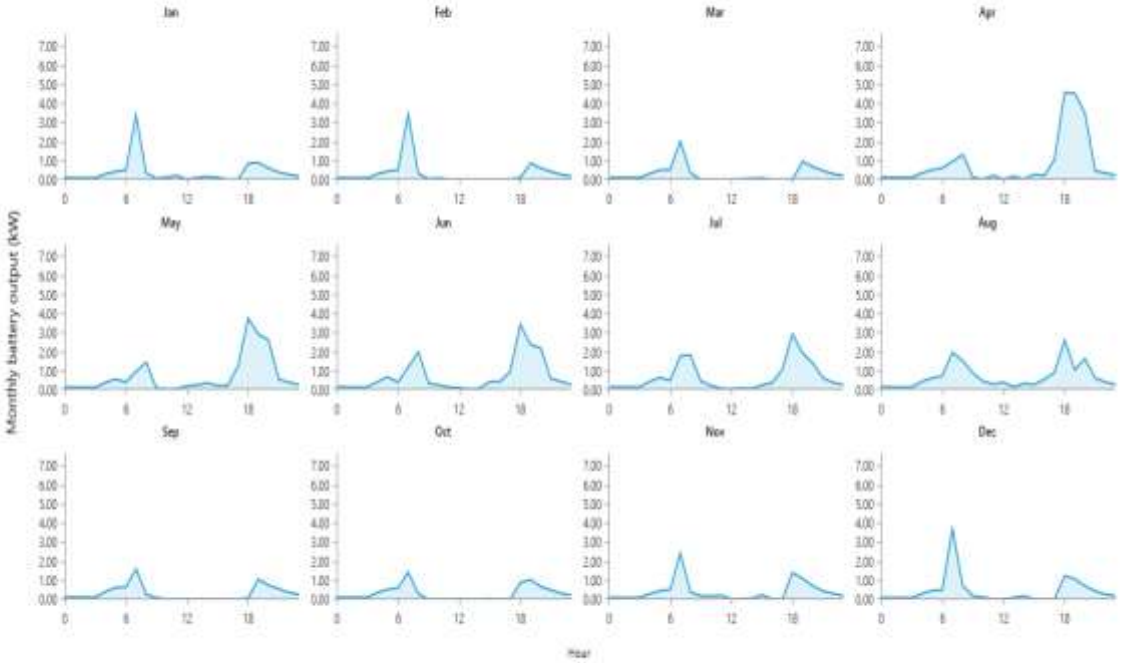

Figure 10. *Monthly average battery discharge*

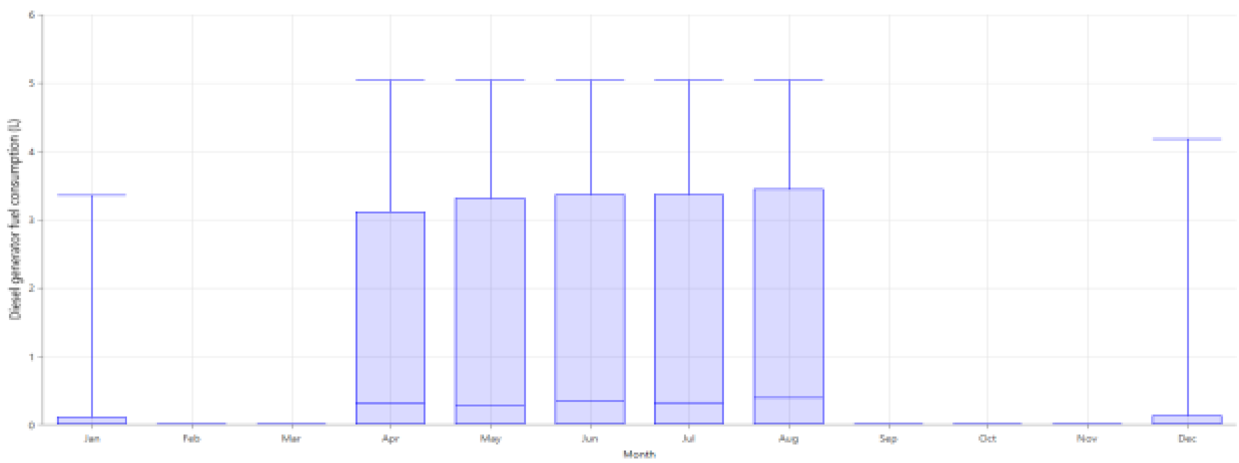

Figure 11. *Diesel generator monthly fuel consumption.*

VI. References

1. Anoune, K.; Bouya, M.; Astito, A.; & Abdellah, A. Sizing methods and optimization techniques for PV-wind based hybrid renewable energy system: A review. Renewable and Sustainable Energy Reviews, 93(2018) 652-673.
2. Khan, M.; Yadav, A.; & Mathew, L. Techno economic feasibility analysis of different combinations of PV-Wind-Diesel-Battery hybrid system for telecommunication applications in different cities of Punjab. India. Renewable and Sustainable Energy Reviews, 76(2017) 577-607.
3. Harrouz, A., & Omar, H. Application of Solar Energies to Reinforce the Flow Water of Foggara in the Adrar Region. International Journal of Smart Grids, International Journal of Smart Grid 2(4) (2018) 203-208.
4. Harrouz, A., Colak, I.; & Kayisli, K. Energy Modeling Output of Wind System based on Wind Speed. In 2019 8th International Conference on Renewable Energy Research and Applications IEEE 11 (2019) 63-68.
5. Bentouba, S.; & Bourouis, M. Feasibility study of a wind–photovoltaic hybrid power generation system for a remote area in the extreme south of Algeria. Applied Thermal Engineering 99(2016) 713-719.
6. Gupta, M.; Pramanik, S.; & Ravikrishna, R. Development of a syngas-fired catalytic combustion system for hybrid solar-thermal applications. Applied Thermal Engineering, 109(2016) 1023-1030.
7. Samu, R.; Fahrioglu, M.; & Taylan, O. Feasibility study of a grid connected hybrid PV-wind power plant in Gwanda, Zimbabwe.HONET-ICT IEEE (2016) 122-126.
8. Ammari, C. Sizing and optimization for hybrid central in South Algeria based on three different generators. International Journal of Renewable Energy Development (2017) 6(3).
9. Gabra, S.; Miles, J.; & Scott, S. Techno-economic analysis of stand-alone wind micro-grids, compared with PV and diesel in Africa. Renewable Energy 143(2019) 1928-1938.
10. Ishaq, H.; Dincer, I.; & Naterer, G. Development and assessment of a solar, wind and hydrogen hybrid trigeneration system. International Journal of Hydrogen Energy 43(52) (2018) 23148-23160.
11. Zhang, W.; Maleki, A.; Rosen, M. A.; & Liu, J. Sizing a stand-alone solar-wind-hydrogen energy system using weather forecasting and a hybrid search optimization algorithm. Energy conversion and management 180(2019) 609-621.
12. Nematollahi, O.; Alamdari, P.; Jahangiri, M.; Sedaghat, A.; & Alemrajabi, A. A techno-economical assessment of solar/wind resources and hydrogen production: A case study with GIS maps. Energy 175(2019) 914-930.
13. Luo, L.; Gu, W.; Zhang, X.; Cao, G.; Wang, W.; Zhu, G.; & Wu, Z. Optimal siting and sizing of distributed generation in distribution systems with PV solar farm utilized as STATCOM (PV-STATCOM). Applied Energy 210(2018) 1092-1100.
14. Nyeche, E. N.; & Diemuodeke, E. Modelling and optimisation of a hybrid PV-wind turbine-pumped hydro storage energy system for mini-grid application in coastline communities. Journal of Cleaner Production (2020) 250, 119578.
