Research Paper

*International Journal of Research and Review*
*Volume 11; Issue: 4; April 2024*
*Website: www.ijrrjournal.com*
*E-ISSN: 2349-9788; P-ISSN: 2454-2237*

# PVsyst and Homer for the Evaluation of a Project to Size a Photovoltaic Solar Power Plant in Reinforcement of the CEET Network in Lomé in Togo by Characterization of the Electrical Energy Consumed

**APALOO BARA Komla Kpomonè[1,2], KOMBATE Damipi[3]**

[1]Department of Electrical Engineering, Polytechnic School of Lomé (EPL), University of Lomé, Togo
[2]Engineering Sciences Research Laboratory (LARSI), University of Lomé, Togo
[3]Department of Renewable Energy, Directorate of Thermal Production and Renewable Energy, (DPTER), SYSAID FASO, Burkina Faso

Corresponding Author: APALOO BARA Komla Kpomonè

**DOI: https://doi.org/10.52403/ijrr.20240435**

## ABSTRACT

The world is currently affected by climate change and the primary cause is the pollution of nature by the sources used for the production of electricity. This article aims to improve this situation by the insertion of photovoltaic sources. Consumption data from 6 a.m. to 6 p.m. from the CEET Lomé A substation in Togo are considered. A statistical characterization is carried out then the PVsyst and Homer software are used to explore the possibilities of installing the solar power plant. The theoretical target area is a no man's land in the locality of Noèpé near the Togo-Ghana border. The results of the characterization show that the data are well distributed around a central value in relation to Gauss's normal law and made it possible to find 73.23 MW as the power requirement. The domestic power factors cosphi =0.9 and industrial cosphi =0.81 imposed by the CEET for network stability are used as correction factors. The results of the project are as follows: PVsyst gives a module power of 550Wp, 25 modules in series for 3640 in parallel and 46 inverters. In addition, we have 95,894 modules by Homer with an energy proposal of 40,936 GWh per year, for an autonomy of 14.5 hours, an operating cost of 2,442,160,000 FCFA and the price per KWh which amounts to 154.2 FCFA. The implementation of such a project will contribute to the protection of nature. However, it is the state which must decide on the installation site for the implementation of the project.

***Keywords:*** Characterization, Electrical Energy Consumption, Homer, PVsyst, Solar Photovoltaic.

## INTRODUCTION

The growth in electrical energy needs around the world is leading to an evolution in its production. Fossil primary energy sources (crude oil, natural gas, coal), used for the production of electricity cause an increase in greenhouse gases. We find ourselves with climatic anomalies, leading to the melting of glaciers, rising sea levels, changes in seasons, heatwaves, etc. [1], [2], [3], [4].

This being said, several global meetings continue to take place to find a lasting solution. We can cite: the Nairobi African

leaders' declaration on climate change and call to action which took place in Nairobi, Kenya from September 4 to 6, 2023, [5]; COP27 in Egypt of the Arab Republic of Egypt, [6]; the Paris climate agreement, [7], [8]; etc. The work resulting from these meetings resulted in a single decision: the change in behavior linked to the production of electrical energy. This is the use of primary energy sources in production. The recommended source is renewable (solar, wind, geothermal, hydroelectric), [9], [10], [11], [12], [13] and particularly for Africa, it is photovoltaic solar.
TOGO being a country in humid and coastal West Africa, it has a significant solar resource [14]. Unfortunately, its electricity supply is ensured by imports and some internal production, [15], [16]. The Electric Community of Benin (CEB) is responsible for transport and the Electric Energy Company of Togo (CEET) for the distribution of electrical energy in the country. The objective of this work is to increase the autonomy of energy production in the CEET network. The aim is to use the energy subscribed at certain interconnection stations to plan photovoltaic-based production, replacing imports at times.
To succeed in this work, we will use the electrical energy consumption at the LOMÉ A substation. Through this data, we will dimension a photovoltaic field capable of taking over the energy needs for the area supplied by LOMÉ A. Indeed, the period from 6 a.m. to 6 p.m., the period during which the sun is visible in the area, will be retained as a target during the characterization. The processing will be done through specific software dedicated to this purpose.
Several software programs exist for sizing photovoltaic solar fields. We can cite: PVsyst, [17]; HOMER [18]; PVsol, [19]; EnergyPlus, [20]; RETScreen, [21]; etc. We realize through the literature that Homer and PVsyst are the most highly rated in terms of the technical-economic evaluation of renewable-based production plants. They will then be used for sizing because of their international reputation. The results will allow the feasibility by the cost of the investment the deduction of the price of the kilowatt hour.

## MATERIALS

To carry out this work, we will use data relating to the powers consumed on the CEET network during the year 2020. Data from the Lomé A distribution station (AKOSOMBO) will be considered. Taking into account the forecasts linked to the expected results, the readings from 6 a.m. to 6 p.m. are only taken into account at intervals of 30 minutes given that the country is located in humid and coastal West Africa according to a study carried out by B. PITON entitled: hydroclimatic characteristics of the coastal waters of Togo, Gulf of Guinea at the French Institute of Scientific Research for Development in Cooperation, Brest center, In the Scientific Document 0RST0M Brest No. 42 1987 which explains that it is 'an area which is not very stable in sunshine. Figure 1 shows the recording sheet for electrical energy withdrawn from the CEET network at the Lomé A substation.

