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Techno-economical Study of PV-Diesel Generator for a remote village in south Algeria

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Dédicaces

To my dear parents

No word in the world can express the immense love that I hold for them, nor the profound gratitude that I have for all the efforts and sacrifices that have never stopped nor been delayed.

To my dear wife

Who has always supported and encouraged me in all my projects.

LAKHDARI Slimane

Dédicaces

To my dear parents

No word in the world can express the immense love that I hold for them, nor the profound gratitude that I have for all the efforts and sacrifices that have never stopped nor been delayed.

BELABBASSI Abderrahim

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SYMBOLS LIST

η_{pv}	Instantaneous PV
P_{pv}	Output of the PV
G_t	global irradiance incident (W/m2)
A_{pv}	Area of single module PV
η_r	reference efficiency PV
η_{pc}	efficiency of power tracking the power conditioning efficiency
β_t	Temperature coefficient of effencicy [0.004 to 0.006]
T_c	Temperature PV
T_{cref}	Reference temperature
T_a	Ambient temperature (°C)
C_B	Battery bank capacity (Wh)
EL	The load in (Wh)
SD	The battery autonomy or storage days
VB	The battery bank voltage
DOD_{max}	The maximum battery depth of discharge
T_{cf}	The temperature correction factor and
η_B	Battery efficiency [0.65 to 0.85]
σ	Self-discharge of the battery bank
SOC (t)	The states of charge of battery bank (Wh)
E_{Gen} **(t)**	The total energy generated by PV array
EL (t)	Load demand at the time t
η_B	Efficiency of battery bank [%]
Df*(t)*	The hourly fuel consumption of DG [L/h]
P_{Dg}	The average power per hour of the DG [kW]
P_{Dgr}	The DG rated power [kW]
α_D, β_D	The coefficients of the fuel consumption L/h

ABBREVIATIONS LISTE

PV: Photovoltaic

DG: diesel generator

NASA: National Aeronautics and Space Administration

KW: Kilo Watt

CO2: Carbon dioxide gas

CO: carbon monoxide

KWh: Kilo watt hour

AC: Alternating current

DC: Direct current

MPP: Maximum power point

MPPT: Maximum power point tracking

LCE: Levelized cost energy

HRES: Hybrid system renewable energy

NREL: National renewable energy laboratory

NPC: Net present cost

COE: Cost of energy

M&O: Maintenance and operating

DZD: Dinar Algerian currency

General introduction

In Algerian's remote villages The electrification of the isolated places (far from the grids) by the extension of the national electric networks is economically impracticable, considering the high costs of electricity to deliver by the electric network,

Usually they use individual installation and supplying by diesel generators. In most of this cases, the supplying with genset becomes highly expensive because of the high costs of fuel, maintenance and operating, and its short lifetime, while hybrid system (photovoltaic /Diesel generator) more reliable in producing electricity than diesel only generation. The diesel generator reduces the photovoltaic panel number while the photovoltaic decrease the operating time of the Diesel generator, the addition of storage batteries reduces the start/ stop cycles of diesel generators thus, considerably reduce the fuel consumption.

In order to effectively explain the benefits of Hybrid system We propose the techno-economical study of the electrification an isolated home in Blidet Amor in rural area, that situate a 130 km North of the wilaya of Ouargla, ALGERIA, by using (solar photovoltaic / Diesel generator) hybrid system with storage batteries.

We use in our study the HOMER program which is sophisticated software developed by the American National Renewable Energy Laboratory for analyzing the economics of small power systems. And we divided our study to three chapters as shown below:

- ✓ First chapter: contains Photovoltaic and Diesel generator generalities.
- ✓ Second chapter: Modeling of hybrid system (PV/DG) with HOMER software.
- ✓ Third chapter: Results and discussion.
- ✓ Finely: Summary and conclusion.

Chapter I

Photovoltaic and Diesel generator generalities

I-1 Introduction

The photovoltaic conversion is based on the photovoltaic effect, that is, on the conversion of the light energy coming from the sun into electrical energy. To carry out this conversion, devices called solar cells are used, constituted by semiconductor materials in which a constant electric field has been created artificially (by means of a pn junction). In this chapter the basics of photovoltaic generation are presented, starting from the fundamentals of the photovoltaic effect, the basic structure and behavior of the solar cell, cell types, the photovoltaic module and a brief introduction to the applications in photovoltaic systems with the estimation of the energy generation of grid connected photovoltaic systems.

I-2 Basics of photovoltaic

The phosphorous gives the wafer of silicon an excess of free electrons. This is called the n type silicon. The n-type silicon is not charged. It has an equal number of protons and electrons. But some of the electrons are not held tightly to the atoms. They are free to move to different locations within the layer. The boron gives the base of the silicon a positive character, because it has a tendency to attract electrons. The base of the silicon is called p-type silicon. The p-type silicon has an equal number of protons and electrons; it has a positive character but not a positive charge.

Where the n-type silicon and p-type silicon meet, free electrons from the free electrons from the n-layer flow into the p-layer for a split second, then form a barrier to prevent more electrons from moving between the two sides. This point of contact and barrier is called the p-n junction. When both sides of the silicon slab are doped, there is a negative charge in the p-type section of the junction and a positive charge in the n-type section of the junction due to movement of the electrons and holes at the junction of the two types of materials. This imbalance in electrical charge at the p-n junction produces an electric field between the p-type and n-type silicon. If the PV cell is placed in the sun, photons of light strike the electrons in the p-n junction and energize them, knocking them free of their atoms. These electrons are attracted to the positive charge in the n-type silicon and repelled by the negative charge in the p-type silicon. Most photon electron collisions actually occur in the silicon base. A conducting wire connects the p-type silicon to an electrical load, such as a light or battery, and then back to the n-type silicon, forming a complete circuit.

As the free electrons are pushed into the n-type silicon they repel each other because they are of like charge. The wire provides a path for the electrons to move away from each other. This flow of electrons is an electric current that travels through the circuit from the n-type to the p-type silicon. In addition to the semi-conducting materials, solar cells consist of a metallic grid or other electrical contact to collect electrons from the semi-conductor and transfer them to the external load, and a back contact layer to complete the electrical circuit.

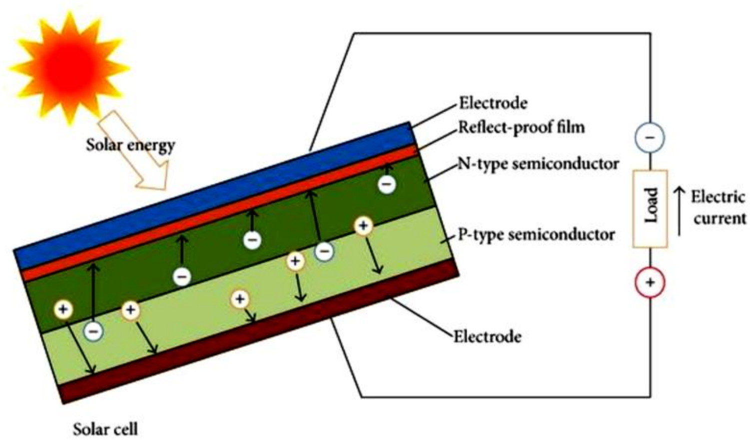


Figure I-1: P-N-junction, Cell components and current movement

However, in order to make the cell conduct current a crossover voltage has to be applied. For silicon diodes the crossover voltage is usually around 0.6 Volts. Furthermore adding a contact in the front and back enables for the solar cell to collect electrons crossing the barrier. Conversely, when light is shone onto the solar cell not all of the light is converted into current. A minimum energy, known as band-gap, is required in order to excite the electrons sufficiently enough to pass the barrier. As such diffuse and albedo light has a lower probability in producing electricity, since they are less energetic than direct light. Meanwhile, the light containing more energy than required will dissipate as heat, consequently lowering the performance due to increase in losses. With the prior knowledge of how the crystalline cell are able to harness the suns energy. An equivalent circuit of photovoltaic cells can be represented by a diode, current generator and a resistor in parallel with an additional resistor in series as shown in Figure I-2.

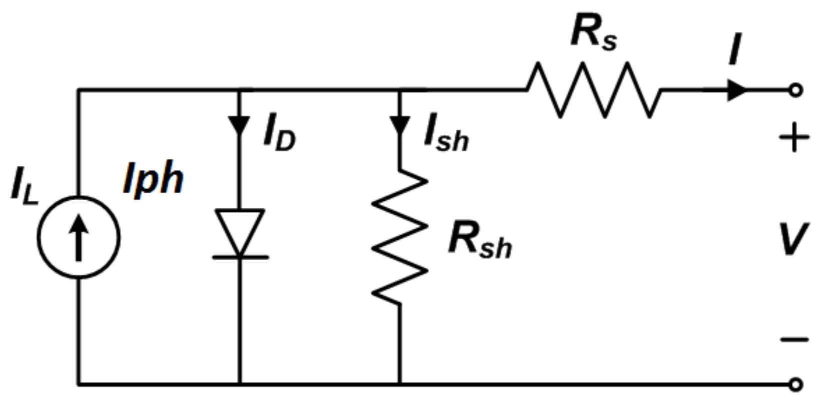


Figure I-2: Equivalent circuit of a Photovoltaic cell

Rsh is the shunt resistance that compensate for leaking currents in the diode, *Rs* is the series resistance that correspond e.g. resistance in contacts. Iph represents the current generated when exposed to sunlight. The current going through the junction is denoted *Id* and is calculated through the formula:

$$Id = Io\,(e^{qV} / kT) - 1) \qquad \text{(I-1)}$$

Where *Io is* the reverse saturation current of the diode, *q* the charge of an electron, *V* the open circuit voltage, *K* the Boltzmann constant and *T* temperature. Hence, by applying Kirchhoff‟s law the output current, *I* is calculated through the formula below:

$$I = Iph - Id \qquad \text{(I-2)}$$

In addition the current I is almost directly proportional to the insolation which is shown in figure 1-3below, as the voltage is close to fixed for when insolation varies [1].

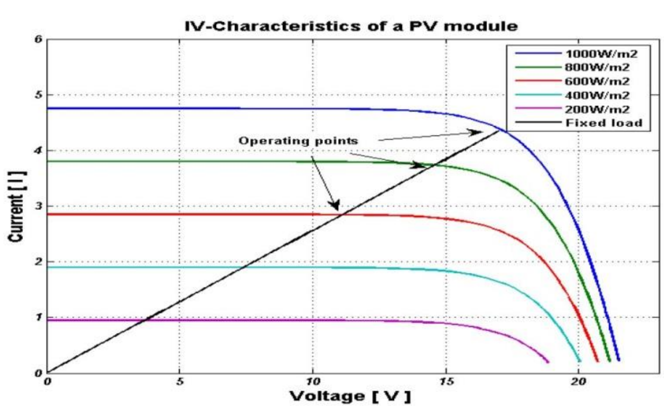


Figure I-3: I-V characteristics of different levels of insolation

I-3 Performance

The silicon solar cell has a theoretical efficiency of about 45 %. However typical efficiencies range from 11-16% depending on type, i.e. mono or poly crystalline. The low efficiency is an intricate matter and is linked to quantum physics and the spectral distribution of sunlight.

As stated in previous sections the sunlight emits wavelengths ranging from ultraviolet to infrared. Consequently the energy required, i.e. bandgap, to make the jump may sometimes be redundant, while other times not. As such, excess energy will dissipate as heat which has a negative effect on the cell. If the cells temperature increases the performance is lower. In order to for the cell to operate efficiently, the recommend band gap for the suns energy is between 1.0-1.6eV with the silicon cell having 1.1eV. Furthermore, a single silicon cell is seldom applicable for powering any large loads due to the voltage level being too low. Connecting cells in series however raise the voltage meanwhile the current remains roughly the same, whereas in parallel coupling the relationship is reversed.

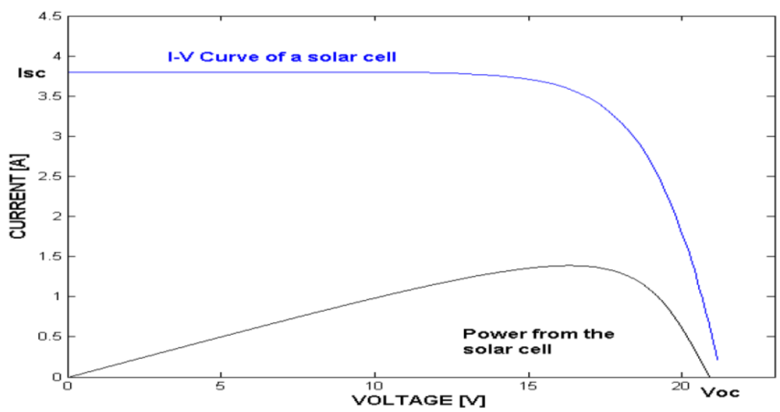


Figure I.4: Typical I-V & P-V curve of a photovoltaic cell

As seen in figure I-4 above, the current level is somewhat constant over the majority part of voltage levels. Consequently, the power generated from the cells is almost entirely dependent on the insolation, i.e. P ≈ I. Moreover, the maximum extractable power from the cell is found through the formula:

$$Pmpp = Vmpp * Impp \quad \text{(I-3)}$$

Where Vm and Im corresponds to the point on the curve where the power output is at its maximum, i.e. where the product between Vm and Im are at its maximum. In addition, for every level of isolation there is a corresponding MPP i.e. the values of Vm and Im will change depending on isolation, depicted in (figure I.5) below.

