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Research Paper

Design of an autonomous photovoltaic power supply system for Nyabikenke Hospital (Burundi) using the ETAP tool

Joel Niyonzima [a,*] and Jean Bosco Niyonzima [b]

[a] *Ecole Normale Supérieure du Burundi, Department of Applied Sciences, Electrical Engineering, Boulevard Mwezi Gisabo, B.P.: 6983 Bujumbura, Burundi.*

[b] *University of Burundi, Center for Research in Infrastructure, Environment and Technology (CRIET), Chaussée Prince Louis Rwagasore 164, Bujumbura, Burundi.*

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A B S T R A C T

Our energy future must be based on non-polluting energies with signi resources. Renewable energies are the best candidates, but the intermittency of production requires finding efficient and environmentally friendly storage m Solar electricity must be stored to be used later when needed. There are many to store electricity, and they all involve converting it to another form of energ is easier to contain. A study on the design of an autonomous electrical systen carried out at Nyabikenke Hospital to solve the major problem of the la hydroelectric power at Nyabikenke Hospital. We therefore first sought to est the energy needs of the user and then proceeded to an optimal dimensioning c system using the ETAP software. In normal operation, the photovoltaic field ar battery bank will operate, in the event of a cut in the two sources, the emer Diesel generator intervenes. The design tool simulates the operation c autonomous electrical system for a load of 131.5kW necessary for the hospital supplied. He can design any system from the experimental results of the compo The results of the simulation make it possible to characterize the operation c system in an autonomous application, determine its performance, and evalua influence of the various losses.

* *Corresponding author, E-mail address: joelniyonzima363@gmail.com*

Tel.: +25761278140

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1. Introduction

Energy is present everywhere on our planet and in many forms: heat and sunlight, moving water or air, wood or hot underground water, and coal or oil deposits [1] & [2].

Taking advantage of solar energy is one of the possible ways of producing electricity [3].

There are many isolated sites around the world powered by stand-alone electricity generation systems. These generators use local renewable sources. There are photovoltaic panels, wind turbines, and microturbines [4]. Electricity from renewable sources is intermittent, depending on weather conditions. These renewable generators are coupled to a storage system ensuring continuous energy availability [5].

In Burundi, particularly in major urban centers such as Bujumbura, Ngozi, and Gitega, planned and unplanned power cuts remain commonplace. The vast majority of rural and often urban households primarily use firewood and traditional three-stone stoves. They have limited access to alternative energy sources or improved stoves, although the latter could be more energy efficient and reduce the environmental and health impacts of cooking with wood [6] & [7].

The variation of the parameters over time of these inexhaustible sources such as wind speed, sunshine, etc. not coinciding with the energy demand of a site and its peak consumption times, having several renewable energy sources to hybridize is not an advantage in itself if you are not able to find the sizing corresponding to the combination of these different sources of energy which meets the demand for electricity at the best cost and to set up a control strategy which is essential for the distribution of power between the different sources at all times [8].

To increase the energy delivered by PV-Battery systems, an auxiliary generator can be added. These Diesel generators make it possible to produce significant energy depending only on the supply of fossil energy. However, the operating constraints are numerous and its maintenance is important [8].

The objective of this study is to design an autonomous system for the photovoltaic power supply of the Nyabikenke Hospital using the ETAP tool.

A study was carried out to produce a useful and sufficient quantity of electrical energy for the simultaneous operation of all services to increase hospital income. The simulation results showed that the active power observed after simulation (131.5kW) is equivalent to the active power that we have identified to cover all of the hospital's needs.

Apart from the introduction and the conclusion, this study has developed three main parts. The first part and the second part present the method used for the design, the simulation results, and the discussion of these results. The third part of this study focuses on the analysis of the best-fit design results for Nyabikenke Hospital.

2. Method and Observations

2.1 Location, description, and selection of the site

The fieldwork begins with the location of the hospital and the inventory of the services on which the electrical devices likely to be installed must be inventoried. Figure 1 is a photo of Nyabikenke Hospital and Figure 2 is an interactive map of Nyabikenke which was found using Google MAP weather information software. The locality of Nyabikenke is located in the north of the country in the Vumbi Commune of the Kirundo province; in the natural region of Bugesera. Nyabikenke Hospital is a communal hospital located west of Kirundo in Vumbi commune with an area of 150m by 140m or 210ha. It is surrounded to the east by Burambira Hill of Gashoho commune, to the west by Rwimanzovu Hill, to the north by Kabuye-Kitanga Hill, and to the south by Butsimba Hill.

The hospital blocks occupy an area of 7.28 ares and the photovoltaic field occupies an area of 11.5 ares.

Fig.1 Nyabikenke Hospital

Some hospitals in Kirundo province are located in municipalities connected to electricity while the Nyabikenke hospital is located in localities not connected to a public electricity distribution network. The site is a bit far from the national electricity grid. This Gasura electricity network supplies electricity to the center of the commune's capital, which is about 10 km from Nyabikenke Hospital. This is why I was able to carry out the study at Nyabikenke Hospital so that it is supplied with photovoltaic electricity like the other hospitals in Kirundo.

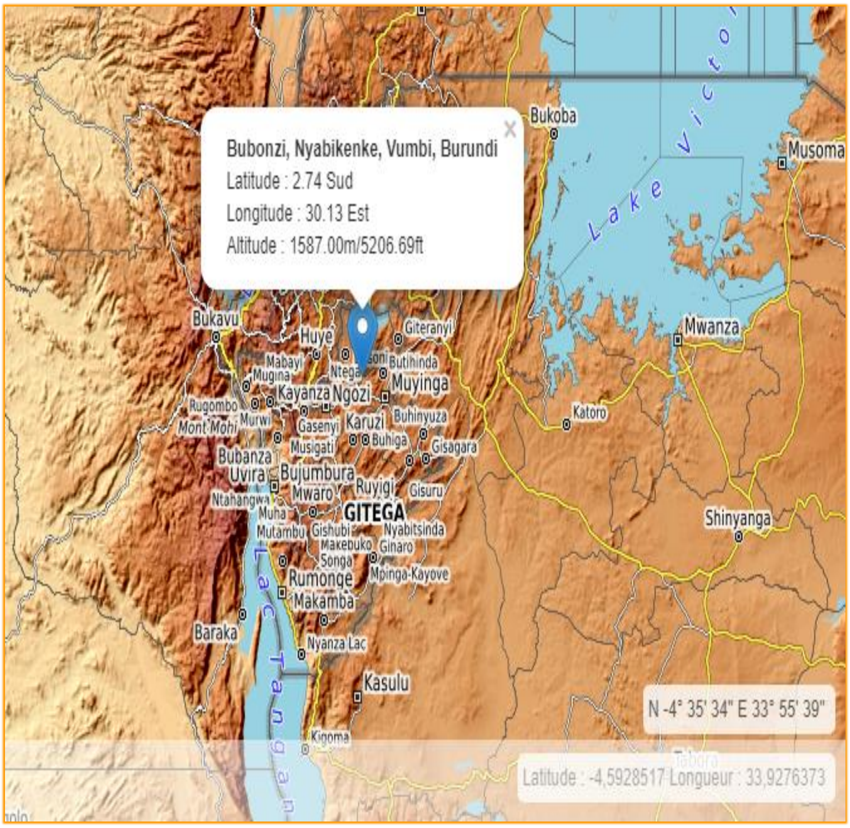

Fig.2 Interactive map of Nyabikenke

For the simulation of our autonomous electrical system, we first consulted Google MAP to obtain the geographical coordinates of the site such as the latitude in degrees, the longitude in degrees, and the altitude in meters; the latitude is -2.74^{o}s, the longitude of 30.13^{o}E and the altitude of 1587m. We also obtained via Google MAP the meteorological data such as the irradiation or the sun's rays of 4,367kWh/m^2/day.

2.2 The energy sources of our autonomous electrical system

Many stand-alone electrical systems also use renewable energy to recharge the batteries [9]. Solar energy is the most popular option for charging batteries due to its quiet and maintenance-free operation. Other sources of reliable renewable energy are wind and microturbines installed in water currents [9].

The renewable generator selected for our study is a photovoltaic (PV) array. Generally, storage is provided by batteries. These systems, called PV-Battery systems, are currently one of the most widely used solutions. The batteries have very good yields, around 80-85%, and a very competitive price, if we consider the Gel technology. The aforementioned Figure 3 is a photo illustrating the block diagram of an autonomous electrical system [9].