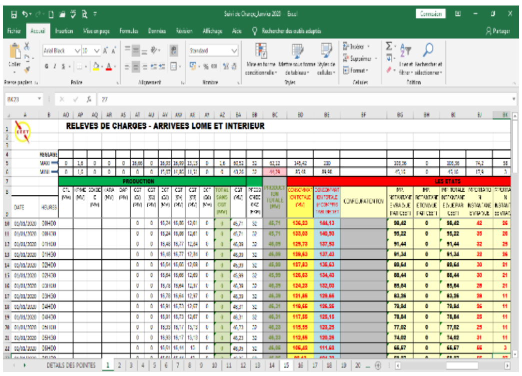



**Figure 1. CEET data recording sheet**

In order to make a good assessment of the loads at the Lomé A substation, we have gathered the semi-hourly information on a spreadsheet, the appearance of which is shown in Figure 2. The twelve months of the year 2020 are considered.

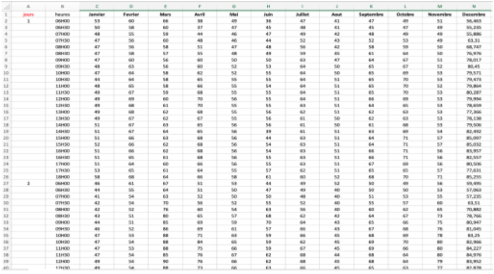


**Figure 2: Processing table for study and characterization**

## METHODS

After assembling and processing the load monitoring data, a monthly characterization is carried out. The parameters taken into account are mean, mode, mode, standard deviation, minimum, maximum, Skewness and Kurtosis. Several software programs allow data processing. We can cite: Python, R, Anaconda, Open VSS IBM Watson, Microsoft Azure Machine Learning, Google Cloud AI Platform, MATLAB, etc...

We have opted for the Python programming environment in this work. It is a free, interpreted, multi-paradigm and multi-platform programming language. We used it particularly because of its free license and its ease, especially since the codes are inspired by and close to C++. Four complementary libraries (Numpy; Pandas; Scikit-learn; Matplotlib) were added and installed to facilitate data processing. Gauss's normal law is explored to properly follow the distribution of the data. It is given by relation (1).

$$P(x) = \frac{1}{\sigma\sqrt{2\pi}} e^{\frac{1}{2}\left(\frac{x-\mu}{\sigma}\right)} \quad (1)$$

Where:

- ➢ $\sigma$ is the standard deviation of the distribution of consumption data;
- ➢ $\mu$ is the average of the consumption data;
- ➢ $x$ is to the consumption recorded.

To evaluate the capacity of the photovoltaic solar field, we considered the value of the highest average power of the year. Two power factors are used as correction factors for the different types of loads and the field power is then calculated by relation (2).

$$P_{Champ} = \frac{P_{Consommée}}{\text{Cos}\,\varphi} \quad (2)$$

Où :

- ➢ $P_{Champ}$ is the power to be installed for the photovoltaic solar field
- ➢ $P_{Consommée}$ is the average power considered for the study
- ➢ $\text{Cos}\,\varphi$ is the power factor

If $P_{champ}$ field is the power of the field; $k_G = 0{,}66$ is the conversion factor of the generator and $I_r = 5{,}01\ \text{kWh}/m^2/\text{j}$ , the peak power of the panels to be installed is given by relation (3) and the average value of the monthly irradiation of the country by figure 3.

$$P_c = \frac{P_{ch}}{k_G \times I_r} \quad (3)$$

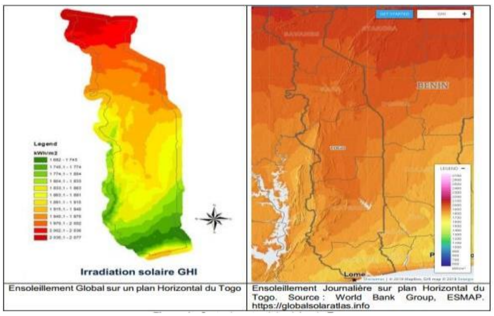



**Figure 3: Solar potential map in Togo, [22]**

The values obtained will be implemented in Homer and PVsyst for comparison. In reality, PVsyst is a design software allowing you to do: solar site modeling, solar system design, energy production simulation, energy yield estimation, sensitivity analysis, energy forecasting. self-consumption, financial analysis, detailed report, regular updates, etc. [17]. Likewise, Homer is also a software that plays almost the same roles as PVsyst. We can cite: energy system modeling, cost and sensitivity analysis of the performance of the energy system, optimization of energy self-sufficiency and reduction of carbon emissions, analysis through reports and graphs, etc. [18].