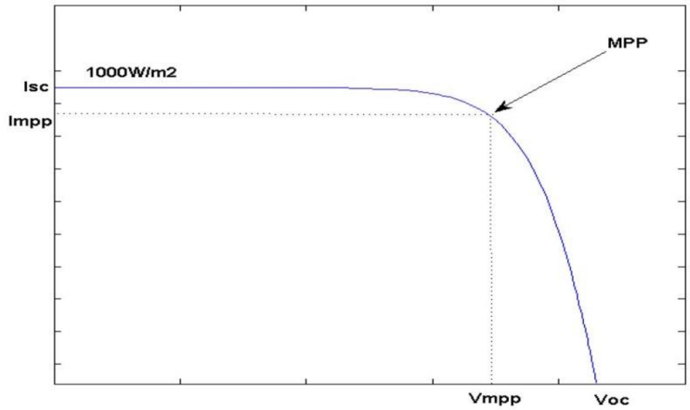


Figure I-5: I-V characteristics of different levels of insolation

However, when connecting a load to the cell, or module, the MPP is not always obtained, as can be seen in figure I.5 for insolation levels below 1000W/m2. The reason for this is due to the load having an I-V-characteristic of its own. Thus, when connecting a load to the photovoltaic cell the voltage and current of the circuit changes. The new voltage and current for the circuit, i.e. cell and load, is decided upon were the I-V characteristics of the cell and load intersect, and is referred to as operating point. Consequently, if the operating point is not situated at the MPP the full capacity of the cell is not obtained. Though, attaining the MPP can be through impedance matching, i.e. matching the resistance of the load with the cells inner resistance. Accordingly, a measurement of how the cell is performing might be of interest, and can be done through the formula:

$$FF = (\ )/(VocIsc\ ) \qquad \text{(I-4)}$$

Where FF is a unit less factor that indicates how much of the cells potential energy is being used [1].

I-4 PV panel

All photovoltaic (PV) cells consist of two or more thin layers of semi-conducting material, most commonly silicon. When the semiconductor is exposed to light, electrical charges are generated and this can be conducted away by metal contacts as direct current (DC). The electrical output from a single cell is small, so multiple cells are connected together to form a 'string', which produces a direct current.

I-4-1 Types of PV panel

Here, we only look at commercially available types.

I-4-1-1 Monocrystalline silicon PV panels

These are made using cells sliced from a single cylindrical crystal of silicon. This is the most efficient photovoltaic technology, typically converting around 15% of the sun's energy into electricity. The manufacturing process required to produce monocrystalline silicon is complicated, resulting in slightly higher costs than other technologies

Figure I.6: Monocrystalline PV panel

I-4-1-2 Polycrystalline silicon PV panels

Also sometimes known as multicrystalline cells, polycrystalline silicon cells are made from cells cut from an ingot of melted and recrystallised silicon. The ingots are then saw-cut into very thin wafers and assembled into complete cells. They are generally cheaper to produce than monocrystalline cells, due to the simpler manufacturing process, but they tend to be slightly less efficient, with average efficiencies of around 12%.

Figure I-7: Polycrystalline PV panel

I-4-1-3 Thick-film silicon PV panels

This is a variant on multicrystalline technology where the silicon is deposited in a continuous process onto a base material giving a fine grained, sparkling appearance. Like all crystalline PV, it is normally encapsulated in a transparent insulating polymer with a tempered glass cover and then bound into a metal framed module.

I-4-1-4 Amorphous silicon PV panels

Amorphous silicon cells are made by depositing silicon in a thin homogenous layer onto a substrate rather than creating a rigid crystal structure. As amorphous silicon absorbs light more effectively than crystalline silicon, the cells can be thinner - hence its alternative name of 'thin film' PV. Amorphous silicon can be deposited on a wide range of substrates, both rigid and flexible, which makes it ideal for curved surfaces or bonding directly onto roofing materials. This technology is, however, less efficient than crystalline silicon, with typical efficiencies of around 6%, but it tends to be easier and cheaper to produce. If roof space is not restricted, an amorphous product can be a good option. However, if the maximum output per square metre is required, specifiers should choose a crystalline technology.

I-4-1-5 Other thin film PV panels

A number of other materials such as cadmium telluride (CdTe) and copper indium diselenide (CIS) are now being used for PV modules. The attraction of these technologies is that they can be manufactured by relatively inexpensive industrial processes, certainly in comparison to crystalline silicon technologies, yet they typically offer higher module efficiencies than amorphous silicon.

I-5 Converter

The use of a DC-DC converter in solar and wind energy inverters is nowadays a preferred topology for control and enabling for MPP tracking. Though the converter is actually nothing more than a transformer for DC circuits i.e. it converts input voltage and current into the desired output voltage and current.

The converter has two modes; Buck and Boost. Boost refers to the case where the output voltage is higher than the input i.e. stepping up the voltage level. Consequently the buck mode is referred to the opposite case i.e. step down. Moreover since the converter is the equivalent of what transformers are for AC power, the energy put into the circuit is conserved: raising the output voltage reduces the output current, and vice versa. However, losses are inevitable during operation, i.e. switching, with typical efficiencies ranging from 85-95%. In addition, the DC-DC converter also has the ability in raising the output voltage to sufficient levels, enough for the inverter to start delivering power the load. Subsequently increasing the time when energy is produced [2].

I-6 Inverter

Inverters are used to transform DC current into AC currents .In the photovoltaics industry, we are going to take in our study about standalone inverter. Inverter is meant to operate isolated from the electrical distribution network and require batteries for proper operation. The batteries provide a constant voltage source at DC input of the inverter. Inverters can be classified briefly as:

- ✓ Square wave inverters
- ✓ Modified since wave Inverter
- ✓ Since wave inverter (quasi-sine wave)

Voltage and current waveforms produced by inverters are never perfect sinusoids (even for sine wave inverters); therefore some harmonic currents are expected during normal system operation. Total harmonic distortion is a measure of the harmonic content in current and voltage waveform. The type of inverter used will depend on the load that it will serve. Resistive loads could tolerate square wave inverters that are able to produce almost perfect sinusoidal voltage and current waveforms in order to operate correctly. These tend to be more expensive and difficult to design. The designer should choose inverters according to load type and power requirement. Modern standalone inverters have software application embedded that monitor and control equipment operation.

I-7 Maximum Power Point Tracking (MPPT)

Maximum power point tracing (MPPT) system is an electronic control system that can be able to coerce the maximum power from a PV system. It does not involve a single mechanical component that results in the movement of the modules changing their direction and make them face straight towards the sun. MPPT control system is a completely electronic system which can deliver maximum allowable power by varying the operating point of the modules electrically [3].

I-8 Storage system

Batteries or Electrochemical accumulators are electrochemical devices that store energy in chemical form.

I-8-1 Types of accumulators

among the most used batteries are:

- ✓ Lead batteries
- ✓ Nickel-cadmium accumulators (NiCd)
- ✓ Nickel Metal Hydride (NiMH) Accumulators
- ✓ Lithium accumulators

I-8-2 Main features of accumulators

A.1 Voltage It is the electromotive force of the accumulator, a function of electrochemical couple used. There is of course 6, 12 or 24V batteries [4].

A.2 Charge voltage This is the minimum voltage to apply for recharging effectively the battery; it is expressed in volts [4].

A.3 Battery capacity Capacity is the amount of electricity that can be stored an accumulator (or a capacitor). Tt is expressed in ampere-hour (Ah) and sometimes in watt-hour (Wh).

A.4 Life time The battery life is counted by number of complete cycles discharge / recharging.

I-9 Diesel generator

(DG) (also known as diesel genset) is the combination of a diesel engine with an electric generator (often an alternator) to generate electrical energy. This is a specific case of engine-generator. A diesel compression-ignition engine is usually designed to run on diesel fuel, but some types are adapted for other liquid fuels or natural gas.

Diesel generating sets are used in places without connection to a power grid, or as emergency power-supply if the grid fails, as well as for more complex applications such as peak-lopping, grid support and export to the power grid.

I-9-1 Diesel generator definition

The packaged combination of a diesel engine, a generator and various ancillary devices (such as base, canopy, sound attenuation, control systems, circuit breakers, jacket water heaters and starting system) is referred to as a "generating set" or a "genset" for short.

The diesel generator Converts diesel engine rotating shaft output (mechanical horsepower) to electrical power (kilowatts output) is accomplished by connecting the electrical generator rotor to the engine output shaft (drive end of crankshaft).

Figure I-8: Diesel generator

The electric generator makes this conversion by means of a process called "magnetic inductance." A magnetic flux field is created through which configured electrical loop windings are rotated to produce an output voltage. This voltage is collected by means of slip rings and brushes to power electrical loads.

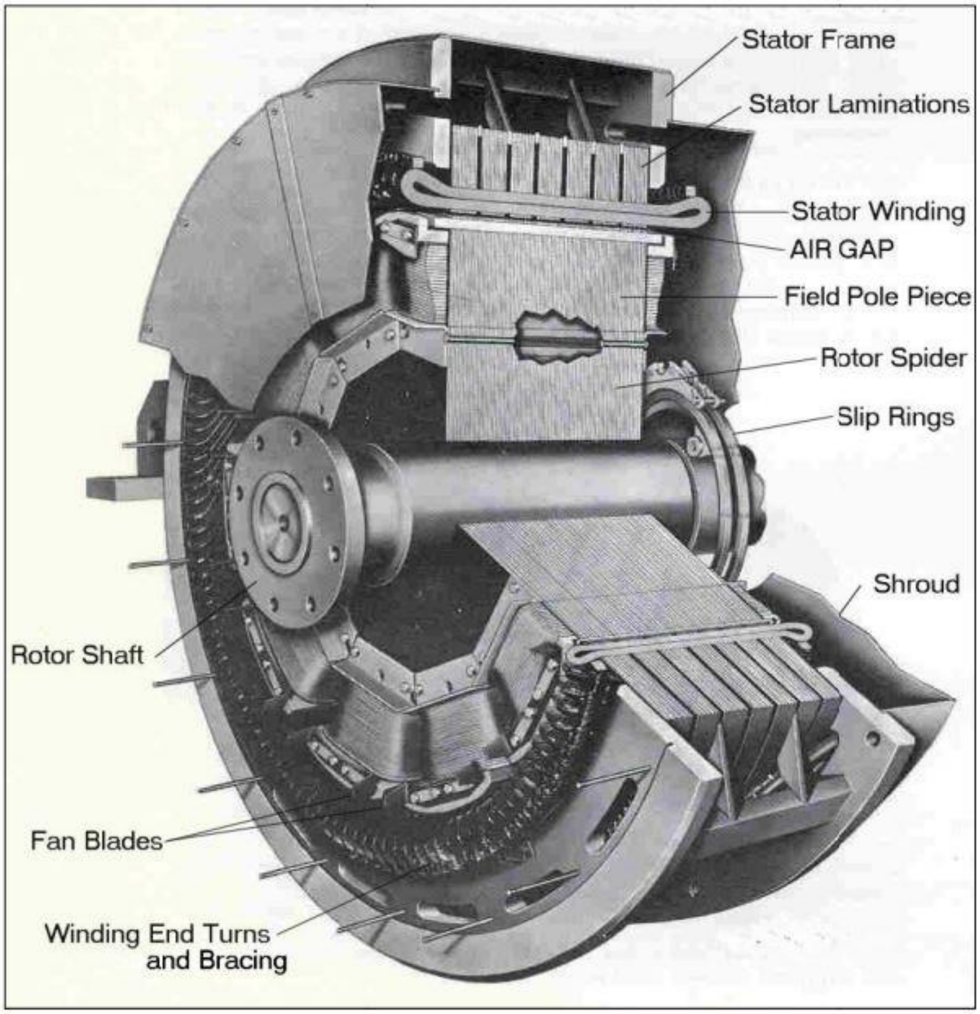


Figure I-9: Cutaway of a typical generator

II-9-2 Generator size

Generating sets are selected based on the electrical load they are intended to supply, the electrical load's characteristics such as kW, kVA, var, harmonic content, surge currents (e.g., motor starting current) and non-linear loads.

The expected duty (such as emergency, prime or continuous power) as well as environmental conditions (such as altitude, temperature and exhaust emissions regulations) must also be considered.

Most of the larger generator set manufacturers offer software that will perform the complicated sizing calculations by simply inputting site conditions and connected electrical load characteristics.

I-9-3 Cost of generating electricity

Fuel consumption is the major portion of diesel plant owning and operating cost for power applications, whereas capital cost is the primary concern for backup generators. Specific consumption varies, but a modern diesel plant will, at its near-optimal 65-70% loading, generate at least 3 kWh per litre (ca. 30% fuel efficiency ratio).

I-10 Conclusion

This chapter has allowed us to give an overview of the solar PV and genset and these sources of electrical energy will be use in our study.

