# PERFORMANCE EVALUATION OF A500 kWp SOLAR PHOTOVOLTAIC POWER PLANT CONNECTED TO GRID USING PVSYST SOFTWARE, IN LAMBAYE AREA, SENEGAL

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*Manuscript Info*

*Manuscript History*
Received: xxxxxxxxxxxxxxxx
Final Accepted: xxxxxxxxxxxx
Published: xxxxxxxxxxxxxxxx

*Key words:*
Connected to grid, Performance Ratio, PVsyst software, Arrow loss diagram



*Abstract*

This article presents a simulated evaluation of the performance of a500 kWp grid-connected solar photovoltaic system. The study aimed to assess the feasibility of installing such a system to supply power to several villages in the municipality of Lambaye in Senegal. The municipality faces electricity load shedding due to high population growth and women's participation in income-generating activities. The system under study comprises 1,350 panels of 370 Wp each. It is configured with 45 strings connected in parallel, each of them consists of 30 panels connected in series.

The results revealed that six Generic solar inverters of 60 kW power each, ensuring DC-AC conversion and interconnection to the grid by a public meter are needed. This study used PVsyst 7.2 simulation software, which incorporates the Meteonorm 8.1 database. The meteorological and geographical data used for the simulation were imported from Meteonorm 8.1. The parameters evaluated in this study were the effective energy production of the photovoltaic generator, the energy fed into the grid, the performance ratio and the normalized energy production per kWp installed. We simulated a 500 kWp solar photovoltaic system for grid injection using PVsyst software. This system produced 835.09 MWh/year of energy at the output of the photovoltaic generator, and 820.07 MWh/year of energy was injected into the grid. The performance ratio of this solar PV system for grid injection in the municipality of Lambaye is approximately 82.24%, with lower losses.






**Introduction:**Today, the world's population is growing due to high energy demand, which is largelydominated by fossil fuels. However, fossil fuel reserves are declining over time and their use has negative environmental problems, such as greenhouse gas emissions, high temperatures and acid rain [1].As the rest of the world, developing African countries are heavily dependent on fossil fuels to meet their energy needs. Despite the intensive use of fossil fuels, many African countries are trying to solve the problem of electricity shortages to meet the needs of their populations, particularly in rural areas [2]. Therefore, to address environmental and energy issues, we use renewable energy sources that produce little or no carbon dioxide or other chemical pollutants [3]. In Africa, these sources include solar photovoltaic energy, geothermal energy, hydroelectric energy, biomass, concentrated solar power (CSP) and wind energy. These countries benefit high levels of sunshine and are gradually adopting renewable energy sources in their policies, which have a very low environmental impact. The Maghreb countries have significant solar resources, with Algeria enjoying more than 3,000 hours of sunshine per year. The average annual daily solar radiation in Adrar is between 5 and 7 kWh/m²/day [4]. Alhamdia et *al*. analyzed experimental data from Al-Baha over a twelve-month period in 2014 to determine the average monthly daily solar radiation on a horizontal surface [5]. They demonstrated the city's enormous solar potential. It receives maximum and minimum solar radiation values in May and January, estimated at approximately 6.5 and 3 kWh/m²/day respectively. A. Sadio et al.'s work in Ngoundiane, Senegal showed an average daily radiation of 5.85 kWh/m²/day [6]. Meanwhile, B. Mbow et *al*.'s study in Koyli Apha in Ferlo worked with the deterministic approach and used the month of December as the one with the least irradiation where a radiation of 3,877 Wh/m²/day isrecorded [7].

Numerical sizing methods are often used to optimize solar PV systems. In this vein, Bouzidi and Diaf [8] sought to optimize solar PV systems with the aim of reducing costs and improving reliability. The Senegalese government has recognized this potential and is building solar power plants in Bokhol, Malicounda, Mekhe and Merina, as well as promoting the use of solar energy in remote areas [9]. The Senegalese government has always placed great importance on the energy sector, with each administration putting forward projects to support energy security. In 2014, the Emerging Senegal Plan (ESP) project is launched, setting out clear objectives such as achieving universal access to electricity, increasing the share of renewable energy in the energy mix, and reducing the price of the kilowattperhour (kWh) of the energy. In March 2024, following the change in government, the Senegalese's governementreplaced the ESP by the Senegal Horizon 2050 program, which is based on guidelines for a sovereign nation. This program is organized around a five-year plan for 2025–2029, a strategic master plan for 2025–2035, and a vision for the energy sector in 2050.