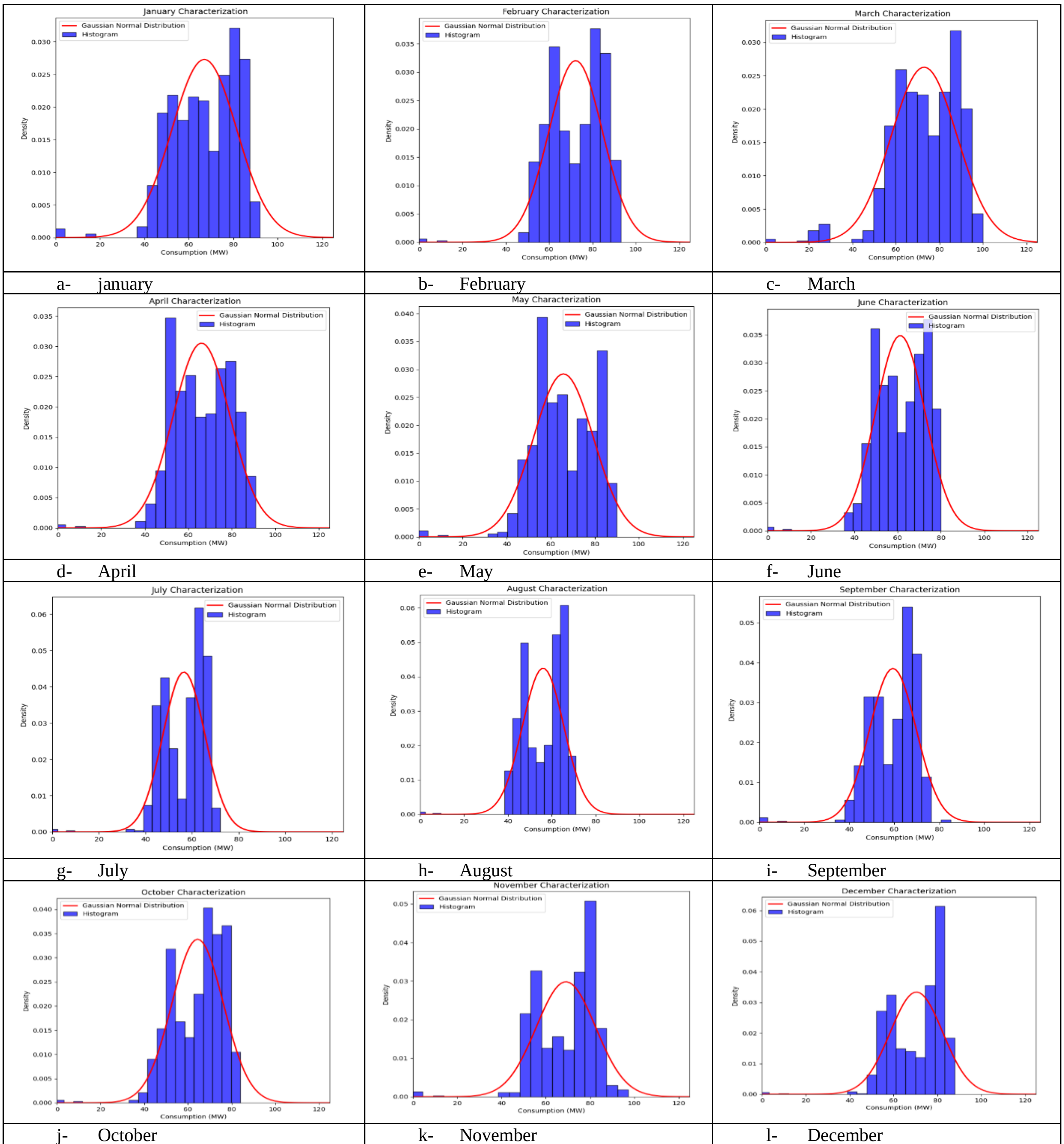
## RESULTS & DISCUSSIONS

The results of the monthly characterization are gathered as follows: Table 1 presents the values obtained, Figure 3 gives a graphical view of the distribution of monthly data and

Figure 4, the distribution of energy consumption for the year 2020.

**Table 1: Statistical status of Lomé A consumption data in 2020**

| Months | mean | mode | Std | min | max | skewness | kurtosis |
|---|---|---|---|---|---|---|---|
| January | 67.23 | 82.00 | 13.91 | 0.00 | 92.00 | -0.48 | 0.13 |
| February | 72.52 | 81.00 | 11.63 | 48.00 | 93.00 | -0.15 | -1.29 |
| March | 73.23 | 87.00 | 14.50 | 23.00 | 100.00 | -0.71 | 0.77 |
| April | 66.37 | 52.00 | 12.43 | 37.00 | 91.00 | 0.01 | -1.15 |
| May | 66.06 | 55.00 | 12.93 | 0.00 | 90.00 | -0.14 | -0.35 |
| June | 61.45 | 75.00 | 10.82 | 36.00 | 80.00 | -0.11 | -1.20 |
| July | 56.75 | 63.00 | 8.37 | 33.00 | 72.00 | -0.34 | -1.32 |
| August | 56.25 | 64.00 | 8.78 | 39.00 | 71.00 | -0.25 | -1.45 |
| September | 59.68 | 66 .000 | 9.47 | 0.00 | 85.00 | -0.62 | 0.91 |
| October | 64.68 | 74.00 | 11.15 | 37.00 | 84.00 | -0.38 | -1.07 |
| November | 69.39 | 79.00 | 12.51 | 0.00 | 97.20 | -0.64 | 1.05 |
| Décember | 70.75 | 55.78 | 11.17 | 39.87 | 87.83 | -0.39 | -1.33 |




a- january
b- February
c- March
d- April
e- May
f- June
g- July
h- August
i- September
j- October
k- November
l- December