Chapter II

Modeling of hybrid system (PV/DG) with HOMER software

II-1 Introduction

The area of Blidet Amor in the state of Ouargla, climatic conditions, including solar irradiance, wind speed, temperature, and so forth, are always changing. Thus, there exist instability shortcomings for electric power production from photovoltaic (PV) modules. In order to efficiently and economically utilize renewable energy resources of solar energy applications, the optimum match design sizing is very important for solar power generation systems with battery banks.

II-2 Modeling of hybrid energy system components:

Different modeling techniques are developed by researchers to model components of HRES. Performance of individual component is either modeled by deterministic or probabilistic approaches. General methodology for modeling HRES components like PV, diesel generator, and battery is described below [4]:

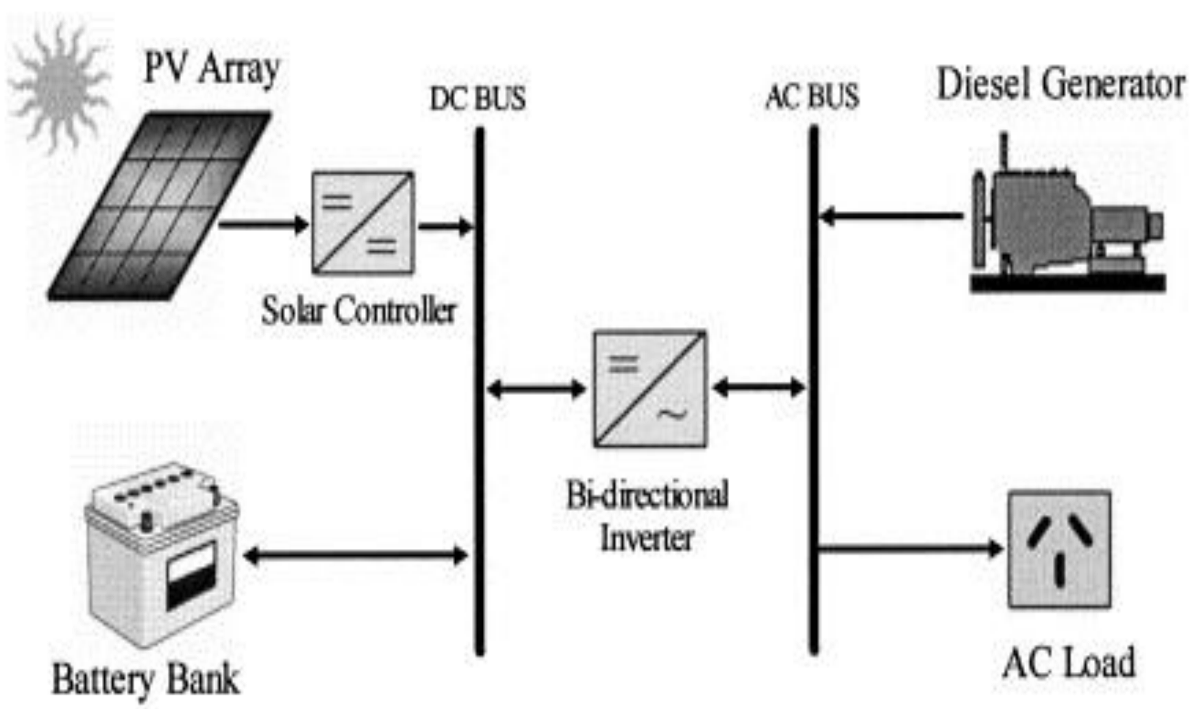


Figure II-1: Configuration of hybrid system

Hybrid solar-diesel power generation system coupled to battery bank consists of a PV module, a diesel generator, a solar regulator a battery bank, and an inverter. A schematic diagram of the basic hybrid system is shown in Figure II.1. The PV module and works to meet the load demand. When the PV energy source is sufficient, the generated power, after meeting the load demand, provides energy to the battery bank up to its full charge. The battery supplies energy demand to help the system to cover the load requirements, when energy from PV modules is inferior to the load demand. The load will be supplied by diesel generators whether power generation the PV array is insufficient and the storage is depleted.

II-3 Hybrid PV/Diesel System model

II-3-1 PV generator model

The hourly output power of the PV generator with an area A_{pv} (m^2) at a solar radiation on tilted plane module Gt (W/m^2) is given by [2]:

$$P_{pv}=\eta_{pv}.\ A_{pv}\ .G_t \qquad \text{(II-1)}$$

Where η_{pv} represents the PV generator efficiency and is given by [3, 4]:

$$\eta_{pv} =\eta_r\ .\eta_{pc}\ .\ (1 -\beta\ (T_c - T_{cref})) \qquad \text{(II-2)}$$

Where η_r is the reference module efficiency, η_{pc} is the power conditioning efficiency which is equal to 1 if a perfect maximum power tracker (MPPT) is used. β is the generator efficiency temperature coefficient, it is assumed to be a constant and for silicon cells the range of β is 0.004–0.006 per (°C), Tcref is the reference cell temperature (°C) and T_c is the cell temperature (°C) and can be calculated as follows [5]:

$$T_c= T_a + ((NOCT-20) / 800).G_t \qquad \text{(II-3)}$$

Where Ta is the ambient temperature (C°) and NOCT is the nominal cell operating temperature (C°).η_{pc} β, NOCT and A_{pv}, are parameters that depend upon the type of module used. The data are obtained from the PV module manufacturers [6].

II-3-2 Battery Bank Model

Battery bank storage is sized to meet the load demand during non-availability period of renewable energy source, commonly referred to as days of autonomy. Normally the number of days of autonomy is taken to be 2 or 3 days [7].

Battery sizing depends on factors such as maximum depth of discharge, temperature correction, rated battery capacity and battery life. The total capacity of the battery bank that is to be employed to meet the load is determined using the following expression [8].

$$C_B = \frac{E_L \cdot S_D}{V_B\,(DOD)_{max}\,T_{cf} \cdot \eta_B} \qquad \text{(II-4)}$$

Where E_L is the load in Wh; S_D is the battery autonomy or storage days; V_B is the battery bank voltage; DOD_{max} is the maximum battery depth of discharge; T_{cf} is the temperature correction factor and η_B is the battery efficiency. Depending on the PV energy production and the load power requirements, the state of charge of battery can be calculated from the following equations:

- ✓ **Battery charging**

$$SOC(t) = SOC(t-1)\times (1-\sigma)+(E_{gen}(t)-E_L(t)/\eta_{inv})\times\eta_B \qquad \text{(II-5)}$$

- ✓ **Battery dicharging**

$$SOC(t) = SOC(t-1)\times(1-\sigma)+(E_L(t)/\eta_{inv}-E_{gen}(t)) \qquad \text{(II-6)}$$

Where SOC (t) and SOC (t - 1) are the states of charge of battery bank (Wh) at the time t and t - 1 , respectively; σ is hourly self-discharge rate; EGen (t) is the total energy generated by PV array and wind generators after energy loss of controller; E_L (t) is load demand at the time t ; η_{inv} and η_B are the efficiency of inverter and charge efficiency of battery bank, respectively. At any time t, the charged quantity of the battery bank is subject to the following two constraints:

$$SOC_{min} \leq SOC\,(t) \leq SOC_{max} \qquad \text{(II-7)}$$

The maximum charge quantity of battery bank SOC_{max} takes the value of nominal capacity of battery bank CB, and the minimum charge quantity of battery bank SOC_{min} is determined by the maximum depth of discharge DOD:

SOC_{min}= (1-DOD).CB. According to the specifications from the manufacturers, the battery‟s lifetime can be prolonged to the maximum if DOD takes the value of 30–50%. In this paper, the DOD takes the value of 50 %.

II-3-3 Diesel Generator Model

DG is the conventional source of energy which is used as a backup to supply the power deficiency in HRES. The hourly fuel consumption of DG is assessed using the following equation [9]:

$$D_F(t) = \alpha_D \, P_{Dg}(t) + \beta_D \, P_{Dgr} \qquad \text{(II.10)}$$

where, $Df\ (t)$ is the hourly fuel consumption of DG in L/h, P_{Dg} is the average power per hour of the DG, kW, P_{Dgr} is the DG rated power, kW, α_D and β_D are the coefficients of the fuel consumption curve, L/kWh, these coefficients have been considered as 0.246 and 0.08145, respectively [10].

II-4 Site and data description

The houses located in the isolated areas are electrified by solar energy and diesel generator, an economical alternative and climate of the region Ouargla: The solar potential of Ouargla region is one of the highest in the world. The annual sunshine duration reaches 3900 hrs in the Sahara. The received energy is 2.65 kWh/m²/year in the Sahara.

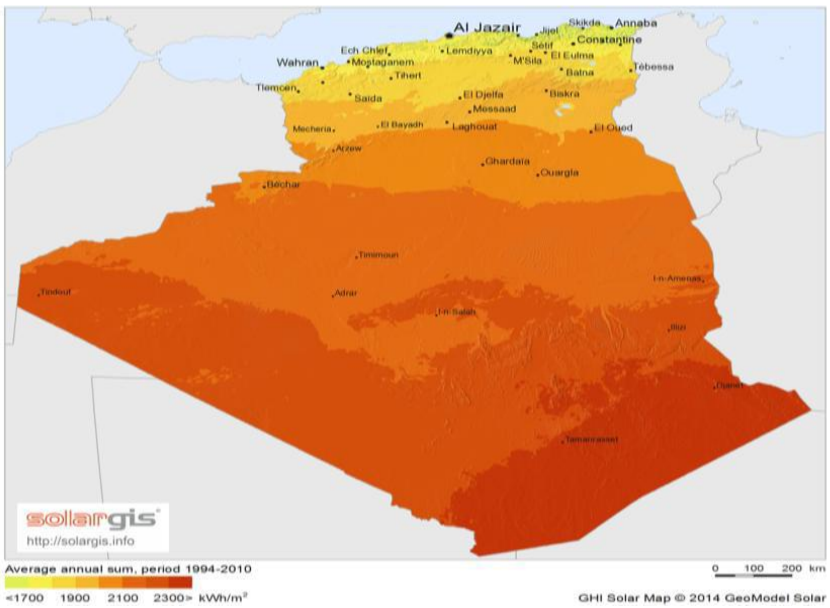


Figure II-2: Algeria solar radiation Kw/m2/h [2]

Blidet Amor touggourt (Ouargla) Oasis are used as the solar energy resource at (32°56'N, 5°58.8'E)

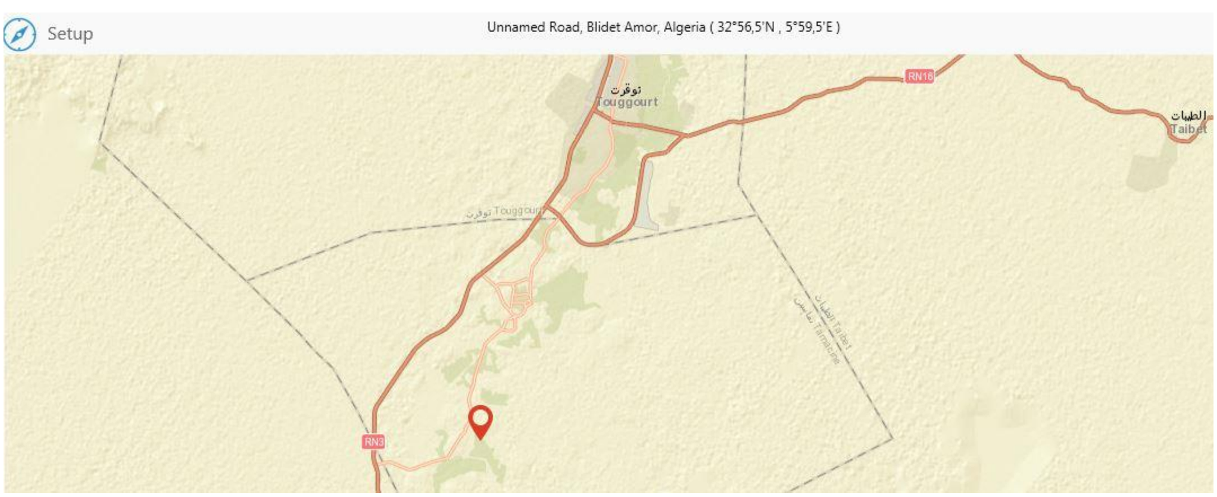


Figure II-3: Location of Blidet Amor touggourt (Ouargla) by satellite

II-5 Load profile

An important consideration of any power generating system is the load requirements and characteristics, not only for load itself but also for the efficiency and reliability of power transmission. The load factor for the project is important in the design process. The project team is usually distributed strategically. Figure II-4 shows the average daily load rate over a 24 hour program which consists of the PV/ DG and battery storage system is displayed in the hybrid system chart in Figure II-5 simulated studies using real weather data (solar radiation) Blidet Amor area in the state of Ouargla, The home requires electricity to provide lighting, cooling and operation of many household appliances such as TV LCD, Washing machine, Electric Oven, Mobile Phone Charge, Smoothing iron, Computer, Radio-Alarm clock and Water pump The total load demand of this house approximately is 35300 watt hour per day