The strategic energy master plan aims to: increase electricity production capacity from 1,789 MW to 2,200 MW; set the average electricity price at 80 CFA francs per kWh (down from 110 CFA francs); and increase universal electricity access from 84.3% to 100% by 2034. The goal is to demonstrate that 32% of Senegal's energy comes from renewable sources,The goal of the senegalese government is to increase until 32% energy renewable on the production capacity whereas Morocco's one ist to produce 52% of its electricity from renewable sources by 2030 whereas Morocco's one isto produce 52% of its electricity from renewable sources by 2030 [10]. S. Yilmak et *al*. show in their article that Thailand is ambitious to ensure its energy security by developing policies to reduce its dependence on fossil fuels and increase its use of renewable energy sources [11]. Through the Alternative Energy Development Plan (AEDP) and the Energy Development Plan (PDP), Thailand plans to increase its renewable energy capacity to 19,635 MW by 2036, with the aim of installing 6,000 MW of solar capacity.

The performance's results of the solar photovoltaic systems was the subject of several studies in the bibliography. These studies have focused on the performance parameters of grid-connected photovoltaic power plants in different geographical regions. One can cite the examples of :

R. Sharma et *al*. who simulated and analyzed an 11.2 kWp solar photovoltaic system connected to the grid and installed on a roof [12]. In February 2014, they installed a grid-connected solar energy system with a capacity of 11.2 kWp. The solar panels are on the roof of a 25-metre-high building and are tilted at an angle of 21°. The parameters studied in this system were the efficiency of the photovoltaic modules, the generator efficiency, the final efficiency, the inverter efficiency and the system coefficient of performance. Simulation results recorded between September 2014 and August 2015 for injection into the national grid show a total energy output of 14.960 MWh, with respective efficiencies of the photovoltaic modules, inverter and coefficient of performance of 13.42%, 89.83% and 0.78%.

V. P. Singha et *al*.[13]. analyze the performance of 101 kW photovoltaic systems installed on the roof of IIT Jodhpur during 2011. The load is divided into blocks equipped with 43.30 kW photovoltaic solar systems in the block n°1 and 58.08 kW in the block n°2. The performance metrics analyzed are the amount of energy produced, the performance ratio and system losses. The results of these photovoltaic systems installed in Jodhpur, India, produced an average annual energy output of 1,290.64 kWh/kWp and 1,290.64 kWh/kWp in block n°1 and block n°2, respectively. They conclude that, the key factor behind the variability in energy and the system efficiency is the location of the solar photovoltaic system,They revealed in their work that the variability of the system's energy and efficiency is the location of the solar photovoltaic system and despite the difference in power between the two blocks, the system generated the same overall average yield of 75%.

This study done by D. Kumaret *al*. [14]focuses on evaluating of the performance of a ground-mounted photovoltaic power plant and its components. Data was generated, from 1 March to 31 August 2014, by the 5 MW solar power plant of Gujarat Power Corporation Limited (GPCL), located in the Charanka solar park in the state of Gujarat. The authors studied the quality of the data ofthe global horizontal irradiance and the global tilted irradiance in order to obtain the estimated performance ratio of the photovoltaic power plant in question. The performance analysis revealed that the performance ratios is based on GHI and GTI for the months of March and April. The results generated average monthly performance ratios of 89.15% (PR-GHI) and 77.37% (PR-GTI) for March, and 73.41% (PR-GTI) and 77.37% (PR-GHI) for April.

In our case study, we analyzed the performance of a 500 kWp grid-connected solar photovoltaic system designed to supply power to several villages in the municipality of Lambaye, Senegal, using the widely adopted PVsyst simulation software.

**Presentation of Lambaye area**

Lambaye is located, approximately,at 14.80° north latitude and 16.53° west longitude. According to the 2023 general population and housing census (RGPH-5) published by the ANSD, the population of Lambaye is estimated at30,486 inhabitants.Agriculture is the dominant economic activity, particularly peanut cultivation, while livestock farming is mainly practiced by the Fulani in certain regions. Trade and livestock farming are secondary, subsistence or complementary activities. Young people are increasingly emigrating to urban centers such as Dakar, Diourbel and Touba, as well as abroad to countries such as Spain, Italy, Ivory Coast and Gambia. Meanwhile, due to the presence of a phosphate mine, Lambaye is attracting regional migrants from countries such as Mali, Guinea and Gambia. The municipality is now responsible for health, education, urban planning and social action infrastructure (among the nine sectors transferred).Health, education, urban planning and social services are among the responsibilities now delegated to the municipality.In May 2023, the town hall launched a municipal development plan to support the municipality until 2027. Itsgoal is to establish Lambaye as a hub of socioeconomic development centered on a modernized, attractive and equitably governed city. The figure 1 showsthe location of Lambaye area.

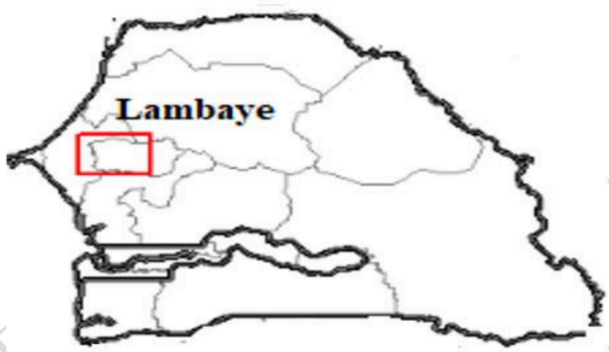


**Figure 1**. The localization of Lambaye, area

## Description of the grid-connected solar photovoltaic power plant under study

The solar plant consists of 1,350 monocrystalline solar panels, with a capacity of 370 Wp each. Itis arranged in 45 strings of 30 panels in series. The plant also includes six inverters and grid connection components. The plant is to be installed on a 2,522 m² site in Lambaye for the productionof energy. This configuration results in a nominal power ratio of 1.39. Figure 2 shows an example of a grid-connected photovoltaic plant.