**Figure 3: Graphical views of the distribution of monthly consumption**

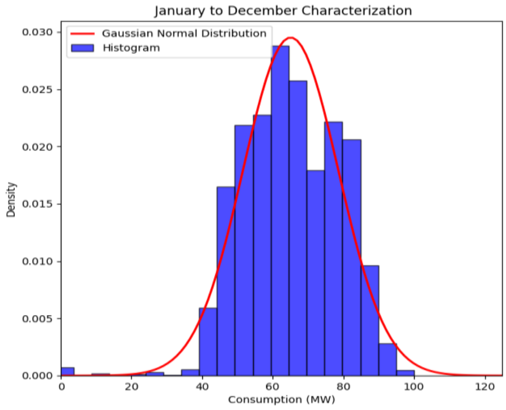
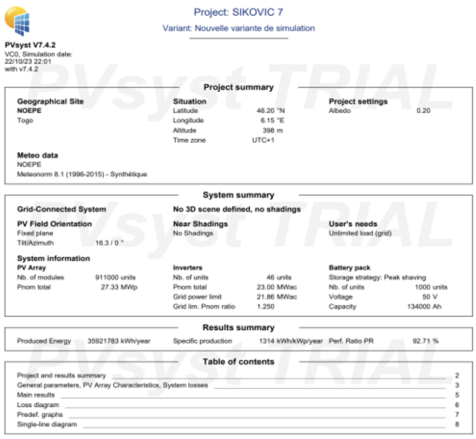



**Figure 4: Distribution of consumption in 2020**

The highest average power of the year is 73.23 MW. It is obtained in March and is used for the calculations. It gives 81.367 MW with $cos\rho_1 = 0{,}9$ and for $cos\rho_2 = 0{,}81$ we obtain 90.408 MW. The characteristics of the curves show that the values in this database are centered around the mean and conform to Gauss's law. The distribution of electrical energy consumption during the year 2020 is generally normal because the values are concentrated in this curve. Figure 5 shows the state of the simulation by PVsyst; Figure 6, the general parameters of the simulation by PVsyst, Figure 7, the normalized production and the histogram of the performance index, Figure 8 Summarizes the results of the simulation by month then Table 2 Summarizes the results obtained by PVsyst.



Project: SIKOVIC 7
Variant: Nouvelle variante de simulation

PVsyst V7.4.2
VC0, Simulation date:
22/10/23 22:01
with v7.4.2

**Project summary**

Geographical Site
NOEPE
Togo

Situation
Latitude 46.20 °N
Longitude 6.15 °E
Altitude 398 m
Time zone UTC+1

Project settings
Albedo 0.20

Meteo data
NOEPE
Meteonorm 8.1 (1996-2015) - Synthétique

**System summary**

Grid-Connected System
No 3D scene defined, no shadings

PV Field Orientation
Fixed plane
Tilt/Azimuth 16.3 / 0 °

Near Shadings
No Shadings

User's needs
Unlimited load (grid)

System information
PV Array
Nb. of modules 911000 units
Pnom total 27.33 MWp

Inverters
Nb. of units 46 units
Pnom total 23.00 MWac
Grid power limit 21.86 MWac
Grid lim. Pnom ratio 1.250

Battery pack
Storage strategy: Peak shaving
Nb. of units 1000 units
Voltage 50 V
Capacity 134000 Ah

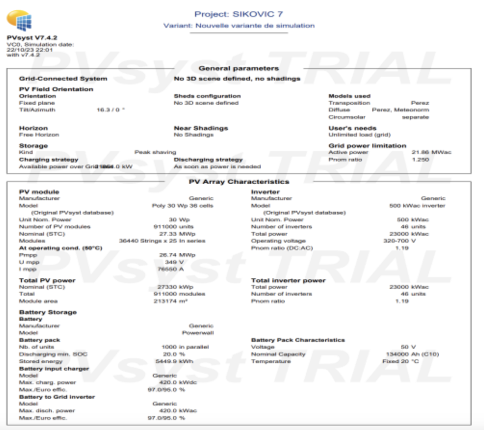
**Results summary**

Produced Energy 35921783 kWh/year
Specific production 1314 kWh/kWp/year
Perf. Ratio PR 92.71 %

**Table of contents**



**Figure 5: Status of simulation by PVsyst**



Project: SIKOVIC 7
Variant: Nouvelle variante de simulation

PVsyst V7.4.2
VC0, Simulation date:
22/10/23 22:01
with v7.4.2

**General parameters**

Grid-Connected System
No 3D scene defined, no shadings

PV Field Orientation
Orientation
Fixed plane
Tilt/Azimuth 16.3 / 0 °

Sheds configuration
No 3D scene defined

Models used
Transposition Perez
Diffuse Perez, Meteonorm
Circumsolar separate

Horizon
Free Horizon

Near Shadings
No Shadings

User's needs
Unlimited load (grid)

Storage
Kind Peak shaving
Charging strategy
Available power over Grid [illegible] kW

Discharging strategy
As soon as power is needed

Grid power limitation
Active power 21.86 MWac
Pnom ratio 1.250

**PV Array Characteristics**

PV module
Manufacturer Generic
Model Poly 30 Wp 36 cells
(Original PVsyst database)
Unit Nom. Power 30 Wp
Number of PV modules 911000 units
Nominal (STC) 27.33 MWp
Modules 36440 Strings x 25 In series
At operating cond. (50°C)
Pmpp 26.74 MWp
U mpp 349 V
I mpp 76550 A