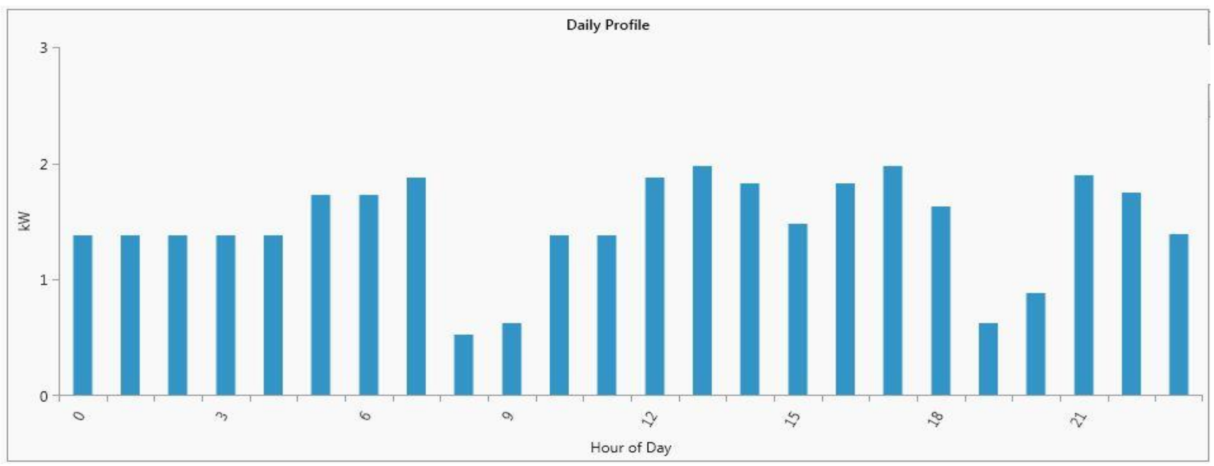


Figure II-4: Daily load profile of the house

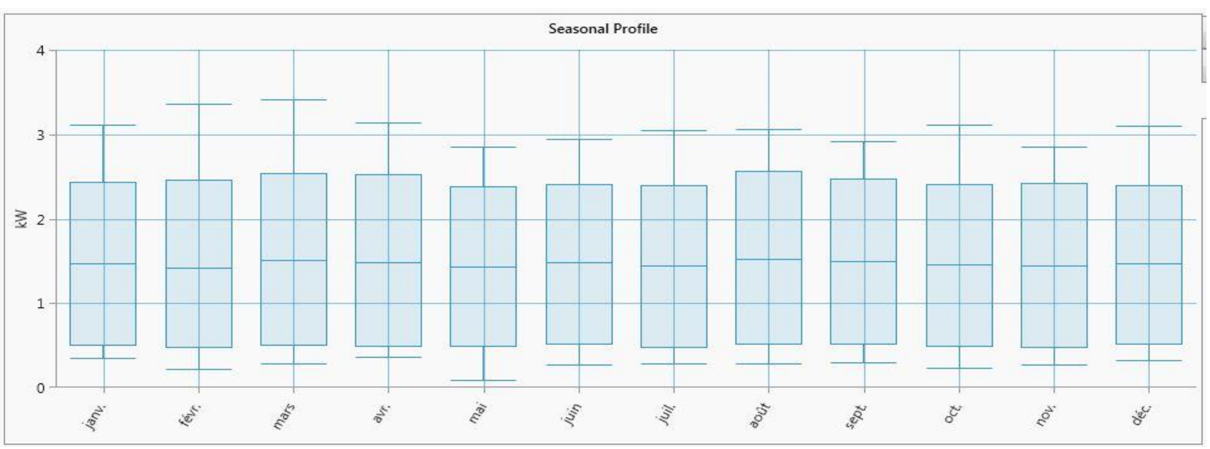


Figure II-5: Seasonal profile electric load

Table II-1: Details of consumption daily profile

time	Refre.	ac	tv+acces.	waching macine	light	water pump	accesories	computer	Charg.	tot
00:00	350	1000					30			1380
01:00	350	1000					30			1380
02:00	350	1000					30			1380
03:00	350	1000					30			1380
04:00	350	1000					30			1380
05:00	350	1000				350	30			1730
06:00	350	1000				350	30			1730
07:00	350	1000				350	30	150		1880
08:00	350	0					30	150		530
09:00	350					100	30	150		630
10:00	500			750		100	30			1380
11:00	500			750		100	30			1380
12:00	500	1000				350	30			1880
13:00	500	1000	100			350	30			1980
14:00	350	1000	100			350	30			1830
15:00	350	1000	100				30			1480
16:00	350	1000	100			350	30			1830
17:00	350	1000	100			350	30	150		1980
18:00	350	1000			100		30	150		1630
19:00	500				100		30			630
20:00	500		100		100	150	30			880
21:00	500	1000	100		100	150	30		15	1895
22:00	350	1000	100		100	150	30		15	1745
23:00	350	1000					30		15	1395
										35315

II-6 The electrical structure of the hybrid system

We have chosen the model of renewable hybrid power generating system off-grid which is a combination of solar panels, diesel generator and electric transformer with storage batteries shown in (figure II-6) solar panels power generator within 12 hours in the presence of solar. Excess energy is stored extracted from sources of (solar panels and diesel generator) with storage batteries.

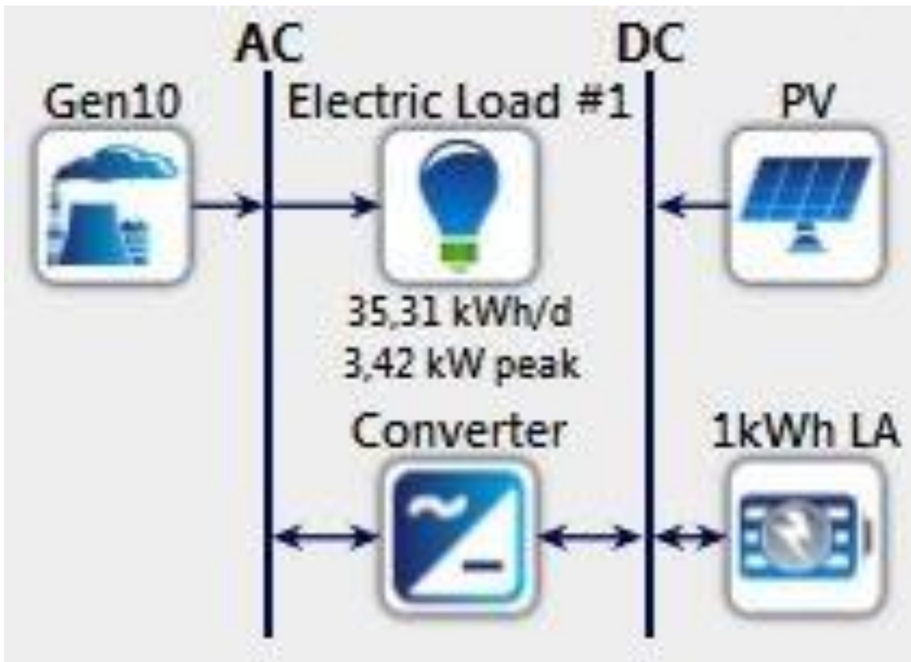


Figure II-6: Schematic of system hybrid

II-7 Materials and Methods

HOMER simulates and optimizes hybrid power systems, which are standalone power plants that employ some combination of photovoltaic panels and diesel generators to produce electricity [11].

The primary tool used in this research was the HOMER optimization model. The National Renewable Energy Laboratory (NREL), under the guidance of Peter Lilienthal and Tom Lambert, developed HOMER, a computer model for optimizing electrical resources. HOMER "simulates and optimizes hybrid power systems, which are standalone power plants that employ some combination of photovoltaic panels and diesel generators to produce electricity" (Lambert 2000). HOMER is capable of simulating more than 1000 different hybrid systems per minute. HOMER has two types of data windows: Inputs and Outputs. The Inputs provide the definition of the search space; the Out- puts provide the results. The Inputs consist of the following: loads, resources, components, and optimizations [12].

The house, require electricity for lighting, refrigeration, Washing machine , Mobile phone charger, Computer, radio Alarm clock, water pump, TV….

Simulations are based on a specific search space and certain sensitivities defining the optimum configuration of the renewable energies system. Monthly average local data regarding solar radiation taken (6kwh/m²/day) The power systems are composed of PV panel, diesel generator, battery, and converter. Standard market prices and power generation statistics of each component provide the base input data for the optimization process. The input parameter for each component is specified under the categories: PV, diesel generator, battery and converter [3].

II-8 HOMER energy software

The HOMER software package used in our thesis, can simulate, analyze and model renewable energy or hybrid power systems that can include generation, cogeneration, solar PV systems, batteries, wind turbines, micro-turbines, hydropower, and fuel cells among other inputs [13].

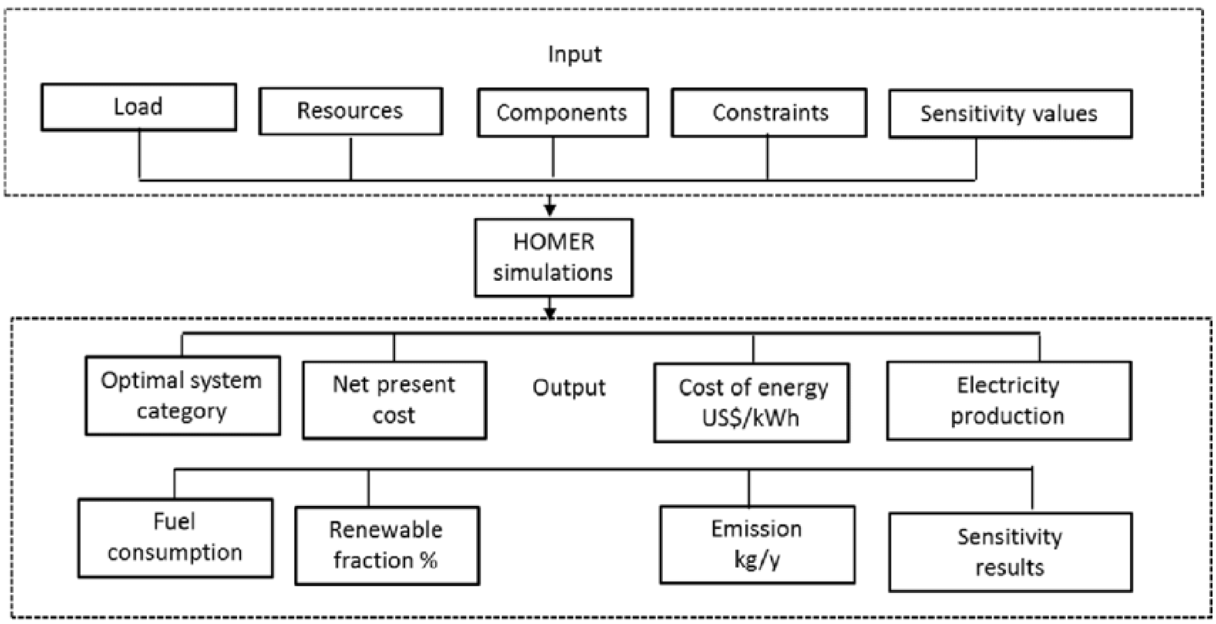


Figure II-7 : HOMER input and output data [12]

Simulation programs and software packages are the common tools for optimizing and evaluating the performances of the hybrid power or renewable energy systems, HOMER being one of the most used. By using such tools, the optimum configuration can be found by comparing the performance and energy production cost of different configurations. HOMER was originally developed at the United States National Renewable Energy Laboratory (NREL). A commercial version has been developed, upgraded and distributed by HOMER Energy.

It can be used to design, analyze and model micro-power and hybrid power systems configurations with various energy resources for economics and sizing to determine the optimal combination of them to meet the load demand and the user requirements. (Figure II-8) shows the basic architecture of this software package. It shows the calculation result of the number of cases of different renewable energy sources under weather conditions, load demands, capacity ranges, fuel costs, and carbon emission constraints to select the optimum system. HOMER software package can facilitate the design and analysis of hybrid power systems for both standalone and grid-connected applications. Input information to be provided to HOMER includes: electrical loads (one year of load data), renewable resources, component technical details and costs, constraints, controls, type of dispatch strategy…etc. It designs an optimal power system to serve the desired loads, performing several simulations to ensure best possible matching between supply and demand in order to design the optimum system. It uses life cycle cost to rank order these systems, while can simulate the operation of a system by making energy balance calculations for each of the 8760 hours in a year. For each hour, HOMER compares the electric demand in the hour to the energy that the system can supply in that hour, and calculates the flows of energy to and from each component of the system. HOMER performs the energy balance calculations, system cost calculations for each of the considered system configuration, listing all of the possible system sizes, sorted by Net Present Cost.