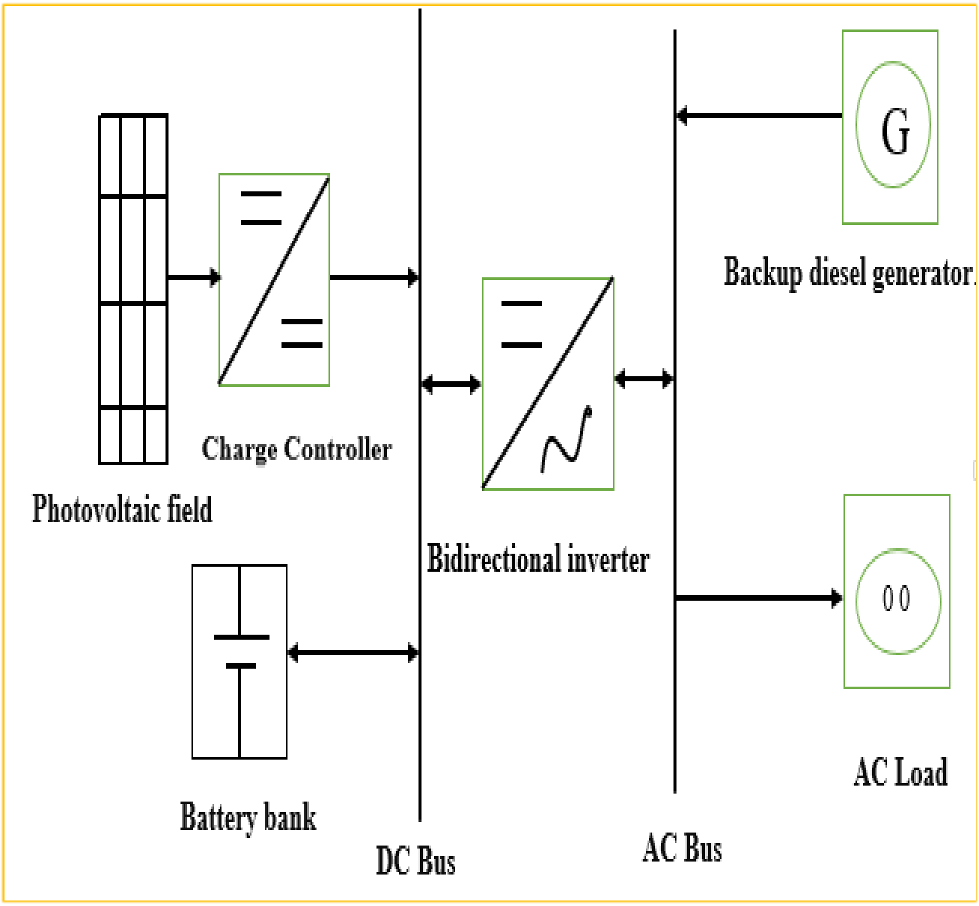

Fig.3 Block diagram of an autonomous electrical system [9].

Our autonomous electrical energy system will consist of a photovoltaic solar system, a battery bank, and an emergency diesel generator.

2.3 Presentation and interface of the ETAP tool

The Tool for Transient Analysis of Electrical Programs, ETAP acronym, is the most complete analysis platform for the design, simulation, operation, and automation of the production, distribution, and energy systems industry [10]. It is developed under an established quality assurance program and is used worldwide as high-impact software. ETAP is completely localized in four languages with output reports translated into six languages. As a fully integrated enterprise solution, ETAP extends to a real-time intelligent power management system to monitor, control, automate, simulate, and optimize the operation of power systems [10]. ETAP is a full-spectrum analytical engineering software company specializing in power system analysis, simulation, monitoring, control, optimization, and automation. ETAP software offers the most comprehensive suite of integrated power system enterprise solutions [10] & [11]. Figure 4 shows us the ETAP interface.

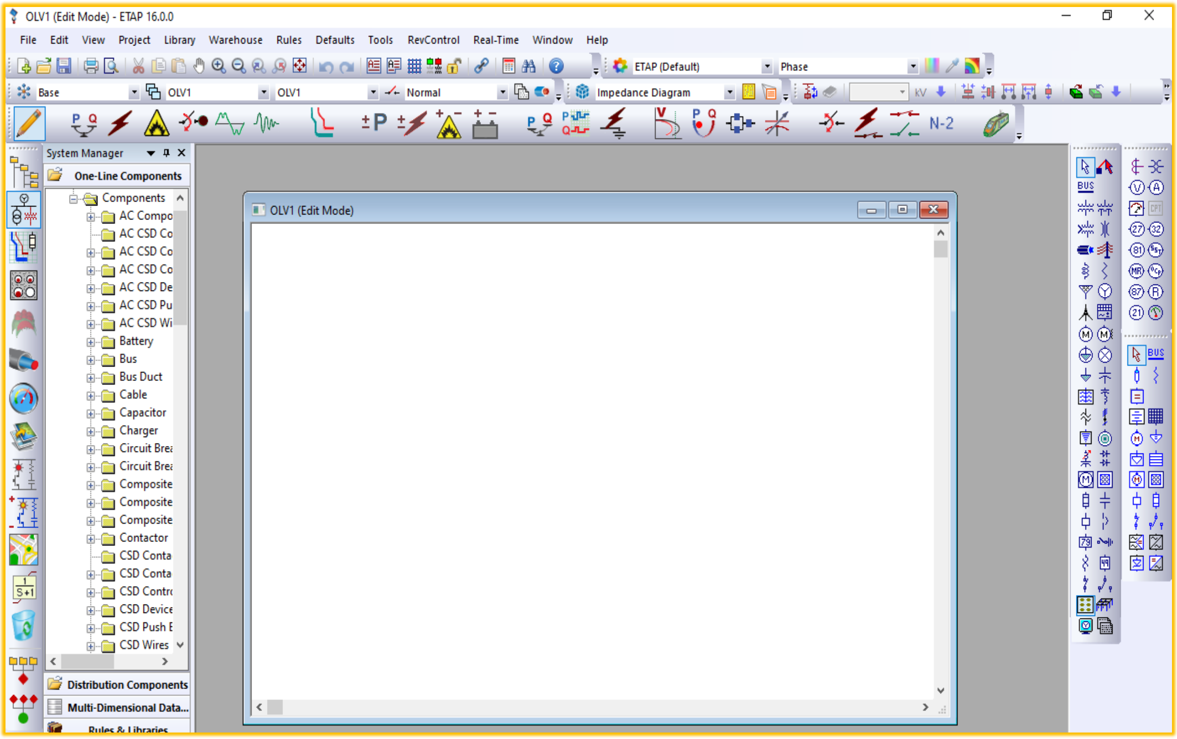

Fig. 4 ETAP interface

2.4 Hospital energy needs

To achieve our objective of determining the total active power absorbed and the total apparent power to be installed in the hospital; the energy needs of the entire hospital are assessed by adding together all the calculated loads. In the aforementioned Table 1 we deduce the total active power, the total apparent power, and the total daily load of the hospital.

Table 1. Energy requirements, total active power, apparent power, and total daily load of the hospital.

Energy needs	AP (W)	RP (VAR)	D_r (Wh/day)
In the sockets	127531	79036	766842
Internal lighting	2054	1270.59	32088
External lighting	2000	1240.51	24000
TOTAL	**131585**	**81547.1**	**822930**

Active power (AP) =131585Watt i.e. 131.5 kW, Reactive power (RP) = 81547.1 VAr i.e. 81.5 Kvar for a power factor of 0.85 and Daily requirement (Dr) = 822930 Wh/day or 823kWh/day. The apparent power Ap P was found by the formula of equation (1) [12]: AP: Active power; RP: reactive power

$$\text{Ap P} = \sqrt{(AP)^2 + (RP)^2}^{\,2} \qquad (1)$$

Ap P $=\sqrt{131.5^2 + 81.5^2}$=154.7kVA

2.5 Choice of equipment

2.5. 1 Photovoltaic Panel

There are many solar panel manufacturers in the solar market today and it can be difficult to choose [12]. Table 2 shows us the characteristics provided by a Longi Solar 525Wp type panel and Figure 5 shows a solar panel Longi Solar 525Wp, they are reliable to give the desired amount of electricity. They include the intensity of the short-circuit current of 13.65 A (Isc), the maximum intensity of 12.75 A (Imp), the maximum supply voltage of 41.2 (Vmp), the voltage of open circuit of 49.05 (Vco), length of 2.256m, width of 1.133m, height of 0.35m and weight of 27.2kg. The operating guarantee of its solar panels is predefined at 25 years [13]. The aforementioned Table 2 shows us the characteristics of the Longi 525Wc solar panel.