Inverter
Manufacturer Generic
Model 500 kWac inverter
(Original PVsyst database)
Unit Nom. Power 500 kWac
Number of inverters 46 units
Total power 23000 kWac
Operating voltage 320-700 V
Pnom ratio (DC:AC) 1.19

Total PV power
Nominal (STC) 27330 kWp
Total 911000 modules
Module area 213174 m²

Total inverter power
Total power 23000 kWac
Number of inverters 46 units
Pnom ratio 1.19

Battery Storage
Battery
Manufacturer Generic
Model Powerwall
Battery pack
Nb. of units 1000 in parallel
Discharging min. SOC 20.0 %
Stored energy 5449.9 kWh
Battery input charger
Model Generic
Max. charg. power 420.0 kWdc
Max./Euro effic. 97.0/95.0 %
Battery to Grid inverter
Model Generic
Max. disch. power 420.0 kWac
Max./Euro effic. 97.0/95.0 %

Battery Pack Characteristics
Voltage 50 V
Nominal Capacity 134000 Ah (C10)
Temperature Fixed 20 °C

**Figure 6: General parameters of the simulation by PVsyst**

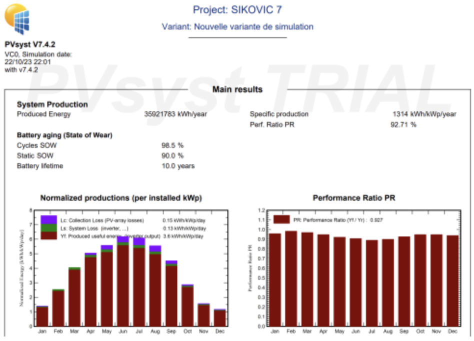
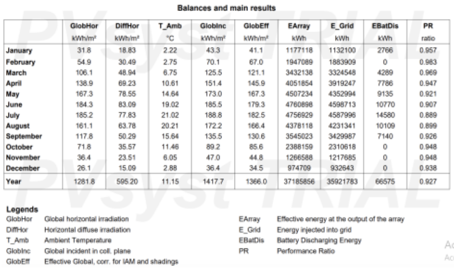


**Figure 7: Normalized production and histogram of the performance index**


Balances and main results

| | GlobHor | DiffHor | T_Amb | GlobInc | GlobEff | EArray | E_Grid | EBatDis | PR |
|---|---|---|---|---|---|---|---|---|---|
| | kWh/m² | kWh/m² | °C | kWh/m² | kWh/m² | kWh | kWh | kWh | ratio |
| January | 31.8 | 18.83 | 2.22 | 43.3 | 41.1 | 1177118 | 1132100 | 2766 | 0.957 |
| February | 54.9 | 30.49 | 2.75 | 70.1 | 67.0 | 1947089 | 1883909 | 0 | 0.983 |
| March | 106.1 | 48.94 | 6.75 | 125.5 | 121.1 | 3432138 | 3324548 | 4289 | 0.969 |
| April | 138.9 | 69.23 | 10.61 | 151.4 | 145.9 | 4051854 | 3919247 | 7786 | 0.947 |
| May | 167.3 | 78.55 | 14.64 | 173.0 | 167.3 | 4507234 | 4352994 | 9135 | 0.921 |
| June | 184.3 | 83.09 | 19.02 | 185.5 | 179.3 | 4760898 | 4598713 | 10770 | 0.907 |
| July | 185.2 | 77.83 | 21.02 | 188.8 | 182.5 | 4756929 | 4587996 | 14580 | 0.889 |
| August | 161.1 | 63.78 | 20.21 | 172.2 | 166.4 | 4378118 | 4231341 | 10109 | 0.899 |
| September | 117.8 | 50.29 | 15.64 | 135.5 | 130.6 | 3545023 | 3429987 | 7140 | 0.926 |
| October | 71.8 | 35.57 | 11.46 | 89.2 | 85.6 | 2388159 | 2310618 | 0 | 0.948 |
| November | 36.4 | 23.51 | 6.05 | 47.0 | 44.8 | 1266588 | 1217685 | 0 | 0.948 |
| December | 26.1 | 15.09 | 2.88 | 36.4 | 34.5 | 974709 | 932643 | 0 | 0.938 |
| Year | 1281.8 | 595.20 | 11.15 | 1417.7 | 1366.0 | 37185856 | 35921783 | 66575 | 0.927 |

Legends
GlobHor Global horizontal irradiation
DiffHor Horizontal diffuse irradiation
T_Amb Ambient Temperature
GlobInc Global incident in coll. plane
GlobEff Effective Global, corr. for IAM and shadings
EArray Effective energy at the output of the array
E_Grid Energy injected into grid
EBatDis Battery Discharging Energy
PR Performance Ratio

**Figure 8: Results and results of the simulation per month**

**Table 2: Summary of results obtained by PVsyst**

| | PV SYST | |
|---|---|---|
| | $\cos\varphi_1$ = 0,9 | $\cos\varphi_2$ = 0,81 |
| Number of modules (in units) | 82 000 | 91 100 |
| Total peak power (in MWp) | 24,60 | 27,33 |
| Number of channels (in units) | 3280 | 3644 |
| Number of PV in series (in units) | 25 | 25 |
| Number of batteries (in units) | 250 | 250 |
| Annual energy produced KWh / year | 32 340 089 | 35 921 783 |
| Performance | 92,73% | 92 ,71% |
| Number of inverters (units) | 41 | 46 |