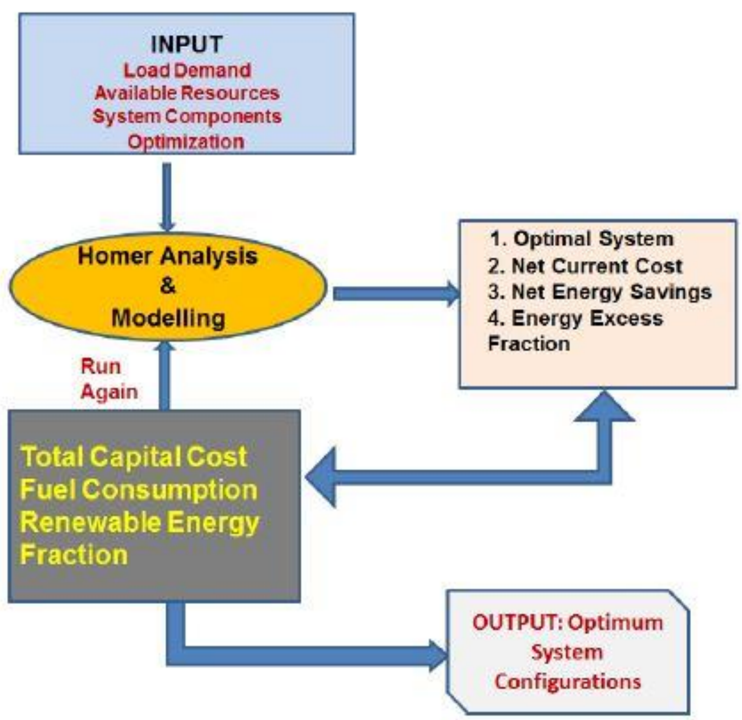


Figure II-8: HOMER package architecture [12]

II-8-1 Interfaces of HOMER Gride 1.8.2

The HOMER pro software is easy to use and its interface is similar to the usual software, so it has a menu at the top as well as icons that can be used without going into the menus. The HOMER interface can be considered to have three important areas as shown in (Figure II-9), the system definition area (house), the resource definition area (Design) and the results area (Results).

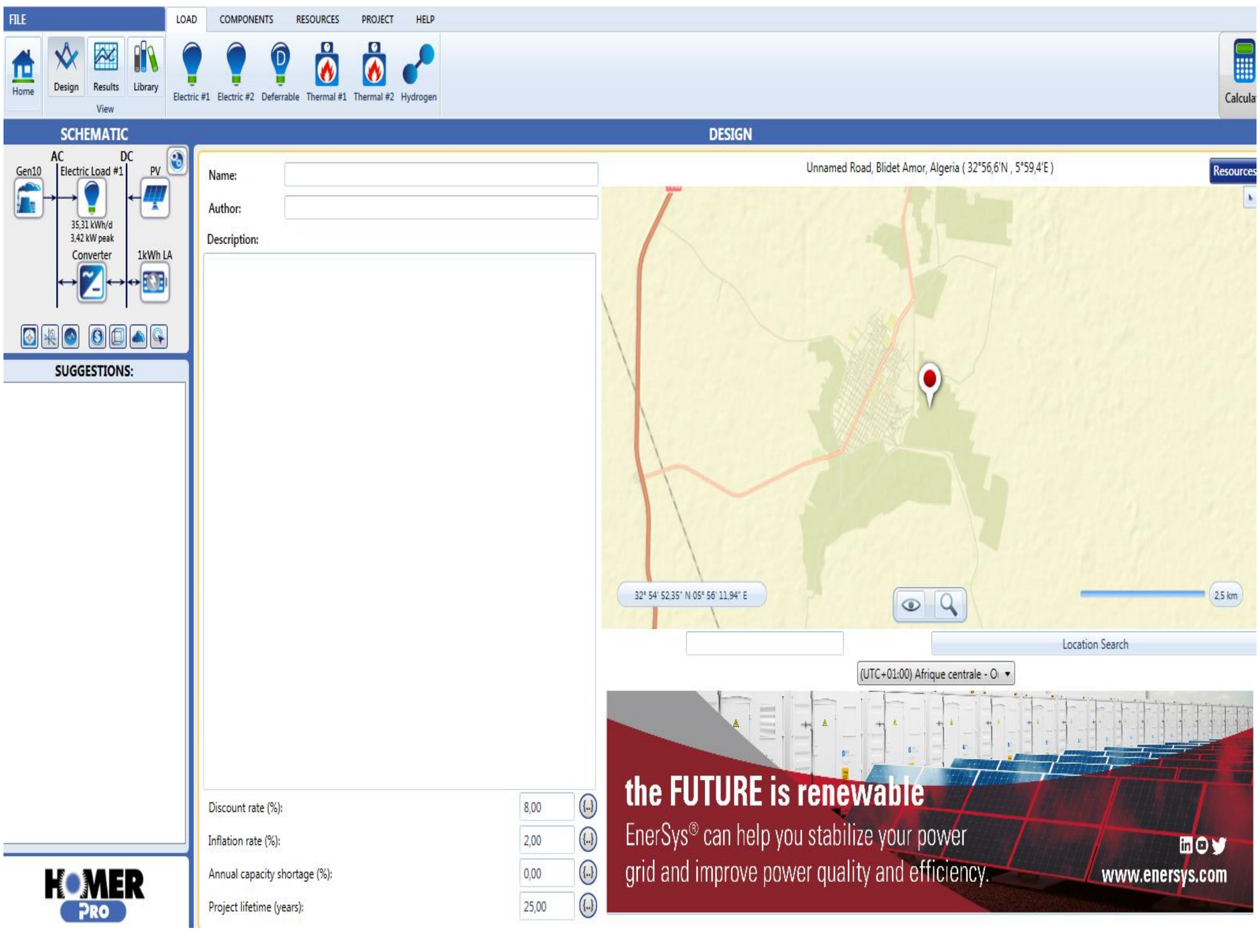


Figure II-9: Homer Pro Interface

II-8-2 Start project information

This tape contains a set of tasks, load components, project resources, and instructions.

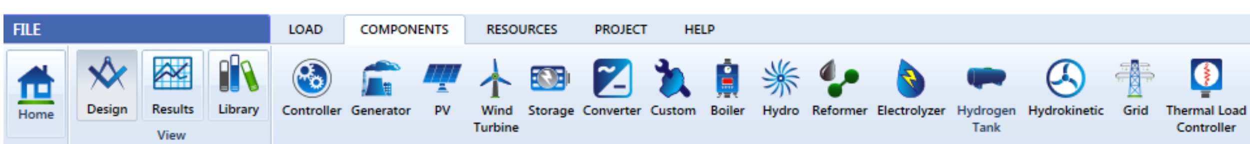


Figure II-10: HOMER components

II-9 Data on Solar radiation and temperature by HOMER® software

HOMER has its own solar database that gives hourly, daily, monthly and annual averages. (Figure II-11) is showing the **Typical annual profile of solar radiation**, while (Figure II-11) is giving the solar radiation for a selected loc

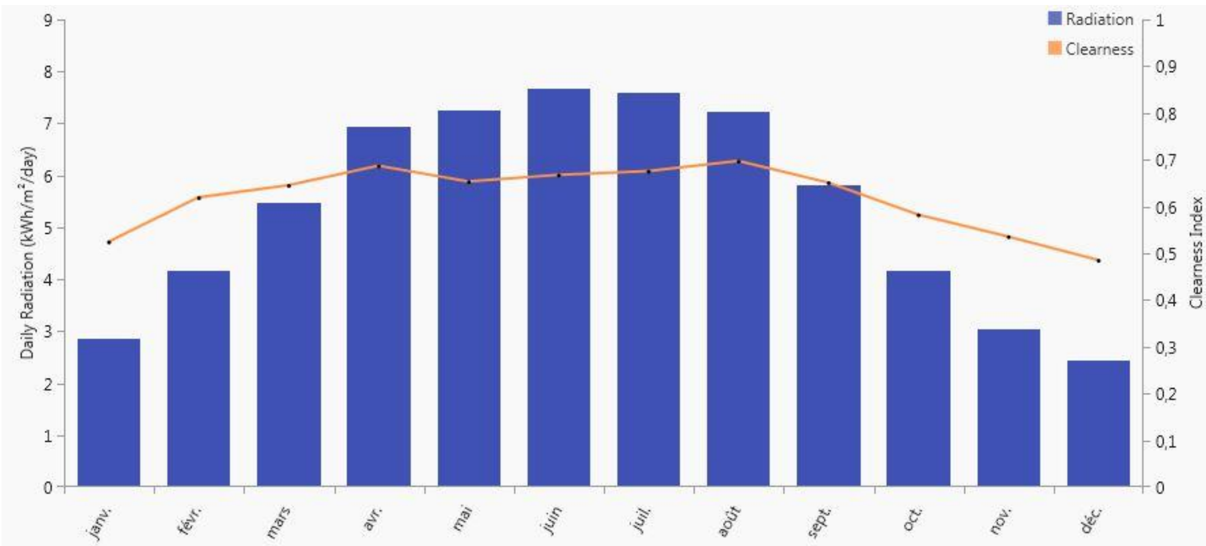


Figure II-11: Typical annual profile of solar radiation [4]

Table II-2: Monthly Average Solar Global Horizontal Irradiance (GHI) DATA

Month	January	February	March	April	May	June	July	August	September	October	November	December
Clearness Index	0.523	0.618	0.644	0.686	0.652	0.666	0.674	0.696	0.650	0.581	0.534	0.484
n (KWh/ m2/day)	2.840	4.170	5.480	6.940	7.260	7.660	7.590	7.230	5.800	4.160	3.030	2.430

HOMER synthesizes solar radiation values for each of the 8760 hours of the year. Its algorithms produces realistic hourly data, being easy to use, requiring only the latitude and the monthly averages, while displaying realistic day to day and hour to hour patterns. The synthetic data are created with certain statistical properties that reflect global average value. However, generated data for a particular location will not exactly replicate the characteristics of the real solar radiation. But tests show that synthetic solar data produce virtually the same simulation results as real data. A user starts by specifying system parameters and hourly electrical load and solar resource data. For each simulated hour the software calculates global irradiation at the photovoltaic array titled surface, calculates the output energy from the array, and performs energy balance at the DC and AC buses to determine amount of energy taken from or transferred to the electrical grid. Energy balance at the DC bus takes in consideration the storage component when present. The software keeps record of hourly, daily monthly and one year simulation results. It displays these results in a tabular format. Results also include economic analysis that takes into account investment costs and financial benefits projected over the life time of the project [12].

II-10 Conclusion

In this chapter we the optimal sizing o of autonomous (hybrid PV/ DG) system with battery storage, with the explanation of the Homer program and how to use it, after the introduction of equipment and prices and meteorological data (sun and temperature), to reach the goals to be achieved .The version (Homer Grid 1.8.2) is used, which is available for free for 30 days (trial version), This program was developed in the National Laboratory of Renewable Energy in America (NREL).

Chapter III

Results and discussion

III-1 Introduction

In this chapter, we will discuss the results obtained by an off-grid (PV /diesel generator hybrid system with independent storage batteries), From these results we will choose the best suitable result to provide the necessary consumption for a standalone House in Ouargla In an isolated area in Blidet Amor village, we have calculated these results by the HOMER® grid 1.8.2 simulation program; Which selects the best models and options for appropriate technology based on cost, energy saving and reliability. We Analysis and simulates the operation of the system with HOMER® based on the components chosen by the designer. In this process, HOMER® will perform the energy balance calculation based on the system configuration consisting several numbers and sizes of component. In this case of our study: PV array system, diesel generator with battery and converter are the components chosen for the analysis. And then we search to determine the best feasible system configuration which can adequately serve the electric demand. HOMER® simulates the system based on the estimation of installing cost, replacement cost, operation and maintenance cost, fuel and salvage.

III-2 Hybrid system (PV/ DG) with batteries storage

After selecting the components of the hybrid power system, (PV and diesel generator with storage batteries), the simulation of the HOMER® program gave us the quantity of the electric output for each limit. As shown in the following table:

Table III-1: The optimal system Compenants

Compenant	Model	Size	Unit
Diesel generator	Generic 10kW Fixed Capacity Genset	10	KW
PV panel	Generic flat plate PV	8.15	KW
Storage	Generic 1kWh Lead Acid	45	String
System converter	System Converter	3	KV

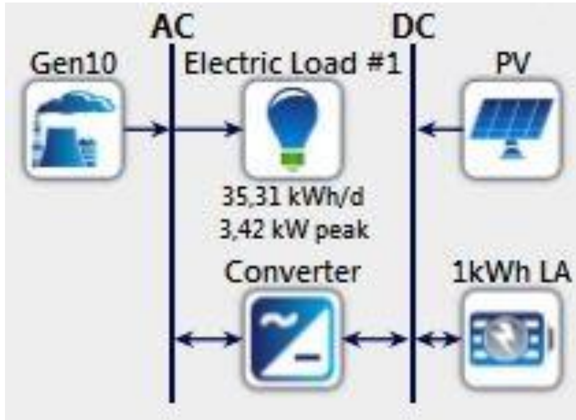


Figure III. 1: electrical assembly of the hybrid system

III-2-1 Interpretation of simulation results

After simulations we got the following results

Architecture					Cost				System		Gen10					PV		1kWh
PV (kW)	Gen10 (kW)	1kWh LA	Converter (kW)	Dispatch	COE (د.ج.)	NPC (د.ج.)	Operating cost (د.ج./yr)	Initial capital (د.ج.)	Ren Frac (%)	Total Fuel (L/yr)	Hours	Production (kWh)	Fuel (L)	O&M Cost (د.ج./yr)	Fuel Cost (د.ج./yr)	Capital Cost (د.ج.)	Production (kWh/yr)	Autonomy (hr)
8,15	10,0	45	3,00	LF	20,74 €	3,46 €M	122 030 €	1,88 €M	80,2	1 221	1 019	2 557	1 221	306	36 616	978 233	14 012	18,4

Export...