Table 2. Different characteristics of solar panels [14]

Power Class	**525**
Maximum Power (Pmax/W)	525
Open Circuit Voltage (Voc/V)	49.05
Short Circuit Current (Isc/A)	13.65
Voltage at Maximum Power(Vmp/V)	41.20
Current at Maximum Power(Imp/A)	12.75
Module efficiency (%)	20.5

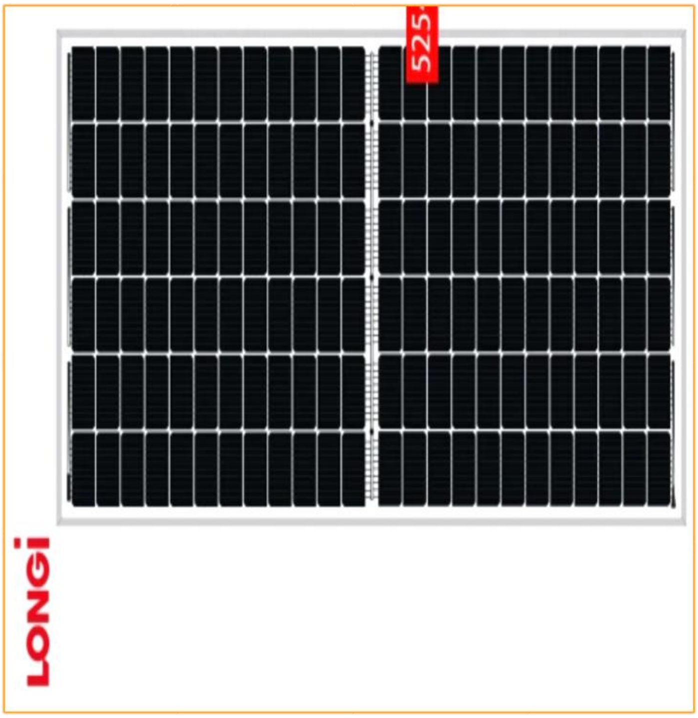

Fig.5 Longi Solar 525Wp solar panel.

2.5.2 Diesel generator

By coupling a generator to our autonomous electrical system with batteries, we can reduce its operating costs by up to 75% [15].

We have chosen a 200kVA-Diesel standby generator set which has the following technical characteristics mentioned in Figure 6: maximum power of 170Kw, 6 cylinders, piston speed of 6.35m/s, the maximum oil pressure of 3.75bar, three-phase, power factor is 0.80, hundred percent load efficiency 92.50%, longitudinal synchronous unsaturated (Xd) 155%, transverse synchronous unsaturated (Xq) 155%, longitudinal transient saturated (X 'd) is 14.40%, longitudinal subtransient saturated (X"d) 19%, zero sequences unsaturated (Xo) 7, ring and brushless technology, excitation current under load (ic) 2.75A, voltage d excitation load (uc) of 38.40V, no-load loss of 3401.03W, heat dissipation of 12867.77W, maximum unbalance rate of 100%, number of poles is 4 poles, air flow (m3/s), capacity engine and radiator 27.6L, speed 1500 rpm, engine brand is JOHN DEERE, length 3.52m, width 1.19m, the height of 2.12m, net weight of 2786kg, tank capacity of 860L, frequency of 50Hz and the reference voltage of 400/230V. Figure 6 shows the Standby 200kVA-diesel generator

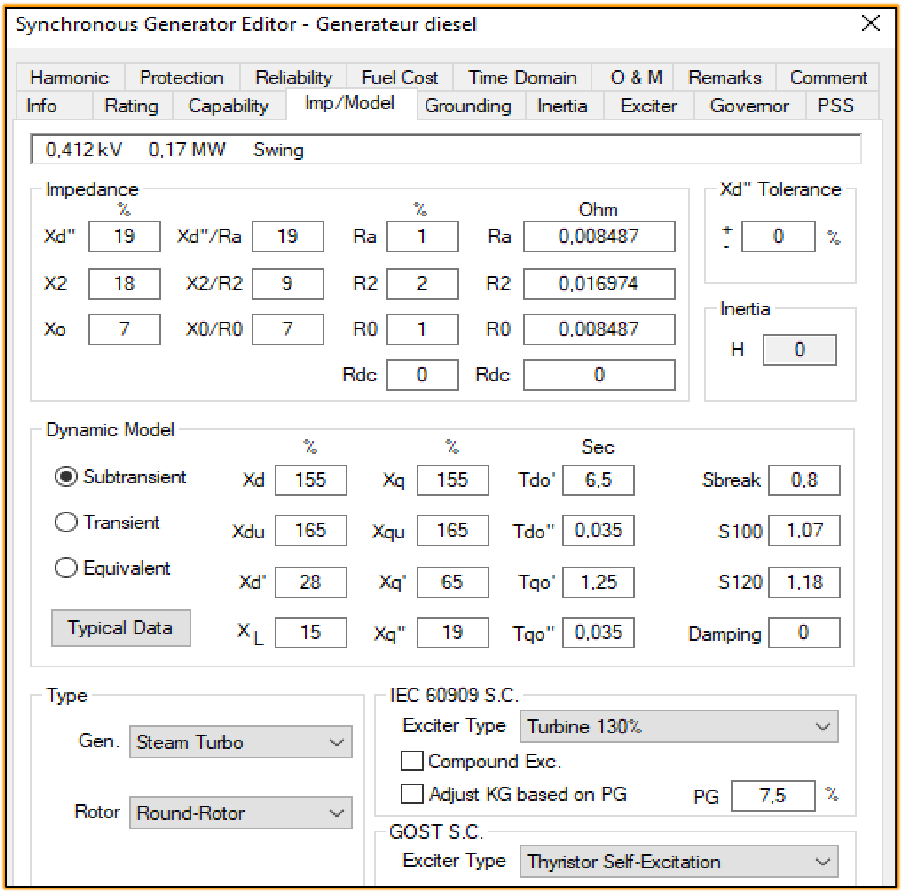

Fig. 6 Standby 200kVA-diesel generator

2.6 Sizing of an autonomous electrical system

The ETAP software used to calculate and estimate the load allows us to have a view of our sizing as well as the different elements found there:

- ✓ A photovoltaic field
- ✓ Charge Controller
- ✓ A Battery bank
- ✓ A Bidirectional inverter
- ✓ A Backup diesel generator.
- ✓ Cable

2.6.1 Choice of a photovoltaic field

In our study, we notice that we need a daily energy of 823kWh/day.

The peak power of the panels to be installed depends on the irradiation of the place of installation, the efficiency of the panels, the efficiency of the regulator, and the efficiency of the batteries as shown by equation (2)[16]&[17]:

$$P_p = \frac{E_c}{E_p . E_r . E_b . I_r} \tag{2}$$

Where Pp: peak photovoltaic field power in peak kilowatts (kWp), Ir: irradiation (kWh/m^2/day), Ep: the efficiency of the panel (0.8), Er: the efficiency of the regulator (0.8), Eb: the efficiency of the batteries (0.85), Ec: energy consumed.

Thus, we have $P_P = \mathbf{346,43}$ kWp

The number of solar panels required for the installation is given by the relation of Eq. (3) [17] & [18]:

$$N_p = \frac{Pp}{Upp} \tag{3}$$

With: N_p: total number of solar panels; U_{pp}: Unit peak power [Wp]

Thus, we have: N_p = 660 panels

Panels placed in series only produce a large voltage across the module terminals while the current intensity remains the same due to the same characteristics of the panels. The relation of Eq. (4) shows us the number of panels connected in series [19]:

$$N_s = \frac{Tfv}{Usp} \tag{4}$$

With: T_{fv}: total field voltage [V], U_{sp}: the voltage delivered by a single solar panel [V]

Thus, we have: N_s= 10 panels

In our work, we combine 10 panels in series that produce 5250W.

The module of the panels placed in parallel allows the production of a large intensity of current and the same voltage at the terminals of the module of the panels. The relation of Eq. (5) shows us the number of panels connected in parallel [20]:

$$N_{pp} = \frac{Tp}{Ns} \quad (5)$$

With: T_p: Total number of panels, Ns: Number of panels connected in series, N_{pp}: number of panels connected in parallel.

Thus, we have: N_{pp} = 66 panels

The ETAP software presents us with the characteristics of the photovoltaic field as they are found for the sizing. Figure 7 traces the useful and noteworthy values.

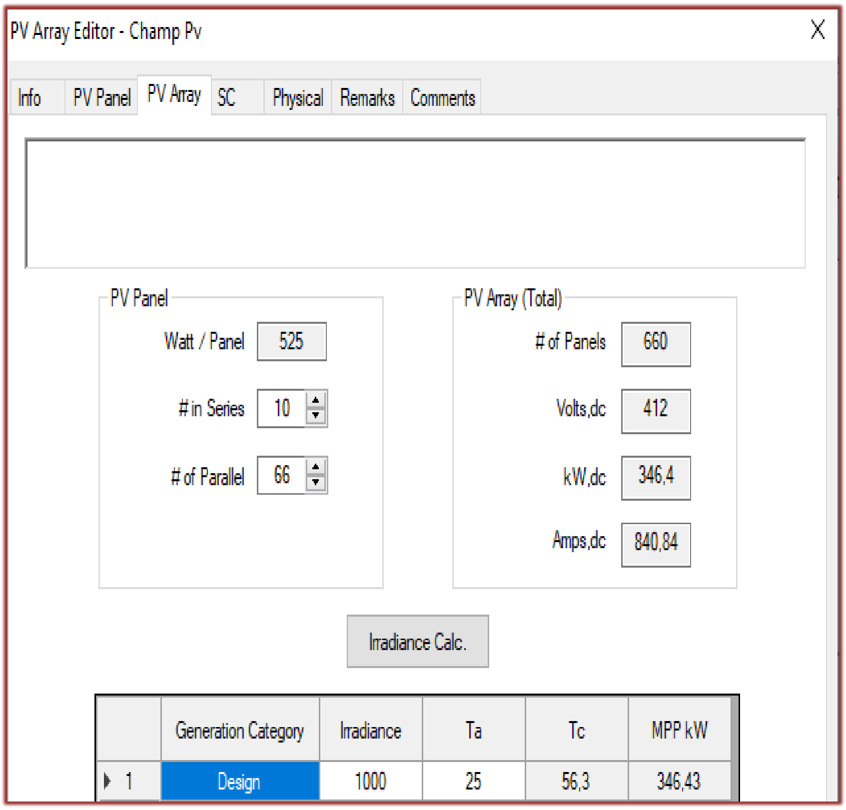

Fig. 7 Sizing of the photovoltaic field under ETAP

The report displayed by the software specifies the different characteristics of the modules. They include a Longi Solar brand module, a unit power of 525Wp, and several PV modules of 660 units including 66 units in parallel and 10 units in series with a total power of 346.43kWp.