The $\cos\varphi_1$ gives us a better coefficient of performance compared to the $\cos\varphi_1$. Which gives 92.73% and 92.71% respectively, with a loss difference of 0.01% kW_h/kW_c/day. For a small residential system, such a percentage loss may not have a significant impact. PVSYST does not offer a price per kilowatt hour, this gives the advantage of this subject which lies in the production of energy from renewable sources as requested by the President of Kenya William Ruto at the first African climate summit opening on September 4 2023 adopted by African heads of state and government in the presence of world leaders and high-level representatives on September 6, 2023 in Nairobi, Kenya and it is quoted: "Africa must become an emerging power in terms of growth green”. Furthermore, HOMER simplifies the task of designing distributed generation systems, both on-grid and off-grid. HOMER's optimization and sensitivity analysis algorithms make it possible to evaluate the economic and technical feasibility of a large number of technological options. They also take into account variations in technological costs and the availability of energy resources. Modeling by Homer involves inserting the place or location of the installation site. Here we have chosen theoretically a no man’s land in Noepe of Togo, near the border of Ghana. This is an area unoccupied by border countries. This is particularly due to the fact that Togo and Ghana already have agreements regarding the supply of electrical energy. It is located at an altitude of 72 meters. The geographic coordinates are 6°15'41" N and 1°2'34" E in DMS (degrees, minutes, seconds). The UTM position is BG89 and the Joint Operation Graphics reference is NB31-05. The theoretical installation area of the photovoltaic power plant (Noepé) is shown in Figure 9 by Homer and Figure 10 presents the results of the simulation at cosphi = 0.9 by HOMER.

**Figure 9: Location of the NOEPE locality**

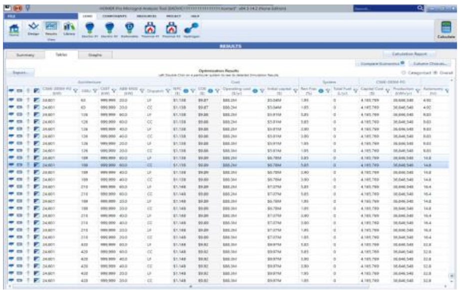


**Figure 10: Simulation results at cosphi = 0.9 by HOMER**

This configuration has an operating cost of $88.2 million, which corresponds to 54,896,482,620.00 CFA francs. The initial cost (initial capital) which represents the basic investment which is 6.78M (4,219,933,698.00 F CFA) with a battery life of 14.8 hours which is more than sufficient for our system. This configuration has an operating cost of $88.2 million, which corresponds to 54,896,482,620.00 CFA francs. The initial cost (initial capital) which represents the basic investment which is 6.78M (4,219,933,698.00 F CFA) with a battery life of 14.8 hours which is more than sufficient for our system. Figure 11 shows the results of the simulation at cosphi = 0.81 by HOMER.

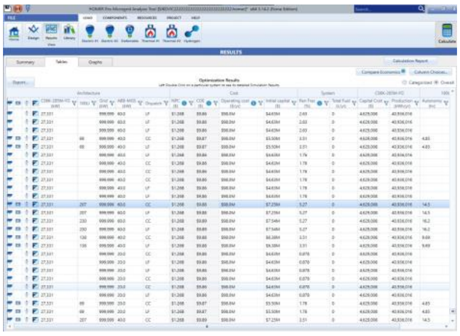


**Figure 11: Simulation results at cosphi = 0.81 by HOMER**

Cette configuration présente un coût d'exploitation (operating cost) de $ 98,0 M ce qui vaut 61 054 000 000,00 F CFA. Le coût initial (initial capital) qui représente l'investissement de base qui est de $ 7,25M (4 516 750 000,0000 F CFA) avec une autonomie de batterie de 14,5 heures ce qui est largement suffisant pour notre système. La modélisation du système énergétique par Homer est schématisée par la figure 12

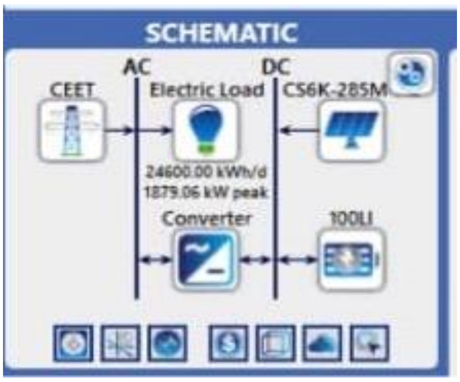



**Figure 12: System diagram**

**Table 3: Summary of results obtained by Homer**

| | HOMER | |
|---|---|---|
| | $\cos\varphi_1 = 0{,}9$ | $\cos\varphi_2 = 0{,}81$ |
| Number of modules (in units) | 86 316 | 95 894 |
| Total peak power (MWp) | 24.60 | 27.33 |
| Operating cost (in FCFA) | 2 195 859 305 | 2 442 160 000 |
| Battery life (in hours) | 14.8 | 14.5 |
| Number of batteries (in units) | 189 | 207 |
| Annual energy produced KWh / year | 36 846 548 | 40 936 016 |
| Yield (%) | 94.15 | 94.73 |
| Battery power (Kilowatt) | 100 | 100 |
| Price of kWh (in FCFA) | 143.91 | 154.2 |
| Inverter Power (Kilowatt) | 60 | 60 |