Optimization Results
Left Double Click on a particular system to see its detailed Simulation Results.

Categorized Overall

Architecture					Cost				System		Gen10					PV			
PV (kW)	Gen10 (kW)	1kWh LA	Converter (kW)	Dispatch	COE (د.ج.)	NPC (د.ج.)	Operating cost (د.ج./yr)	Initial capital (د.ج.)	Ren Frac (%)	Total Fuel (L/yr)	Hours	Productio (kWh)	Fuel (L)	O&M Cost (د.ج./yr)	Fuel Cost (د.ج./yr)	Capital Cost (د.ج.)	Production (kWh/yr)	Autonomy (hr)	Ann
8,15	10,0	45	3,00	LF	20,74 €	3,46 €M	122 030 €	1,88 €M	80,2	1 221	1 019	2 557	1 221	306	36 616	978 233	14 012	18,4	7 2
	10,0	15	1,86	CC	29,59 €	4,93 €M	339 445 €	542 969 €	0	6 380	4 401	14 920	6 380	1 320	191 385			6,12	5 7
	10,0			CC	39,29 €	6,55 €M	483 201 €	300 000 €	0	10 481	8 760	21 946	10 481	2 628	314 442				
0,0469	10,0		0,00781	CC	39,32 €	6,55 €M	483 202 €	306 016 €	0	10 481	8 760	21 945	10 481	2 628	314 432	5 625	80,6		
22,2		152	5,13	CC	46,15 €	7,68 €M	250 680 €	4,44 €M	100	0						2 667 176	38 204	62,0	8 1

Figure III-2: tables of simulations results

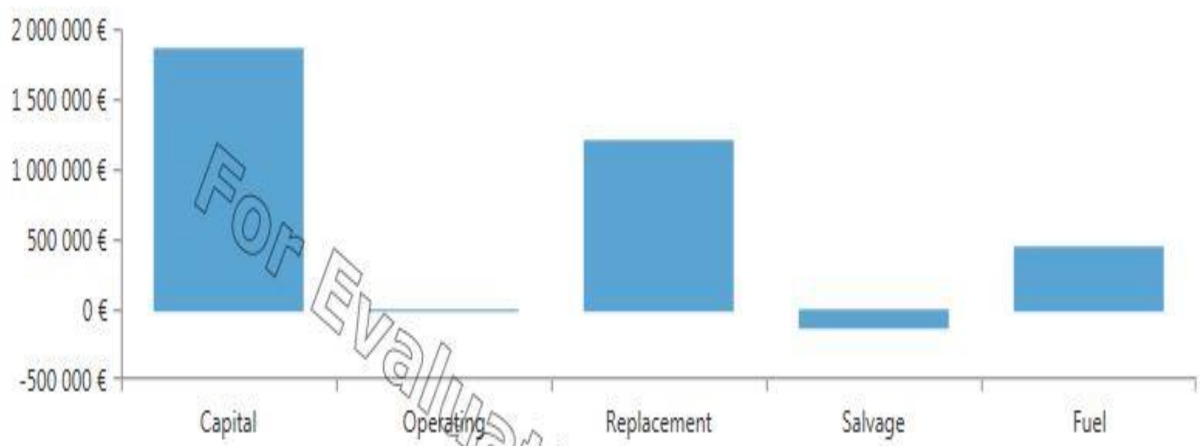
This arrangement of net current cost and the order of results and values rated from the best to the least choice. that the best result used is hybrid system that contains (PV, DG and batteries) was shown in the first line. where we noted that the best result appears in the first line because it consists of a suitable hybrid system (PV, DG and batteries) and at an appropriate cost. We got the optimal result using HOMER® software:

PV (kW)	Gen10 (kW)	1kWh LA	Converter (kW)	Dispatch	COE (د.ج.)	NPC (د.ج.)	Operating cost (د.ج./yr)	Initial capital (د.ج.)	Ren Frac (%)	Total Fuel (L/yr)	Hours	Productio (kWh)	Fuel (L)	O&M Cost (د.ج./yr)	Fuel Cost (د.ج./yr)	Capital Cost (د.ج.)	Production (kWh/yr)	Autonomy (hr)	Ann
8,15	10,0	45	3,00	LF	20,74 €	3,46 €M	122 030 €	1,88 €M	80,2	1 221	1 019	2 557	1 221	306	36 616	978 233	14 012	18,4	7 2

Figure III- 3: optimal results for the hybrid system

III-2-1-1 Discussion of the economic aspect

Cross-cutting issues of cost and reliability are the most important issues in the minds of those responsible for technology services, where economic cost plays an important role in selecting and evaluating this project. As we note that the system of hybrid proverbs in economically term is technically analyzed through the results obtained to design the hybrid system model to an off- grid House. Thus, in order to evaluate this project economically, it must be studied by the economic criteria of the renewable energy system. Total estimated cost: the smaller cost (NPC) is (3 455 608 DZD) with (Initial capital) value of (1 878 265 DZD), which in fact justifies this position from ranking and choice side.



Component	Capital (€)	Replacement (€)	O&M (€)	Fuel (€)	Salvage (€)	Total (€)
Generic 10kW Fixed Capacity Genset	300 000,00 €	129 333,28 €	3 951,94 €	473 359,81 €	-21 679,99 €	884 965,05 €
Generic 1kWh Lead Acid	450 000,00 €	1 038 657,68 €	5 817,38 €	0,00 €	-104 626,58 €	1 389 848,48 €
Generic flat plate PV	978 233,01 €	0,00 €	1 053,84 €	0,00 €	0,00 €	979 286,85 €
System Converter	150 031,95 €	63 654,63 €	0,00 €	0,00 €	-11 980,44 €	201 706,13 €
System	1 878 264,95 €	1 231 645,59 €	10 823,17 €	473 359,81 €	-138 287,01 €	3 455 806,51 €

Figure III-4: Costs summary

The total cost estimated over 25 years of work at all project costs (Capital, Replacement, O&M, Salvage) is (3 455 608 DZD) with levelized cost energy 20.24 DZD/ KWh.

The costs are allocated as follows:

Table III-2: Net Present Costs (25years)

Component	Capital (DZD)	Replacement (DZD)	O&M (DZD)	Fuel (DZD)	Salvage (DZD)	Total (DZD)
Generic 10kW Fixed Capacity Genset	300 000	129 333	3 951	473 359	-21 679	884 965
Generic 1kWh Lead Acid	450 000	1 038 657	5 817	0,00	-104 626	1 389 848
Generic flat plate PV	978 233	0,00	1 053	0,00	0,00	979 286
System Converter	150 031	63 654	0,00	0,00	-11 980	201 706
System	1 878 264	1 231 645,59	10 823	473 359	-138 287	3 455 806

This table show the total cost of the project during 25 years was (3 455 806 DZD) based on Capital of (1 878 264 DZD) followed by (Replacement) of (1 231 645 DZD) after fuel of (473359 DZD) and (O&M) of (10 823 DZD) and (Salvage) of (-138 287 DZD).

Table III-3: Annualized Costs

Component	Capital (DZD)	Replacement (DZD)	O&M (DZD)	Fuel (DZD)	Salvage (DZD)	Total (DZD)
Generic 10kW Fixed Capacity Genset	23 206	10 004	305	36 616	-1 677	68 455
Generic 1kWh Lead Acid	34 809	80 344	450	0,00	-8 093	107 510
Generic flat plate PV	75 670	0,00	81	0,00	0,00	75 752
System Converter	11 605	4 923	0,00	0,00	-926,74	15 602
System	145 292	95 273	837	36 616	-10 697	267 321

Total estimated cost over a year of work at all project costs: (Capital, Replacement, O&M, fuel) is (267 321DZD) with levelized cost energy (20.74 DZD/KWh).

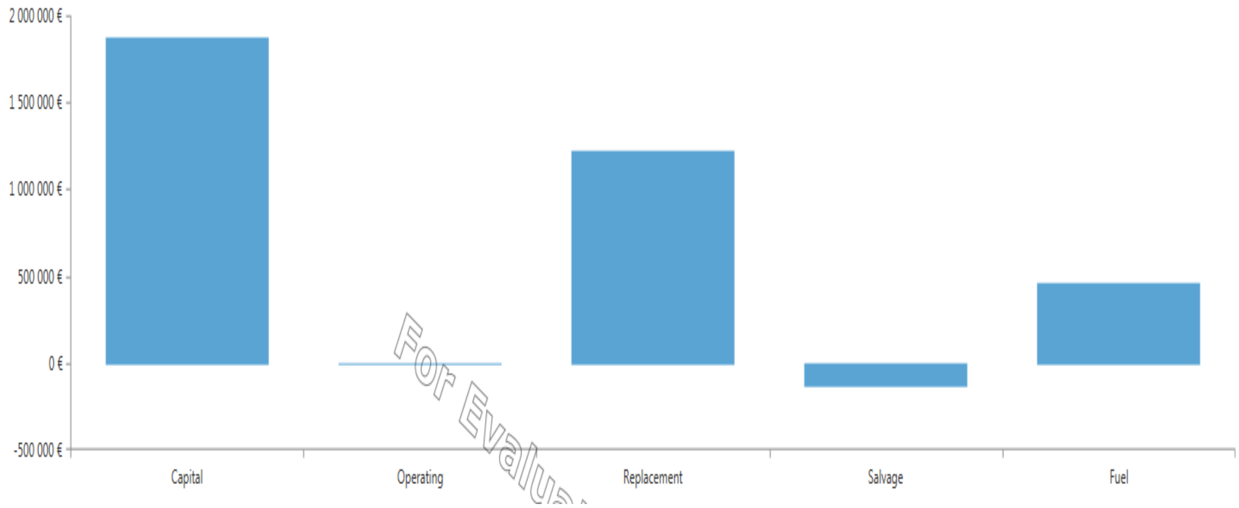


Figure III-5: System cost summary during 25 years

during 25 years of the equipment use, we have found that the system did not Completely change all the components as we expected in begin of the project. Except for a few parts, such as batteries approximately do not keep their efficiency more than 5 years and some other equipment such as diesel generator, electric wiring….etc.

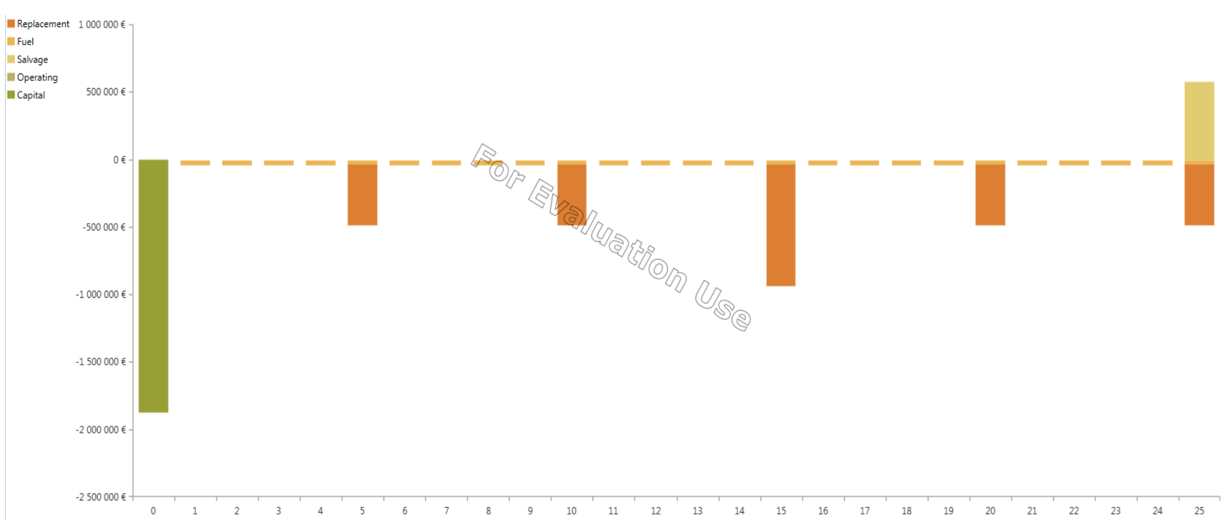


Figure III-6: summary of cash flow by type throughout the operating system lifetime