15. Mokhtara, C.; Negrou, B.; Settou, N.; Gouareh, A.; Settou, B.; & Chetouane, M. Decision-making and optimal design of off-grid hybrid renewable energy system for electrification of mobile buildings in Algeria: case study of drilling camps in Adrar. Algerian Journal of Environmental Science and Technology (2020) 6(2).
16. Deetjen, T.; Martin, H.; Rhodes, J.; & Webber, M. Modeling the optimal mix and location of wind and solar with transmission and carbon pricing considerations. Renewable Energy (2018) 120, 35-50.
17. Ismail, M. S.; Moghavvemi, M.; Mahlia, T.; Muttaqi, K.; & Moghavvemi, S. Effective utilization of excess energy in standalone hybrid renewable energy systems for improving comfort ability and reducing cost of energy: A review and analysis. Renewable and Sustainable Energy Reviews 42(2015) 726-734.
18. Belatrache, D.; Bentouba, S. Contribution à l'optimisation et l'amélioration de l'isolation d'une habitation utilisant une source renouvelable dans les zones arides. Doctoral dissertation, Université Ahmed Draia-ADRAR
19. Rullo, P.; Braccia, L.; Luppi, P.; Zumoffen, D.; & Feroldi, D. Integration of sizing and energy management based on economic predictive control for standalone hybrid renewable energy systems. Renewable energy 140(2019) 436-451.
20. Belatrache D.; Saifi N.; Harrouz A.; Bentouba S. Modelling and Numerical Investigation of the thermal properties effect on the soil temperature in Adrar region. Algerian Journal of Renewable Energy and Sustainable Development 2(2) (2020) 165-174.
21. Maouedj, R.; Mammeri, A.; Draou, M. D.; & Benyoucef, B. Techno-economic analysis of a standalone hybrid photovoltaic-wind system. Application in electrification of a house in Adrar region. Energy Procedia 74(2015) 1192-1204.
22. Mehta, S.; & Basak, P. A case study on pv assisted microgrid using homer pro for variation of solar irradiance affecting cost of energy. Power India International Conference IEEE (2020) 1-6.
23. Dahbi M.; Sellam M.; Benatiallah A.; Harrouz A. Investigation on Wind Power Generation for Different Heights on Bechar, South West of Algeria. Algerian. Journal of Renewable Energy and Sustainable Development (2019) 198-203.
24. Tahiri, F.; Harrouz, A.; Belatrache, D.; Bekraoui, F.; Omar, O.; & Boussaid, I. Technique of Control Pmsm Powered by Pv Panel Using Predictive Controller of Dtc-Svm. Facta Universitatis, Series: Electronics and Energetics 33(3) (2020) 429-444.
25. Tahiri, F.; Bekraoui, F.; Boussaid I.; Ouledali, O.; Harrouz A. Direct Torque Control (DTC) SVM Predictive of a PMSM Powered by a photovoltaic source. Algerian Journal of Renewable Energy and Sustainable Development 1(1) (2019) 1-7.
26. Maatallah, E.; Berbaoui, B. Modelling and Control of Photovoltaic System using the incremental conductance method for maximum power point tracking. Algerian Journal of Renewable Energy and Sustainable Development (2019) 1(2)191-197.

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