In addition, the ETAP software gives us the total voltage of the PV field which corresponds to the voltage of a single module (41.2V) multiplied by the number of modules mounted in series (10 modules). It also gives us the total current of the PV field which corresponds to the current of a single module (12.75A) multiplied by the number of modules mounted in parallel

(66 modules).

2.6.2 Charge Controller

The regulator is chosen according to the following parameters: voltage, input current, and output current [21]. Figure 8 shows us the block of charge regulators.

Nominal voltage: It must be that of the photovoltaic field.

Input current I c: This is the maximum load current that the modules are likely to deliver. It must be supported without problem by the regulator. To estimate this current, the safest way is to take 1.5 times the maximum current

Output current O c: The intensity of the output current of the regulator must be greater than the maximum value that the receivers can draw simultaneously. It can be determined by the formula (6) [21].

$$\mathrm{Mc} = \frac{Pp}{\mathrm{Tfv}} \qquad (6)$$

Mc = 840.84A

Pp: the peak power of the photovoltaic field (W), Tfv: total of the field voltage (V), Mc: the maximum current

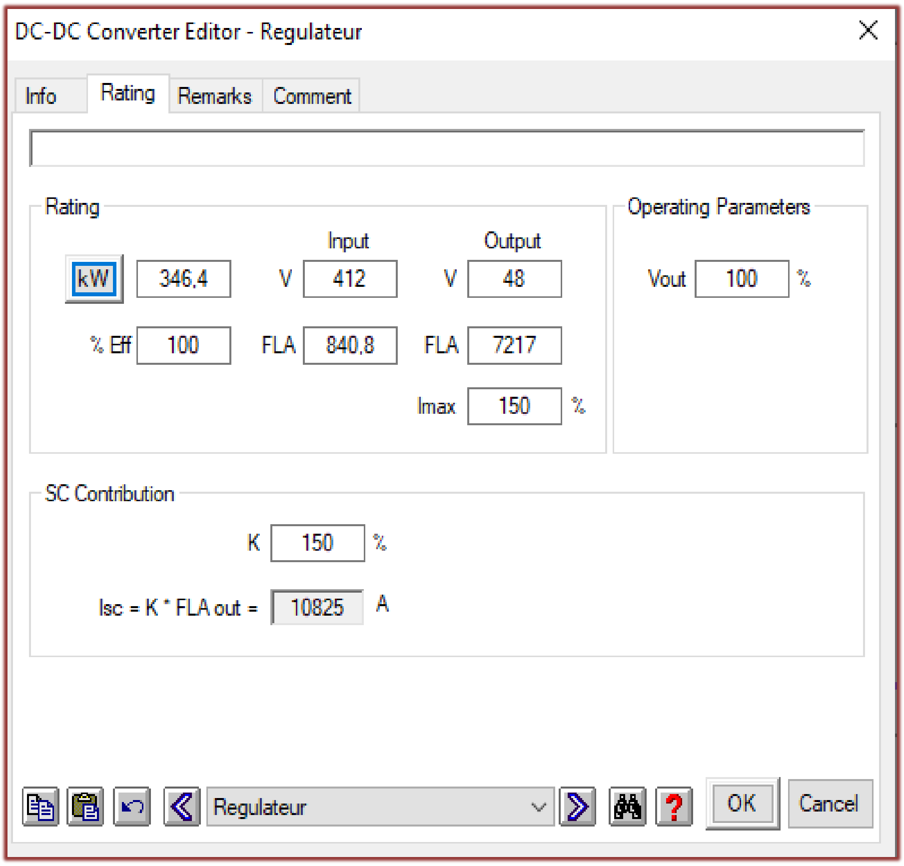

Fig.8 Charge controller block

In our photovoltaic system of 660 photovoltaic panels, we have grouped 22 subfields each comprising 30 panels including the 3 panels in parallel to total the short-circuit current of 40.95 A (13.65*3) and 10 panels in series to total a complex voltage of 412V (41.2*10). So we need 22 charge controllers.

2.6.3 Sizing a battery

Since Nyabikenke is an isolated site not connected to the electricity grid, the battery bank is, therefore, necessary as a second source of energy. The modeling of the batteries, therefore, requires special attention to increase their lifespan while reducing the overall cost of the system. The nominal capacity of the batteries is given by the relation of the following Eq. (7) [21]:

$$B_{fc} = \frac{Ec.N}{D.U.E} \qquad (7)$$

Where: B_{fc}: Battery field capacity in ampere-hour [Ah]; Ec: energy consumed per day [Wh/day] N: number of days of autonomy (1 day); D: maximum admissible discharge (0.8 for GEL batteries); U: battery voltage (48V because the power is greater than 2kW), E: battery efficiency [22].

Thus, we have: B_{fc} = 21432. 29Ah

The relation of Eq. (8) shows us the number of batteries to put in series [16], [18]: N_{bs}: number of batteries in series, U_P: Voltage of the park, U_{vb}: unit voltage of a battery.

$$N_{bs} = \frac{U_P}{U_{vb}} \qquad (8)$$

Thus, we have: N_{bs} = 4 batteries

The relation of Eq. (9) shows us the number of batteries to put in parallel [22]:

$$N_{bp} = \frac{Cb}{Ucb} \qquad (9)$$

With: N_{bp}: number of batteries in parallel, C_b: Capacity of the battery bank, Cunit: Unit capacity of a battery.

Thus, we have: N_{bp} = 107, 16 ≈ 108 batteries

We, therefore, have a surplus of the capacity of 167.71Ah and energy E= 8050.08Wh.

So in total, we have 108 batteries multiplied by 4, i.e. 432 batteries (108 blocks in parallel, each block is composed of 4 batteries in series). We want to use 200Ah and 12V capacity GEL batteries.

The energy produced by the battery is given by the relation of equation (10) [23]:

$$E_{bat} = U \times B_c \qquad (10)$$

With: E_{bat} : energy of the battery, U: battery voltage, B_c: battery capacity

Thus, we have Ebat = 1028749.92Wh plus a surplus of 8050.08Wh that gives 1036.8 kWh. With this energy found, we can derive the total capacity of a battery bank by the relation Eq. (11) [23] with E_{bat}: energy of the battery, T_u: total voltage of the battery, and T_{cb}: total capacity of a battery bank.

$$T_{cb} = \frac{Ebat}{Tu} \quad (11)$$

Thus, we have: T_{cb} =21600Ah

Figure 9 shows the sizing of a battery bank composed of 432 batteries each of 12V 200Ah whose four batteries are in series to total the voltage of the park of 48V and 108 batteries are in parallel with a total capacity of the park of 21600Ah batteries.

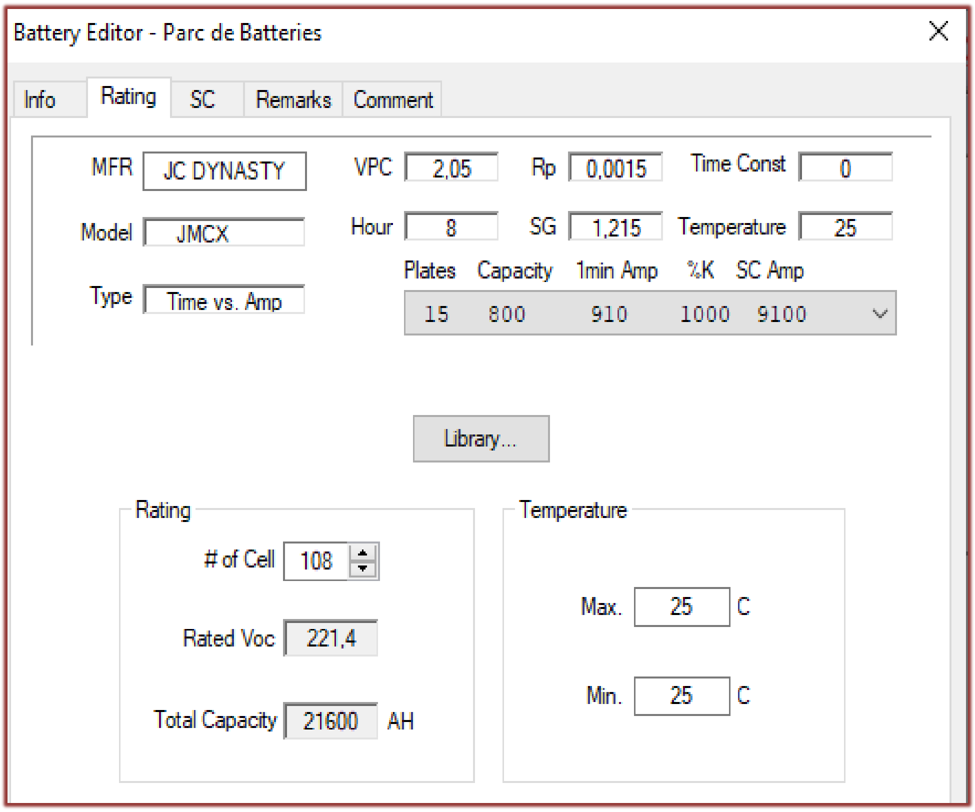

Fig.9 Sizing of a battery bank under ETAP.