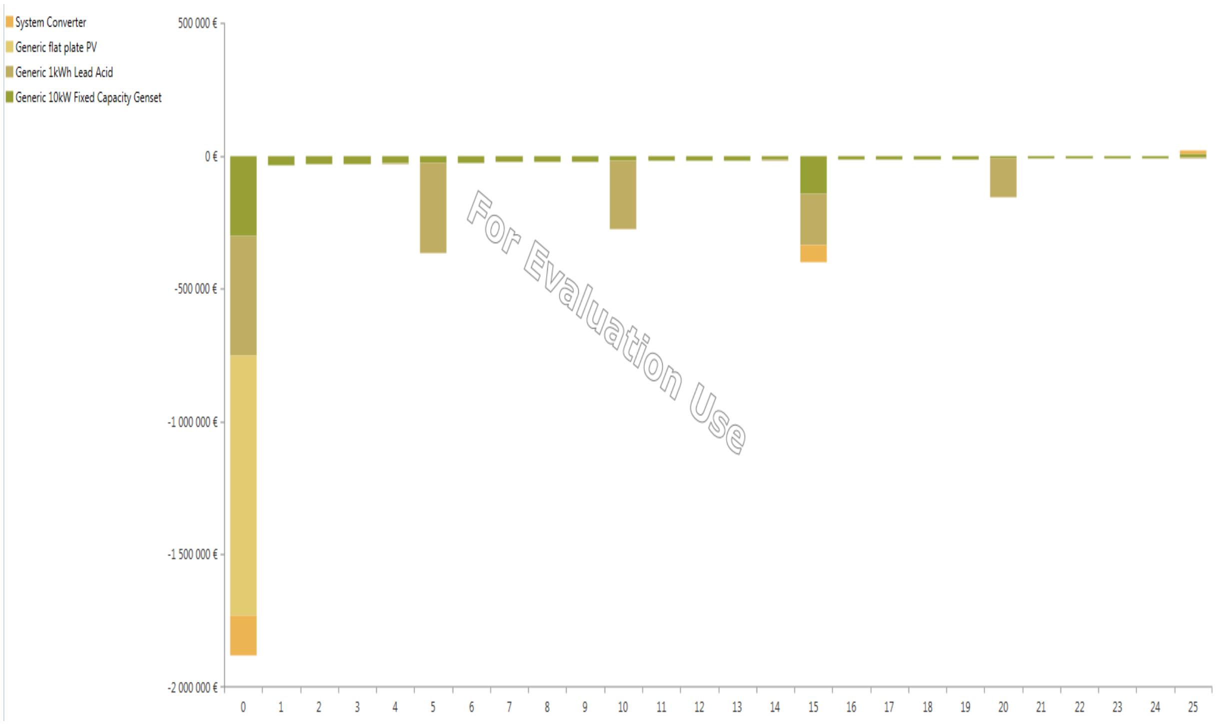


Figure III-7: summary of cash flow by component throughout 25 years

Noticed that the largest cost of the project was at the beginning (Capital cost). Some changes occurred regularly during the 25 years of the project, these changes including:

- ✓ Change the diesel generator after 15 years
- ✓ Change for the batteries every 5 years.
- ✓ Change converter after 15 years.

At the end of the project, batteries, converter and Diesel generator are gained as a benefit of this project (salvage).

III-2-1-2 Electrical output of the system

On the other hand, when we talk about electrical results, we find that the rate of production of this energy, which was obtained by: (PV, DG, with batteries bank) Distributed as follows:

Table III-4: Production, consumption and quantity of PV-DG system

Production	kWh/yr	%
Generic flat plate PV	14 012	84,6
Generic 10kW Fixed Capacity Genset	2 557	15,4
Total	16 569	100
Consumption	**kWh/yr**	**%**
AC Primary Load	12 890	100
DC Primary Load	0	0
Total	12 890	100
Quantity	**kWh/yr**	**%**
Excess Electricity	1 470	8,87
Unmet Electric Load	0	0
Capacity Shortage	0	0

Noticed that the amount of produced energy from the hybrid system is (16569KWh/yr) divided as:

- ✓ PV produced the largest amount which is (14012 KWh/yr) with 84.6%.
- ✓ Diesel generator produced (2557KWh/yr) with 15.4%.

Noticed that the total produced electrical energy is (16569KWh/yr) consumed as follows:

- ✓ The house consuming (12890KWh/yr).
- ✓ The rest quantity which is (1470KWh/yr), used in other services.

Note: The overload in electrical output in our study (Excess Electricity) is caused by the diesel generator produces (10 KWh). This is due to the absence of a (5 KWh) diesel generator under the HOMER® program options (5 KWh enough for system). Where the height following figures shows electric output for each of the (PV and diesel generator) during the months of the year, we say that the largest value of the production will be in April, about (2.1 KWh), and the lowest value in December about (1.75 KWh) This decline is due to the change of solar radiation during the year Blidet Amor area. These differences in the electric production of the hybrid system that in April we have good radiation and temperature, and in December we have a minimum electric production by PV system.

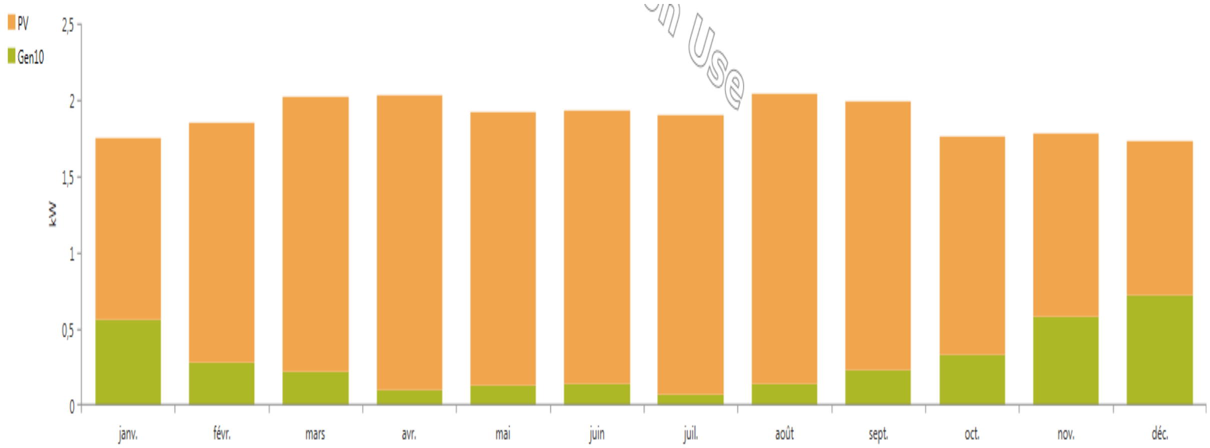


Figure III-8: Monthly energy production by the system

III-2-2 Generic flat plate (PV)

The production of the electrical energy begins after the sunset. in winter and autumn, the sunrise is between (6:00h/7:30h).(7:00h/16:00h) in this period, The electrical energy has different values. In spring and summer, the sunrise is between (4:30h/6:00h). The production is also variable. a low Electrical energy is produced at the beginning of the sunrise around 7:00h to 9:30 with a different value (0.5KW) up to 4KW then the production is increased from 9:30h till 15:00h to reach its maximum value of value 8.38KW, and from 15:00h till sunset the low production is gradually decreased.

Table III-5: Generic flat plate PV Electrical Summary

Quantity	Value	Units
Minimum Output	0	kW
Maximum Output	8,38	kW
PV Penetration	109	%
Hours of Operation	4 351	hrs/yr
Levelized Cost	5,41	€/kWh

Table III-6: Generic flat plate PV Statistics

Quantity	Value	Units
Rated Capacity	8,15	kW
Mean Output	1,60	kW
Mean Output	38,4	kWh/d
Capacity Factor	19,6	%
Total Production	14 012	kWh/yr

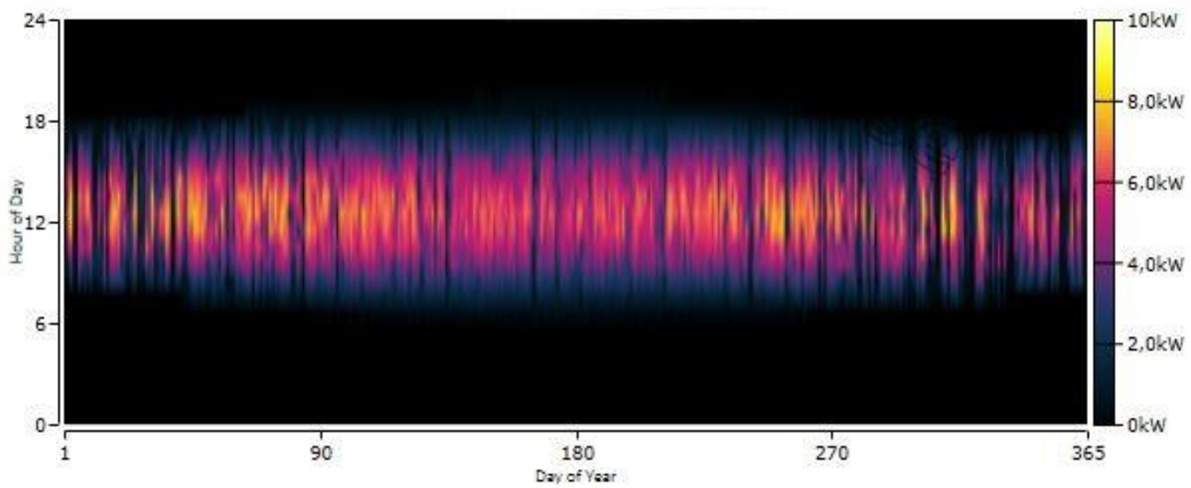


Figure III-9: Total daily energy produced by the PV during one year

III-2-3 Storage batteries (Lead Acid 1Kwh)

The battery is an important and fundamental part in this system by saving electrical energy. Batteries are permanently used during all the day. Its load level is between 40 and 100% during the days of the year (8068 and 6478 KWh / year).

Table III-7: Generic 1kWh Lead Acid Properties

Quantity	Value	Units
Average Energy Cost	0	€/kWh
Energy In	8 068	kWh/yr
Energy Out	6 478	kWh/yr
Storage Depletion	26,3	kWh/yr
Losses	1 616	kWh/yr
Annual Throughput	7 242	kWh/yr

Table III-8: Generic 1kWh Lead Acid Result Data

Quantity	Value	Units
Autonomy	18,4	hr
Storage Wear Cost	14,0	€/kWh
Nominal Capacity	45,0	kWh
Usable Nominal Capacity	27,0	kWh
Lifetime Throughput	36 000	kWh
Expected Life	4,97	yr

Table III-9: Generic 1kWh Lead Acid Statistics

Quantity	Value	Units
Batteries	45,0	qty.
String Size	1,00	batteries
Strings in Parallel	45,0	strings
Bus Voltage	12,0	V

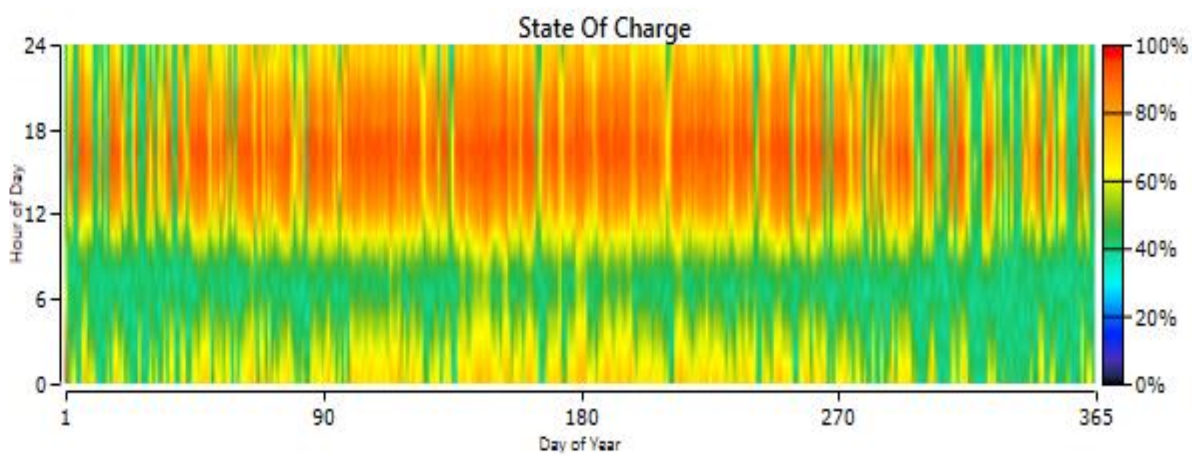


Figure III-10: State of charge through a year

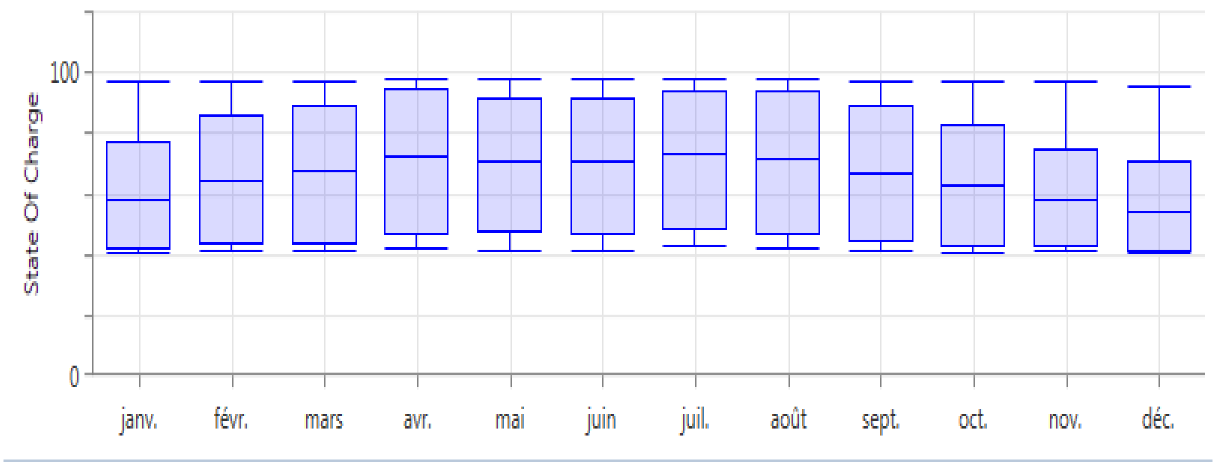


Figure III-11: Charging battery through a year

III-2 Diesel Generator

An analysis of the electric power of the diesel generator was registered throughout the year, which works in parallel with the storage batteries. The working periods of the generator are from (18:00-6:00) which is similar during the months of the year with a total of (1019h) per year. Maximum power produced by the generator is estimated at (3.18Kw).