In fact, the correction factors applied are inspired by the normalized values applied to the stability of the CEET network. For industrials, the tolerated power factor is 0.81 but rises to 0.9 for domestic use. If this is not respected, the CEET charges the penalties to subscribers. As the installation is planned to be operated by CEET, we are inspired to improve the quantity and quality of power to be produced in the plant. Furthermore, the two applications do not present exactly the same parameters as results by way of comparison but, in a complementary way, help to clearly clarify the need and the estimate of the project. In common parameters, we find the number of modules (91100 units for cosphi = 0.81 and for cosphi = 0.9 we have 82000 units) for PVsyst. With Homer and for cosphi = 0.81 we have 95894 modules and 86316 for cosphi = 0.81. The power of the module considered is 550Wp. Thus, the highest annual energy to be produced is given by Homer with cosphi = 0.81 and amounts to 40.936 GWh per year compared to the lowest (32.34 GWh/year) given by PVsyst for cosphi = 0.9. Apart from the performances, the information on the inverter and the autonomy improvement which is given by the two software (PVsyst and Homer), the price of the KWh is given by Homer and amounts to 154.2 FCFA for the industrial power factor and 143.91 FCFA for the domestic one. If we refer to the current price of KWh in force in the country (around 120 FCFA), we can initially observe that the project is promising. The small difference in cost (34.2 FCFA) will not affect the populations in any way if we take into account the damage, they could experience by looking at climate disruption caused by electricity production based on polluting sources. However, the site chosen arbitrarily for this project can be reviewed for better performance because going further towards the north of the country, the solar radiation and the temperature are more interesting for the installation of a photovoltaic solar power plant. If we see the cost of the installation, we find that it is nothing compared to the expenses generated by bush fires, floods, in short climate disruption across the country and in the world today.

## CONCLUSION

The work accumulated in this document concerns the use of software such as Homer and PVsyst to size a photovoltaic solar field, capable of supplying the electrical energy needs of the LOMÉ A substation of the CEET in TOGO. To succeed, we carried out the characterization of the electrical power needs at this station during the year 2020. The period of the day used to estimate the consumption needs goes from 6 a.m. to 6 p.m. (Period during which we the presence of the sun in the area considered). The objective of the work is to find an alternative to the autonomy of electrical energy production. The goal is to focus on clean and renewable energies in order to contribute to reducing the destruction of nature through the production of greenhouse gases.

The results of the characterization show that the maximum power consumed during the year 2020 is 100 MW, observed in the month of March. Always in the same month, we find the highest average value of the power of the year. It amounts to 73.23 MW. The latter was retained for the dimensioning of the photovoltaic field. Two power factor factors (cosφ= 0.9 and cosφ= 0.81) were applied as correction factor. Furthermore, the sizing results are as follows: For cosφ= 0.9 based on the PVsyst software, 82,000 modules, 250 50V batteries and 41 320-700 V converters are required. This field will produce energy equivalent to 32 340,089 kWh/year. On the other hand, if we take cosφ= 0.81 in the same software (PVsyst), we find 91,100 modules, 250 50V batteries and 46 320-700 V converters. This field will produce 35,921,783 kWh/year of electrical energy.

As far as Homer is concerned, the results give: For cosφ= 0.9, we need 86,316 modules, 189 batteries with an autonomy of 14.8 hours and a 60 kW converter. This field will produce 36,846,548 kWh/year. On the other hand, if we take cosφ=0.81, we need 95,894 modules, 207 100 kW batteries with an autonomy of 14.5 hours and a 60 kW converter. This plant will produce an annual energy of 40,936,016 kWh with an operating cost of 2442160000 FCFA and the price per KWh which will amount to 154.2 FCFA. To carry out this work we tried to explore unexploited areas of the territory. Google Earth software is used. We retain 75 Hectares NOEPE because of its characteristic. This is a "no man's land" (zone unoccupied by a country). It would be very well suited because TOGO and GHANA already have agreements related to the production and exploitation of electrical energy.

To complete this work it would be wise to integrate almost all the interconnection stations as a good one. This will lead to the production of renewable-based electrical energy in TOGO, thereby contributing to the protection of nature. However, it is necessary for the proposed installation site to be validated by the state, knowing that moving towards the north of the country, solar irradiation is increasingly important.

***Declaration by Authors***

**Acknowledgement:** None
**Source of Funding:** None
**Conflict of Interest:** The authors declare no conflict of interest.