2.6.4 Sizing an inverter

The peak power of the inverter must be greater than the sum of the starting powers of the devices likely to start at the same time, and the rated power of the devices works continuously [24]. Figure 10 shows the Sizing of a bidirectional inverter under ETAP and the relation of Eq. (12) shows us the power at the output of the inverter [24]: With P_{in}: power of the inverter; ŋ: yield; P_{pf}: power of the photovoltaic field.

$$P_{in} = ŋ{*}P_{pf} \quad (12)$$

Thus, we have: P_{ond} = 3112.78kWc

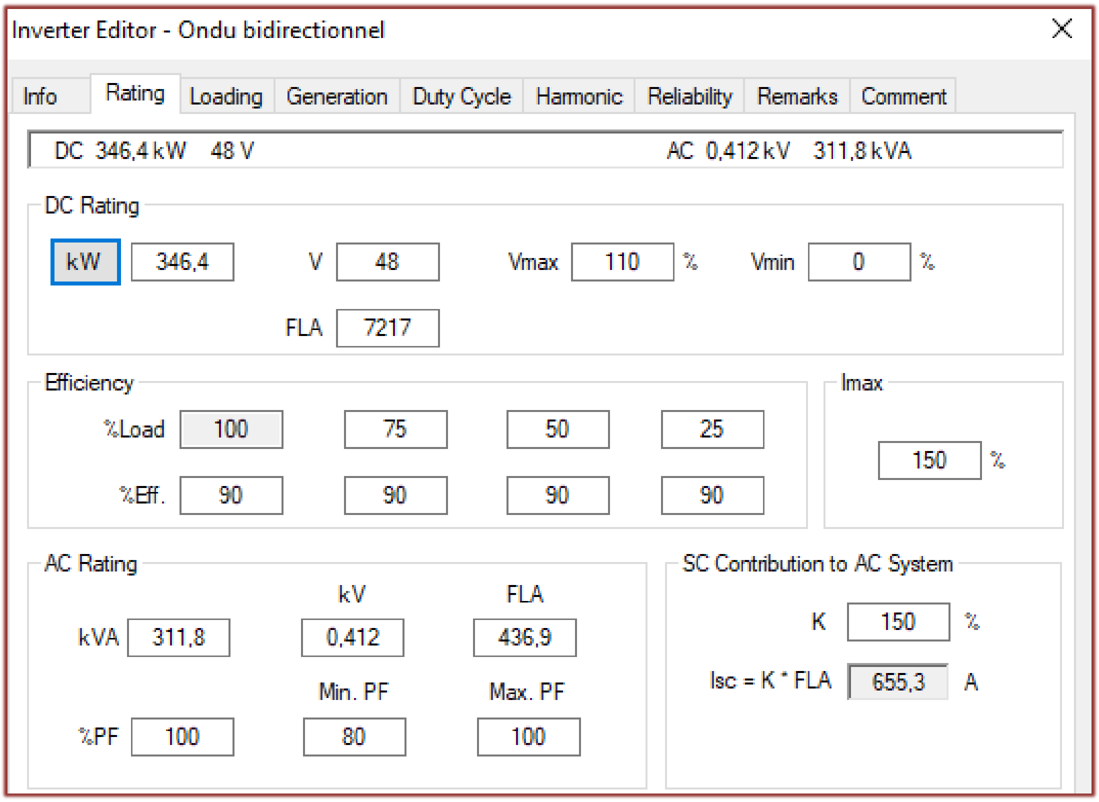

Fig.10 Sizing of a bidirectional inverter under ETAP

The bidirectional inverter works either as a rectifier when the diesel generator covers the electricity consumption and participates in the charging of the battery or as an inverter when the load is satisfied by the photovoltaic panels and/or the battery.

Upstream of the inverter (direct current), we have a power of 346.43 kWp, and downstream (alternating current) of the inverter has a power of 311.8 kWp.

2.6.5 Sizing a Standby Diesel Generator

The dimensioning of a generator depends on the one hand on the total active power of the hospital, on the other hand on the apparent power. Generally, manufacturers recommend operating the set at a power greater than or equal to 30% of its rated power. We then chose a 170kW generator (131.5Kw plus 30% of 131.5Kw which is the nominal power of the hospital) with a power factor of 85%, the emergency generator is 200 kVA, i.e. 0.2 MVA Figure 11 below shows the technical characteristics of a 200 kVA generating set.

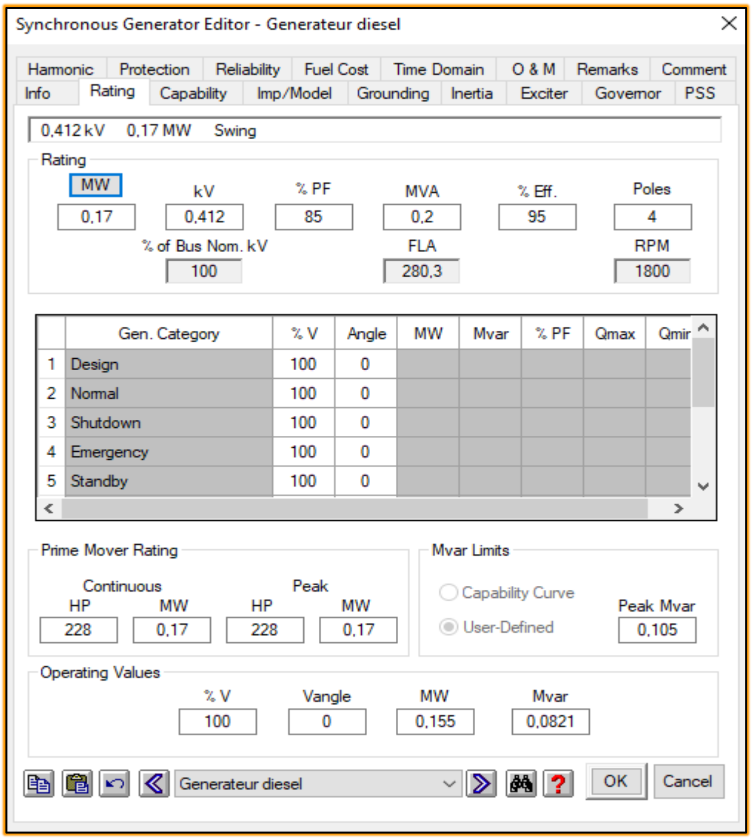

Fig.11 Technical characteristics of a generating set.

As mentioned in Figure 11 generated by ETAP, the generator set chosen has a nominal apparent power of 200KVA or 0.2MVA, a power factor of 85%, a nominal real power of the synchronous generator of 0.17MW, the nominal efficiency of the 85% synchronous generator, the continuous rated motor power of 228 HP (Horse Power) which is equivalent to 0.17 MW (1.34173 HP = 1 kW), the maximum Var output has the maximum output voltage of the exciter of 0.105 Mvar, an operating real active power of 0.155 MW, operating reactive power of 0.0821 Mvar, an operating voltage angle of 0 degrees, a full load current (FLA) of 280.3 A and a voltage real rated 0.412 KV.

2.6.6 Cable sizing

Photovoltaic cables are designed to withstand the conditions associated with their use. They are the only ones able to ensure a long service life (more than 30 years) while minimizing energy losses. The resistance of an electric cable does not depend on the voltage or the intensity of the current which crosses it but depends on the resistivity (ρ) of the material used (copper, silver, iron…), the length of the cable, its section, and its temperature [24]. Figure 12 below shows us the technical characteristics of a single-wire copper cable 20m long that we used from the AC bus to the load.