Table III-10: Generic 10kW Fixed Capacity Genset Electrical Summary

Quantity	Value	Units
Electrical Production	2 557	kWh/yr
Mean Electrical Output	2,51	kW
Minimum Electrical Output	2,50	kW
Maximum Electrical Output	3,18	kW

Table III-11: Generic 10kW Fixed Capacity Genset Fuel Summary

Quantity	Value	Units
Fuel Consumption	1 221	L
Specific Fuel Consumption	0,477	L/kWh
Fuel Energy Input	12 010	kWh/yr
Mean Electrical Efficiency	21,3	%

Table III-12: Generic 10kW Fixed Capacity Genset Statistics

Quantity	Value	Units
Hours of Operation	1 019	hrs/yr
Number of Starts	638	starts/yr
Operational Life	14,7	yr
Capacity Factor	2,92	%
Fixed Generation Cost	34,7	DZD/hr
Marginal Generation Cost	8,58	DZD/kWh

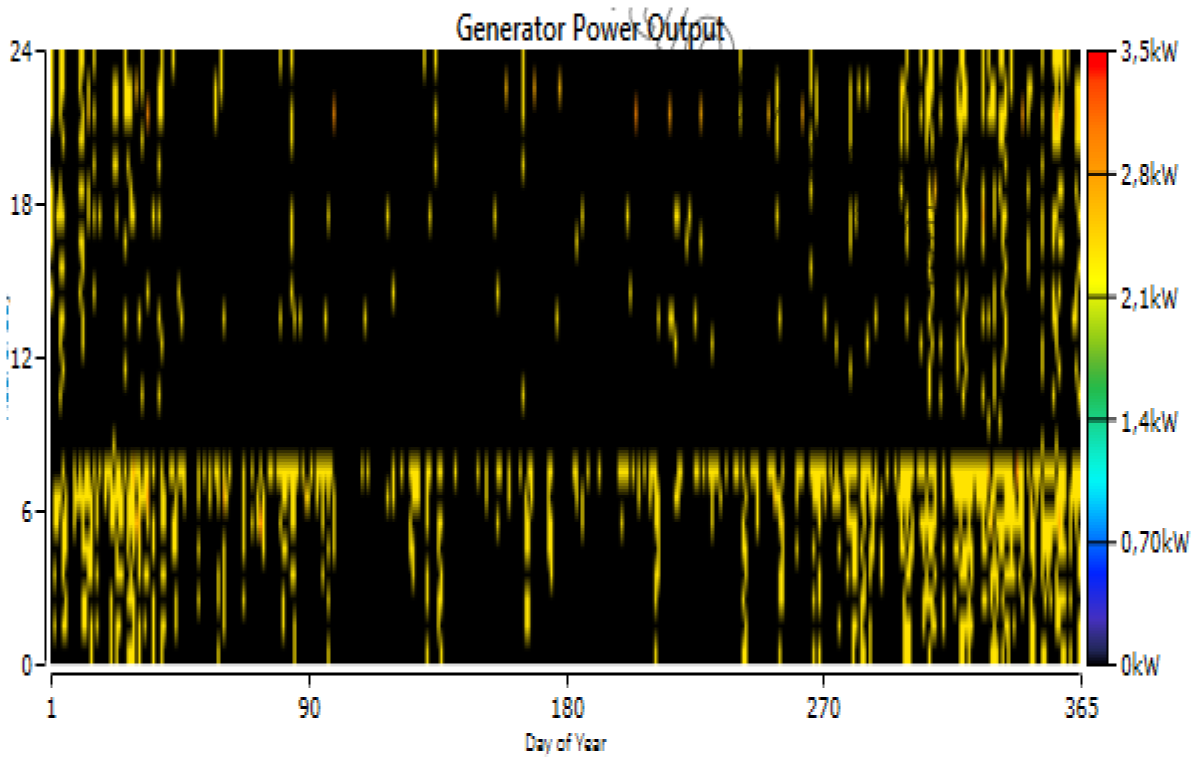


Figure III-12: fixed capacity Genset output (KW)

III-3 The environmental effect

The gas emissions were registered by the HOMER® program for hybrid system (PV/Genset) with storage batteries, are shown in the tables below: CO_2 (3189 kg/yr), CO (24.1 kg/yr).

Table III-13: Hybrid System Emissions

Quantity	Value	Unit
Carbon Dioxide	3 189	kg/yr
Carbon Monoxide	24,1	kg/yr
Unburned Hydrocarbons	0,879	kg/yr
Particulate Matter	1,46	kg/yr
Sulfur Dioxide	7,82	kg/yr
Nitrogen Oxides	27,4	kg/yr

III-4 System with diesel generator alone:

III-4-1 Gen set system flow cash statistics

Table III-14: Gen set system flow cash

Item	Quantity	unit
Capital	300 000,00	DZD
Replacement	2 176 401,39	DZD
O&M	33 973,51	DZD
Fuel	4 064 957,61	DZD
Salvage	-28 746,94	DZD
Total	6 546 585,57	DZD

This table show the total cost of the project during 25 years was (6 546 585DZD) based on Capital of (300 000DZD) followed by fuel of (4 064 957 DZD) after and (Replacement) of (2 176 401DZD) (O&M) of (33 973DZD) and (Salvage) of (-28 746DZD).

III-4-2 Genset emissions

The table below shows the annual emission of different gases registered by the HOMER® program by the genset: CO2 (27983 kg/yr), CO (207 kg/yr).

Table III-15: Genset System Emissions

Quantity	Value	Unit
Carbon Dioxide	27 383	kg/yr
Carbon Monoxide	207	kg/yr
Unburned Hydrocarbons	7,55	kg/yr
Particulate Matter	12,6	kg/yr
Sulfur Dioxide	67,2	kg/yr
Nitrogen Oxides	235	kg/yr

III-4-3 Comparison of hybrid system and generator system emission gazes

Table III-16: Comparison of Hybrid System and genset system Emissions

Quantity	Gen set	Hybrid system	unit	Ratio %
Carbon Dioxide	27 383	3 189	kg/yr	11,6459117
Carbon Monoxide	207	24,1	kg/yr	11,6425121
Unburned Hydrocarbons	7,55	0,879	kg/yr	11,6423841
Particulate Matter	12,6	1,46	kg/yr	11,5873016
Sulfur Dioxide	67,2	7,82	kg/yr	11,6369048
Nitrogen Oxides	235	27,4	kg/yr	11,6595745

This table shows the different emission gases of the both systems, noting the hybrid system have les than 12% of the genset alone

III-5 Conclusion

In this chapter, we dimensioned and simulated with the analysis of the obtained results. We found that the hybrid system (PV/GD/with batteries storage) that operate nearly 25 year with the characteristics of the region costs (3 455 806 DZD), and Capital of (1 878 264 DZD) with levelized cost of energy (20.24 DZD). Which is economical system comparing with gesnet alone.

Summary and conclusion

In our project we had found a solution for supplying with electricity an isolated home in Blidet amor rural area, which is far from the National Electricity Network that faced many problems in supplying these areas. And we achieved an economic solution with renewable energy hybrid system and developed the standard of living in these areas and we have reached a solution to reduce the diesel consumption and the environmental pollution problem, by using the HOMER® simulation program, which contains an interactive language that enables us to predict system tasks quickly and accurately. We have found that the hybrid system (PV/ DG) with batteries storage is the optimal system to solve the problem of electricity in our region (Blidet Amor), which enjoys the climatic conditions suitable for this system, where the solar radiation during the days of the year. The typical and less cost hybrid system given by the computer is as followed:

- ✓ PV modules (8.15 KW)
- ✓ Diesel generator (10 KW)
- ✓ Lead acid batteries (45string)
- ✓ Converter (3 KW)

We found that the cost of energy (COE) in the hybrid system of our study is (20.24 DZD/KWh), whereas the initial capital required is (1 878 264 DZD), and net present cost (NPC) is (3 455 608 DZD). And the total annual power output is 16 569 kW / year, Total energy Solar panels produce the highest value for this production of energy (84.6%).

Our study and comparison over 25 years allowed us to draw the following conclusions:

- ✓ The total cost of the hybrid system almost come on half (53%) the cost of the diesel system project.
- ✓ The cost of fuel consumption for the diesel system represents 117.63% of the total cost of the hybrid system project.

The hybrid system is an environmentally friendly energy source that contributes to reducing greenhouse gas emissions, unlike the diesel system. In our study, the amount of greenhouse gas emissions from diesel generator with hybrid system is relatively small compared to the percentage of gases produced by the diesel generator system alone, which greatly increases the appearance of global warming in the atmosphere.

- ✓ The diesel generator system Carbon dioxide is released 27383 kg/year (CO_2), Unlike the hybrid system is released 3198 kg/year (about11.6%).
- ✓ The diesel generator system Carbon monoxide is released 207 kg/year (CO), unlike the hybrid system is released 24.1 Kg/year (about11.6%).

Finally, this work allowed us to identify the optimal structure of the hybrid system (PV/DG) with batteries storage, by giving the user the necessary elements to determine the approach that leads to the best solution in terms of costs and needs.

- ❖ **Recommendation:** We recommend system using solar panels, wind turbines and 2 Diesel generators each one 5kW with storage batteries and geothermal cooling and heating.

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Abstract

In this memory, we simulated and dimensioned a fully autonomous hybrid system operating with (PV panels / diesel generator) with storage batteries using HOMER Pro code, to operate an isolated house in Blidet amor (Touggourt) in Ouargla (Algeria), based on metrological data Provided by the HOMER code for (toggourt) Ouargla and the prices available in the market, we got the system capital and total cost in 25 years including (fuel, operation, maintenance and alternatives), cost of energy produced (dzd/kWh), optimum number and characteristics of system components, toxic gas emissions (kg / Year). We also obtained a technical economic study and compared it with an independent diesel system.

Keys Words: hybrid system, PV, Diesel Generator, HOMER Energy, isolated house

Conclusion

Dans ce mémoire nous avons simuler et dimensionner avec le code HOMER Energie, un système hybride totalement autonome fonctionne avec (panneaux Photovoltaïques , groupe électrogène diesel) avec batteries de stockage pour alimenter une maison isolée situé à Blidet Amor (touggourt) wilaya de Ouargla (Algérie), en basent sur les données métrologiques données par le code HOMER® de la région de Ouargla et les prix disponibles dans le marché, nous avons obtenu le capital du système et le coût total en 25 ans, y compris (carburant, fonctionnement, remplacement), le coût de l'énergie produite (dzd/kWh), le nombre optimal et les caractéristiques des composants du système, les émissions de gaz toxiques (kg / an). Nous avons également obtenu une étude technico-économique et l'avons comparée à un système diesel indépendant.

Mots clés : système hybride, PV, Générateur diesel, HOMER Energie, maison isolée

ملخص

في هذه المذكرة ، قمنا بمحاكاة وتحديد أبعاد نظام هجين مستقل تمامًا يعمل بـ (الألواح الكهروضوئية / مولد الديزل) مع بطاريات التخزين باستخدام برنامج هومر، لتشغيل منزل معزول عن شبكة الكهرباء في منطقة بلدة عمر تقرت ولاية ورقة (الجزائر), بناءً على البيانات المناخية التي يوفرها كود برنامج الهومر لـمنطقة تقرت (ورقلة) والأسعار المتاحة في السوق ، حصلنا على رأس مال النظام والتكلفة الإجمالية في 25 عامًا بما في ذلك (الوقود والتشغيل والصيانة وقطع الغيار)، تكلفة الطاقة المنتجة(دج \ ك واط سا)، العدد الأمثل وخصائص مكونات النظام، انبعاثات الغازات السامة (كجم / سنة). كما حصلنا على دراسة اقتصادية تقنية وقارناها بنظام ديزل مستقل.

الكلمات المفتاحية: نظام هجين,الألواح الشمسية,مولد الديزل,برنامج هومر, منزل معزول