## REFERENCES

1. MOKHBI Yasmina, DOUADI Mohammed, MEDAKENE Abderrahmane: Etude de l'adsorption d'une eau polluée par des hydrocarbures sur charbon actif, UNIVERSITE KASDI MERBAH OUARGLA MASTER ACADEMIQUE, Spécialité : Génie des procédés Option : Ingénierie du Gaz Naturel, 06/06/2017 http://dspace.univ-ouargla.dz/jspui/handle/123456789/15255/
2. Amélie Viard and al. : Le protoxyde d'azote ($N_2O$), puissant gaz à effet de serre émis par les sols agricoles : méthodes d'inventaire et leviers de réduction, *OCL* 2013 ; 20(2) : 108–118, Agronomie – Environnement Volume 20, Numéro **2**, March-April 2013, 15 mars 2013 https://doi.org/10.1051/ocl.2013.0501
3. ABUDU Muhammed, OLOTU Yahaya: Modeling Climate Change Effects on Sweet potato and Okra Yield in Edo State, South Southern Nigeria, Journal of Scientific and Engineering Research, 9(3):9-16, ISSN: 2394-2630, 2022.
4. Amélie Viard and al. : Le protoxyde d'azote (N2O), puissant gaz à effet de serre émis par les sols agricoles : méthodes d'inventaire et leviers de réduction, OCL 2013 ; 20(2) : 108–118, Agronomie – Environnement Volume 20, Numéro 2, March-April 2013, 15 mars 2013 https://doi.org/10.1051/ocl.2013.0501,
5. Sommet africain pour le climat ouvert le 4 septembre 2023 adopté par les chefs d'État et de gouvernement africains en présence de dirigeants mondiaux et de représentants de haut niveau le 6 septembre 2023 à Nairobi, Kenya
6. La COP 27, Conférence des Nations unies sur les changements climatiques 2022, 6 nov - 20 nov 2022, Sharm el-Sheikh Climate Change Conference - November 2022
7. COP28 refers to the 28th session of the Conference of the Parties to the United Nations Framework Convention on Climate Change (UNFCCC), which convenes from 30 November to 12 December, 2023 in the United Arab Emirates
8. Nagasree Garapati and al. A Hybrid Geothermal Energy Conversion Technology - A Potential Solution for Production of Electricity from Shallow Geothermal Resources, Energy Procedia, Volume 114, Pages 7107-7117, ISSN 1876-6102, 2017, https://doi.org/10.1016/j.egypro.2017.03.1852
9. Olasupo John Ilori : Potential use of Plant Extract for Water Purification: A Review International Journal of Research and Review Vol. 10; Issue: 4; April 2023 : Review Paper E-ISSN: 2349-9788; P-ISSN: 2454-2237, International Journal of Research and Review (ijrrjournal.com) 74 Volume 10; Issue: 4; April 2023 www.ijrrjournal.com

10. Nagasree Garapati and al. A Hybrid Geothermal Energy Conversion Technology - A Potential Solution for Production of Electricity from Shallow Geothermal Resources, Energy Procedia, Volume 114, Pages 7107-7117, ISSN 1876-6102, 2017, https://doi.org/10.1016/j.egypro.2017.03.1852
11. Farhan Lafta Rashid, Ahmed Abdullettif, Ahmed Hashim: Geothermal Energy for Electricity Generation, British Journal of Science, Vol. 3 (2), February 2012,
12. Saïd Diaf : Revue des Energies Renouvelables SMEE'10 Bou Ismail Tipaza, 161–172 161, Estimation de la production éolienne d'électricité dans la région d'Adrar, 2010
13. Liam McHugh : World Energy Needs: A Role for Coal in the Energy Mix, ECCC Environmental eBooks 1968-2022, Series: Issues in Environmental Science and Technology, 02 Oct 2017, https://doi.org/10.1039/9781788010115-00001
14. B. PITON: Caractéristiques hydroclimatiques des eaux côtières du Togo, golfe de guinée, Institut française de recherche scientifique pour le développement en coopération, centre de Brest, Document scientifique 0RST0M Brest N° 42, 1987
15. Apaloo Bara Komla Kpomonè and al.: Multiplayer Perceptron and simple regression linear approaches to predict photovoltaic active power plant: case study, International Journal or Research and Review, Vol 10Issue 12, Website: www.ijrrjournal.com E-ISSN: 2349-9788; P-ISSN: 2454-2237, December 2023, https://doi.org/10.52403/ijrr.20231207
16. Carpophore NTAGUNGIRA : Problématique de l'accès à l'électricité au Togo, Groupe de la banque Africaine de développement, Afrique de l'Ouest policy note, note 03, septembre 2015
17. André Mermoud and Bruno Wittmer, PVsyst USER'S MANUAL, PVSYST SA - Route du Bois-de-Bay 107 - 1242 Satigny–Switzerland, www.pvsyst.com, January 2014
18. HOMER Pro Version 3.7 User Manual © All rights reserved. HOMER® Energy 1790 30th St Suite 100 Boulder CO 80301 USA, +1-720-565-4046, www.homerenergy.com, August 2016
19. Dr. Valentin, Energie Software GmbH Stralauer Platz 34 10243 Berlin Allemagne Version 6.0 Conception et simulation pour les installations photovoltaïques Manuel de l'utilisateur
20. Clean Energy Decision Support Centre, RETScreen Software Online User Manual, Ground-Source Heat Pump, Project Model,
21. AT2ER : « Plan quinquennal d'installation des ouvrages de production d'électricité a base des sources d'énergies renouvelables », journal, 2019.

How to cite this article: APALOO BARA Komla Kpomonè, KOMBATE Damipi. PVsyst and homer for the evaluation of a project to size a photovoltaic solar power plant in reinforcement of the CEET network in Lomé in Togo by characterization of the electrical energy consumed. *International Journal of Research and Review*. 2024; 11(4): 318-327. DOI: *https://doi.org/10.52403/ijrr.20240435*

******