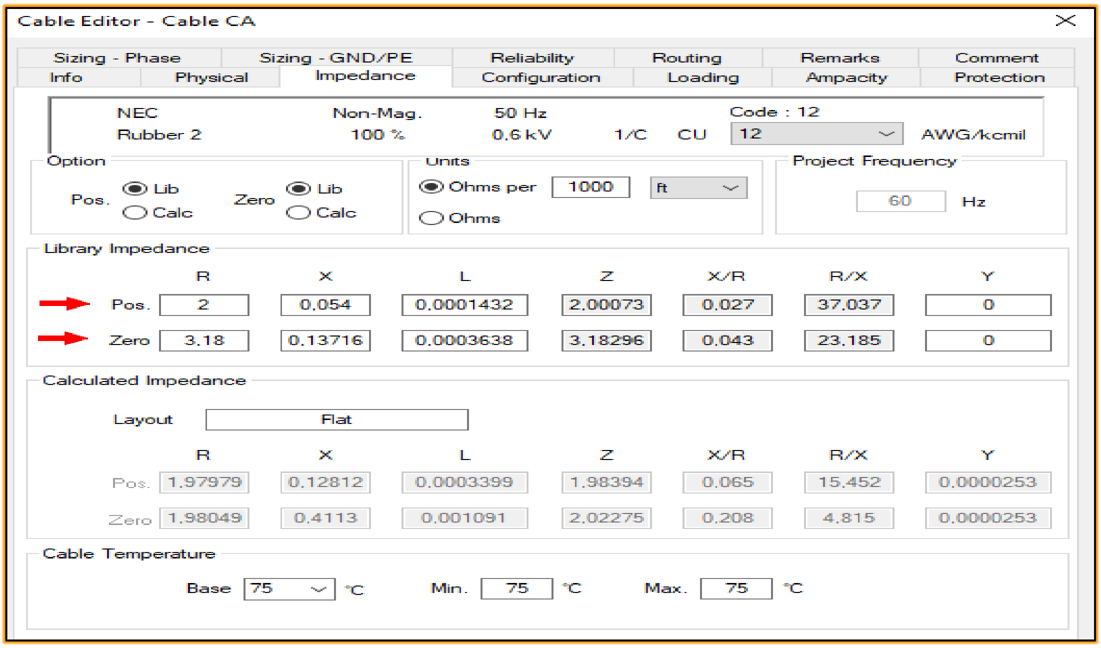

Fig.12 Cable specifications

3. Presentation and discussion of results

In this chapter, we will present the simulation results that we obtained on the ETAP software, from where the latter was a very powerful tool for decision support and design of the autonomous electrical system.

3.1 General presentation

In the system studied (Figure 13), the photovoltaic field supplies the user directly. The solar surplus is stored. When the solar field cannot supply the entire electricity demand, the battery bank is connected, and it generates the stored electricity. To avoid major problems in production the emergency diesel generator is provided. The energy source distribution diagram in Figure 3 is shown below.

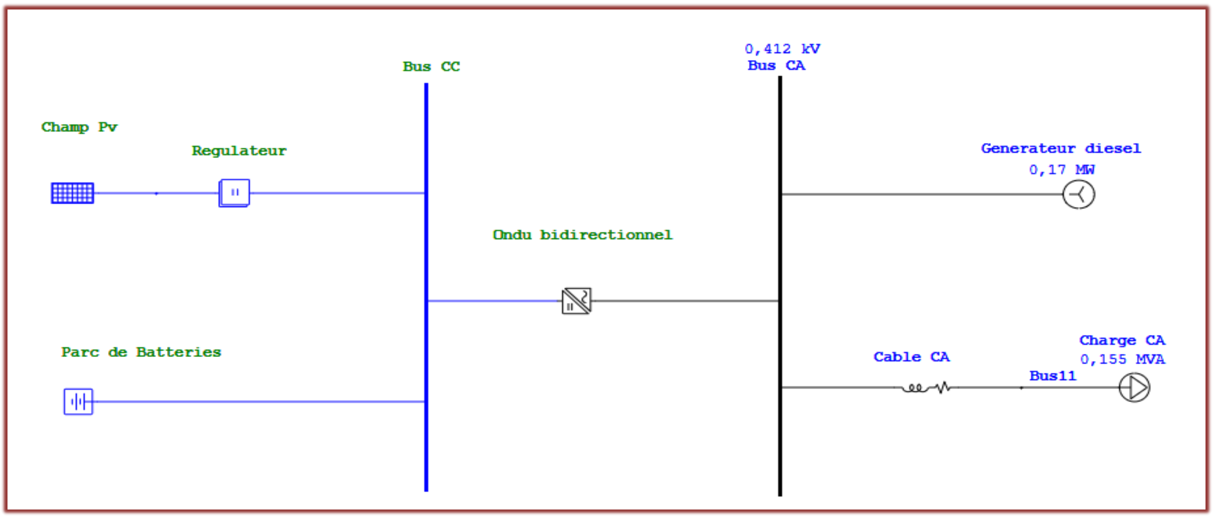

Fig.13 Distribution of energy sources.

In this system, the photovoltaic generator and the battery bank are connected to a direct current bus. The emergency diesel generator is connected to the AC bus. The two buses are connected using a bi-directional electronic converter. It can operate either as a rectifier when the diesel generator covers the electricity consumption and takes part in charging the battery or as an inverter when the load is satisfied by the photovoltaic panels and/or the battery.

3.2 Order 1 (Solar production-Storage)

Order 1 (Figure 17) is the set of two energy sources: a photovoltaic generator (Figure 14) and a battery bank (Figure 15). Connecting this command will shut down the diesel generator set as shown in Figure 16 below.

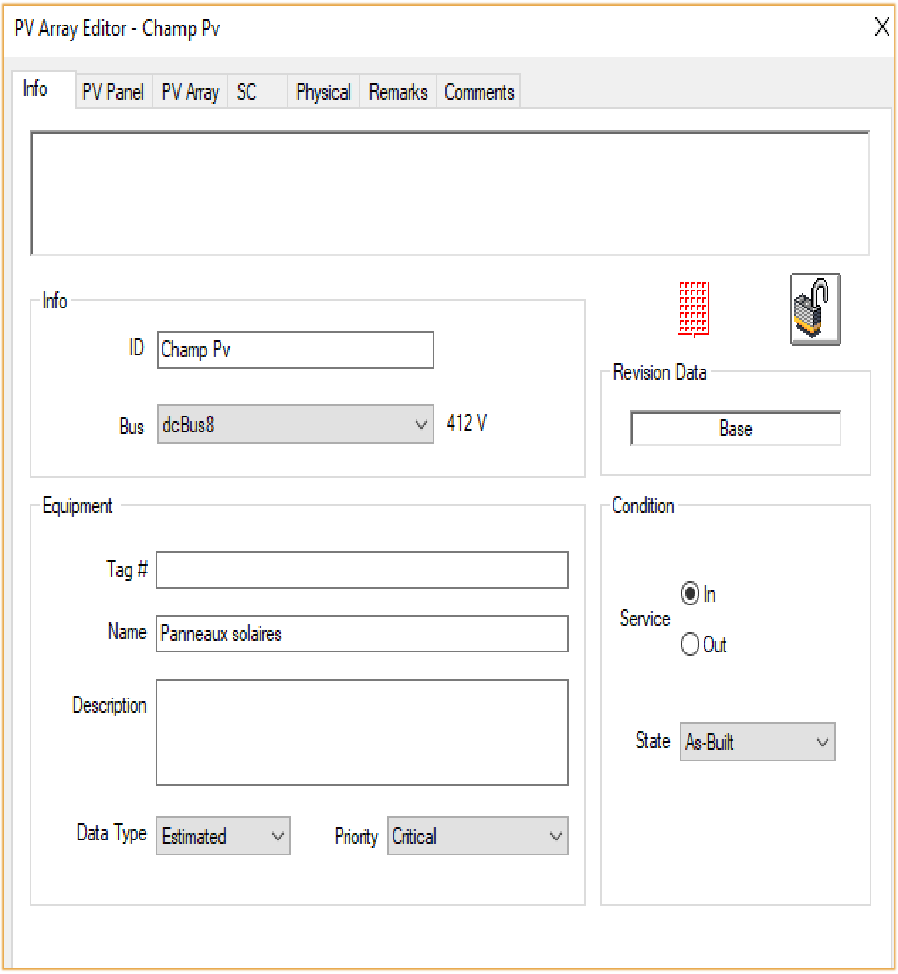

Fig.14 Photovoltaic field in operation

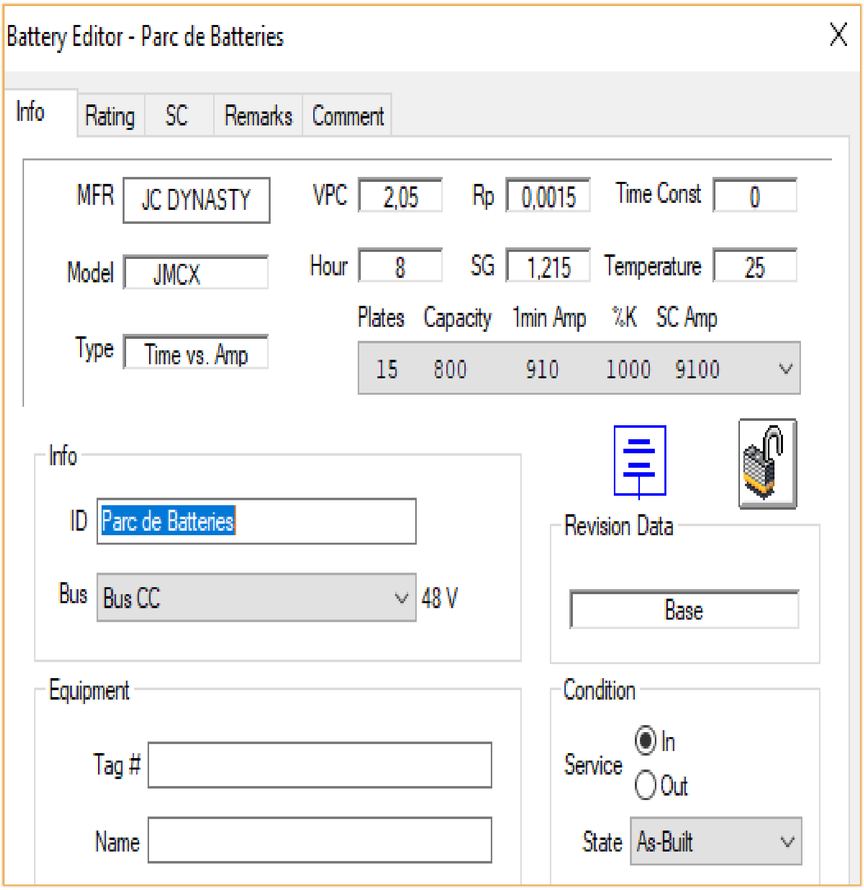

Fig.15 Battery bank in service

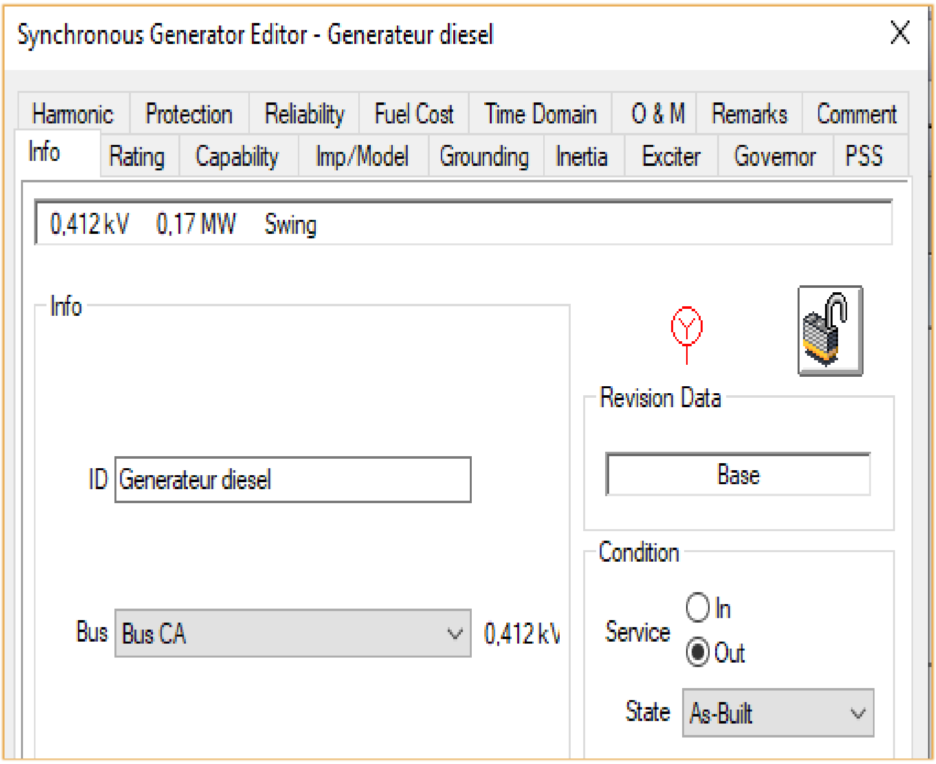

Fig.16 Standby diesel generator out of order

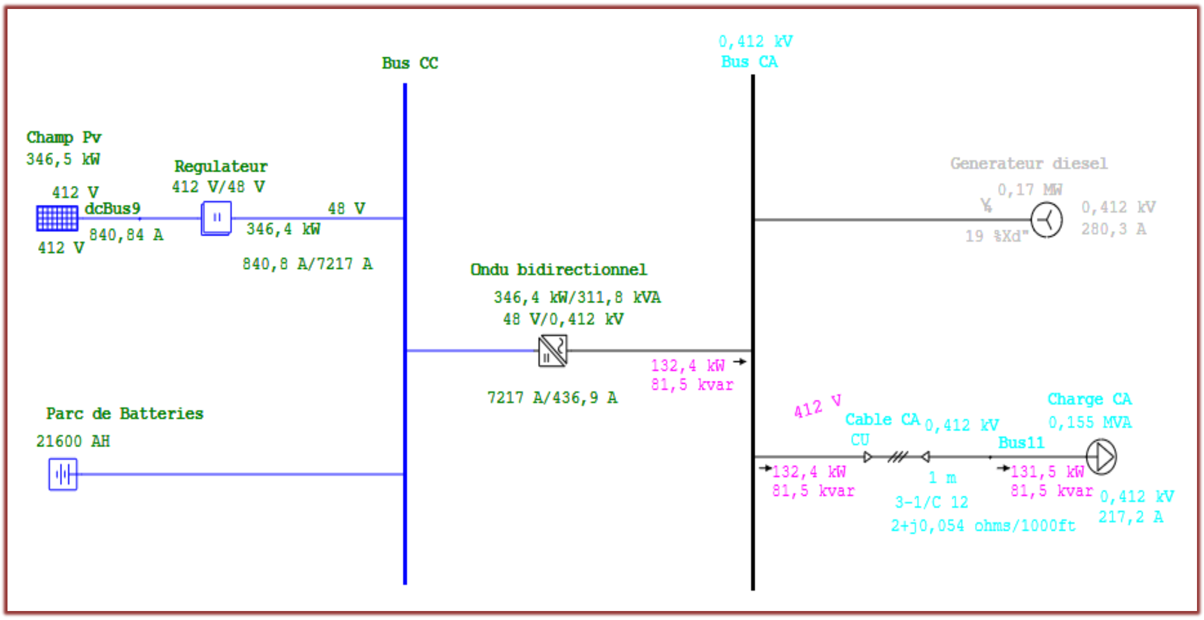

Fig.17 Command 1 (Solar production-Storage)

This command which requires light rays or stored energy is the best. With an average daily sunshine of 4,367 kWh/m^2/d in Nyabikenke, during the day all the hospital services will be in service with a power of 131.5 kW, and the hospital services working at night will never fall into load shedding if the sunshine persists stable.

3.3 Order 2 (Emergency diesel generator)

Command 2 (Figure 20) is the command to shut down the photovoltaic generator (Figure 18) by supplying the emergency diesel generator as shown in Figure 19 below:

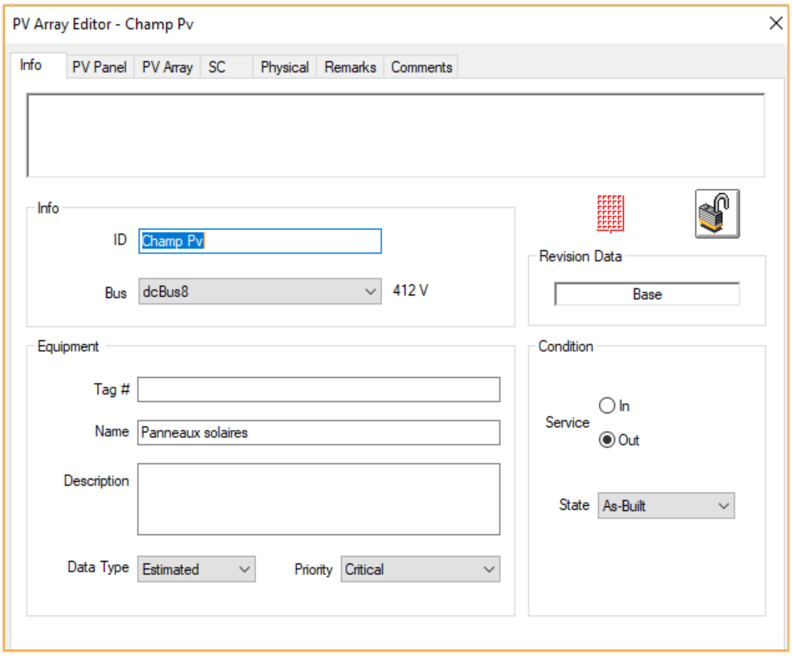

Fig.18 Photovoltaic field out of service

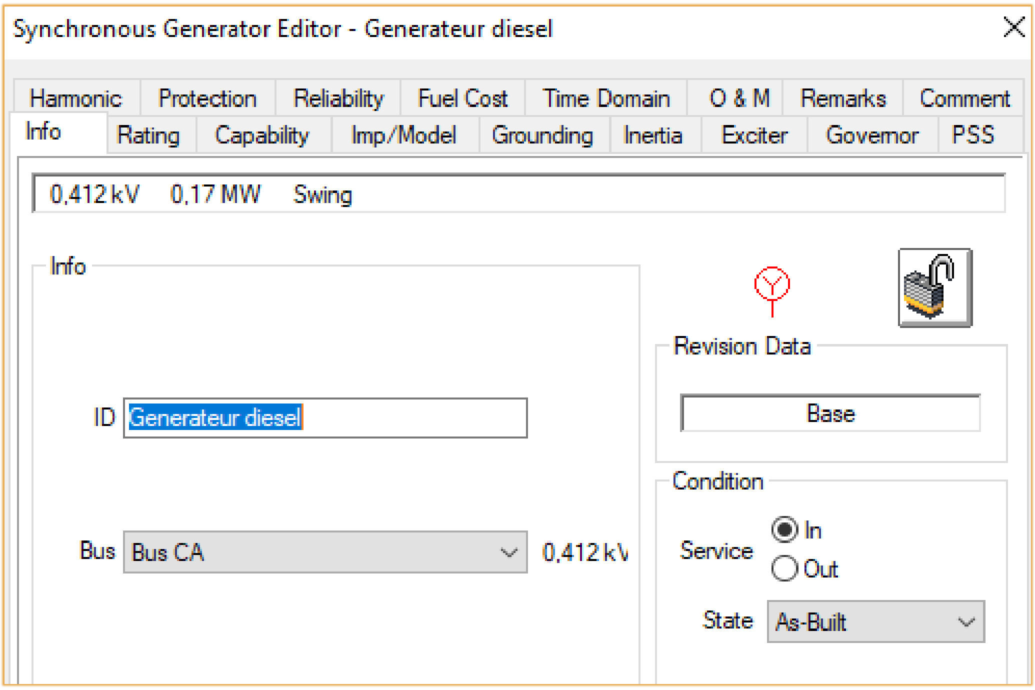

Fig.19 Diesel generator in operation

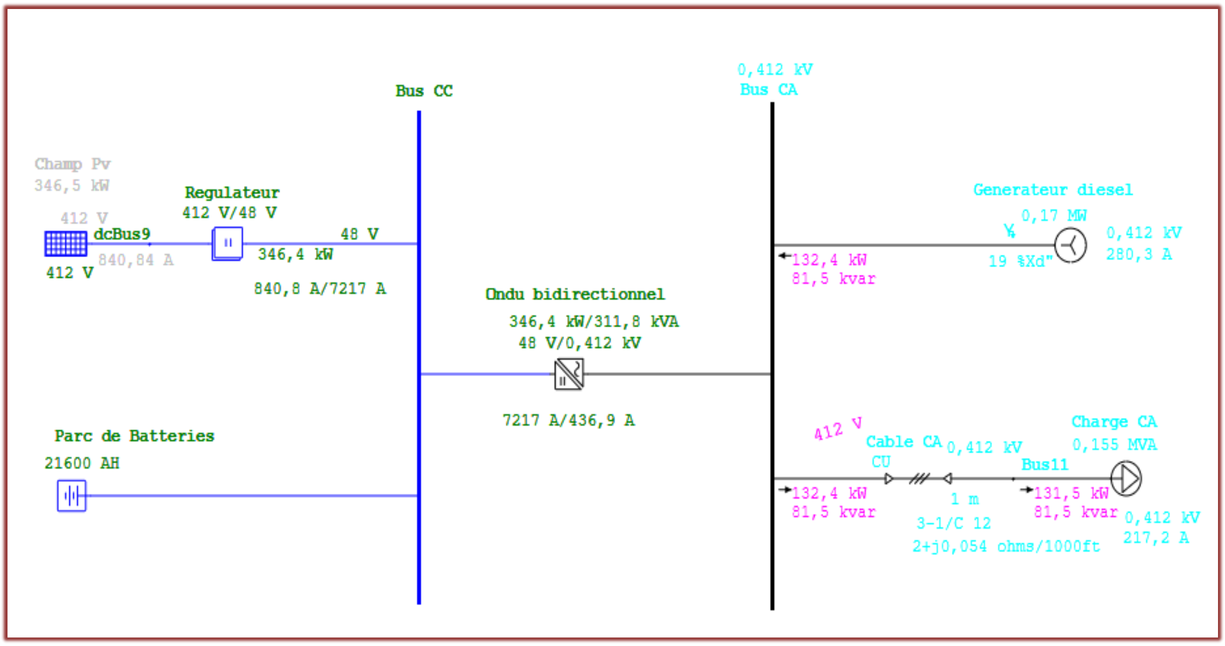

Fig. 20 Command 2 (Emergency Diesel Generator)

By coupling a generator to our autonomous electrical system, it can be used to power the 131.5kW load which covers all the hospital's energy needs, and the rest of the unused energy is stored.

3.4 Main results

In this part, we place particular emphasis on the various collective losses of our autonomous electrical system. While analyzing the load flow, ETAP provides various alerts that require immediate attention for proper system operation. Tables 3, 4, and 5 below show us the Leg Loss Summary Report, Summary Report Illustrating System Production, and Summary Report illustrating System Load, respectively.

Table 3. Leg Loss Summary Report

Buses	2
Branches	1
Generators	1
Power Grids	0
Loads	1
Load-kW	132,4
Load-Kvar	81,5
Generation kW	132,4
Generation-Kvar	81,5
Loss-kW	0,9
Loss-Kvar	0

Table 3 above shows us that our autonomous electrical system consists of two buses (DC bus and AC bus), an electric cable connecting the junction box and the load, a Diesel generator, and a load (Nyabikenke hospital). ETAP shows us that between the AC bus and the load bus (bus11), the powers (active power, apparent power, and reactive power) suffer low transmission losses. Of the active power arriving at the AC cable, there is the loss of active power of the order of 132.4 kW-131.5 kW = 0.9 kW and the loss of reactive power of the order of 81.5 Kvar -81 .5Kvar = 0Kvar.

Table 4. Summary report illustrating the production of the system.

Bus ID	Nominal kV	Amp Rating	Type	Voltage	KW Loading	Kvar Loading	Amp Loading
Bus CA	0,412	0	SWNG	100	132,4	81,5	217,9
Bus11	0,412	0	Load	88,02	131,5	81,5	217,9

Table 4 above shows us the technical characteristics of our system: the system voltage is 0.412kV, the system current is 217.9A, the active power arriving at the AC bus is 132.4KW, and the reactive power arriving at bus 11 is 81.5 Kvar.

Table 5. Summary report illustrating system load.

ID	Rating/Limit	Rated kV	kW	Kvar	Amp	% PF	%Loading	Vtermal
Charge CA	155kVA	0,412	131,5	81,5	217,9	85	100,3	99,48

Table 5 above illustrates the data necessary for the proper functioning of our autonomous electrical system: the maximum apparent power of 155 kVA the voltage of the system of 412V, the reactive power of 81.5 Kvar, the current of the system of 217.9A and the active power of the hospital (AC load) is 131.5kW which is at best according to our hospital needs.

4. Conclusion

Autonomous electrical systems are the most promising for the use of renewable energies. In regions where the solar energy potential is high, it is important to promote the systematic substitution of conventional energy sources, which are becoming increasingly restrictive regarding the cost of exploitation and operation.

Following this study on the design and simulation of an autonomous electrical system, we were able to observe that the tool for Transient Analysis of Electrical Programs, ETAP acronym, is well designed for the design of an autonomous electrical system. Indeed, an autonomous electrical system must be well-designed to overcome certain constraints that can lead to poor energy automation.

Being designed for calculation and simulation, the ETAP software facilitated the design of our system, it allowed us to see how our system will behave in the event of different types of disturbances. During this work, we took care of identifying the medical equipment and materials that will be powered by the photovoltaic system and by the emergency diesel generator, we sought to determine the power necessary to cover all the needs of the hospital. To achieve this objective, we have determined the capacity of the generating set and that of the storage, with the choice of the photovoltaic module, the choice of a diesel generating set, and the battery element adapted to the correct sizing.

In addition, we learned the basics of designing an autonomous electrical system using the ETAP software which provided us with satisfactory results that could carry out the rest of our study, we were able to use the different notions of base that we received in the different modules of our university course.

The simulation using ETAP to carry out the calculation relating to the design gave very satisfactory results, the active power observed after simulation (131.5kW) is equivalent to the active power that we have identified to cover all hospital needs.

We do not claim to have exhausted the study of all aspects of our art object. Other researchers will nevertheless be able to focus on the design of other autonomous electrical systems.

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