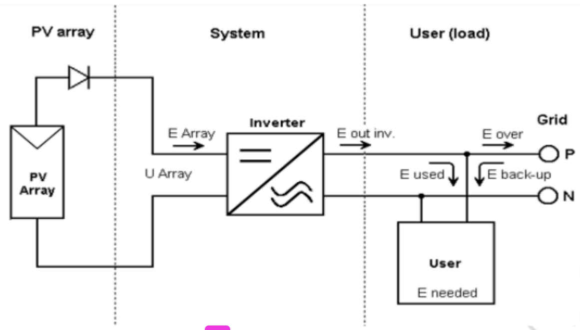


**Figure 2.**Simulated grid-connected photovoltaic plant in PVsyst

In this section, we present a grid-connected photovoltaic solar system located in the municipality of Lambaye. The system is composedof photovoltaic modules, inverters, protective devices, user meters and grid outputs. The panels produce direct current (DC), which is obtained by converting sunlight into electricity. The inverterreceives DC energy DC at enter, which is then converted into AC via DC/AC converters. The energy out inverter is then fed into the grid via an energy meter, having first been protected by a circuit breaker. The remaining current is used for self-consumption by users.

Table 1 gives the specifications of solar module and inverter generated using PVsyst software.

**Table 1**: Characteristics of PV Array

| PV Array Characteristics | | | |
|---|---|---|---|
| **PV module** | | **Inverter** | |
| Manufacturer | Generic | Manufacturer | Generic |
| Model | Mono 370 Wp Twin 120 half-cells | Model | 60 kWac string inverter |
| (Original PVsyst database) | | (Original PVsyst database) | |
| Unit Nom. Power | 370 Wp | Unit Nom. Power | 60.0 kWac |
| Number of PV modules | 1350 units | Number of inverters | 6 units |
| Nominal (STC) | 500 kWp | Total power | 360 kWac |
| Modules | 45 Strings x 30 In series | Operating voltage | 500-1450 V |
| **At operating cond. (50°C)** | | Pnom ratio (DC:AC) | 1.39 |
| Pmpp | 454 kWp | | |
| U mpp | 928 V | | |
| I mpp | 489 A | | |
| **Total PV power** | | **Total inverter power** | |
| Nominal (STC) | 500 kWp | Total power | 360 kWac |
| Total | 1350 modules | Number of inverters | 6 units |
| Module area | 2522 m² | Pnom ratio | 1.39 |
| Cell area | 2236 m² | | |

Here, we present the main components of the grid-connected solar photovoltaic system in Lambaye. Of these 500 kWp, the maximum power, maximum voltage and maximum operating current are 454 kWp, 928 V and 489 A, respectively, at operating ambiant temperature 50°C. The PV array area is 2,522 m² and the solar cell one is 2,236 m². To size the inverters, we carried out a simulation on the PVsyst interface. The results revealed the need for six inverters with a 60 kVac rating, resulting in a total power of 360 kVac. The inverters are Generic brand and have an operating voltage ranging from 500 to 1,450 V, with a nominal DC-AC transformation ratio of around 1.39.

**Optimal combination oftilt angle and the azimuth for analysis of the performance**

To find the maximum amount of energy injected into the network, we will first vary the inclination angle while setting the azimuth to zero. Then, we will fix the inclination angle and vary the azimuth.

**Tableau 2**: Azimuth fixed at 0° and variable tilt angles

| tilt angle | Produced Energy (MWh/year) | Specific Production (kWh/kWp/year) | PR (%) |
|---|---|---|---|
| 0° | 802.8 | 1,607 | 82.32 |
| 5° | 813.0 | 1,628 | 82.27 |
| 10° | 818.7 | 1,639 | 82.24 |
| 15° | 820.1 | 1,642 | 82.24 |
| 20° | 817.1 | 1,636 | 82.27 |
| 25° | 809.6 | 1,621 | 82.33 |
| 30° | 797.9 | 1,597 | 82.42 |
| 35° | 781.9 | 1,565 | 82.53 |
| 40° | 761.6 | 1,525 | 82.63 |
| 45° | 736.9 | 1,475 | 82.72 |
| 50° | 707.8 | 1,417 | 82.77 |

In this section, we varied the tilt angle in 5-degree increments, setting the azimuth value to 0°in each case. After simulating these changes in the PVsyst interface, we obtained the following results for the energy produced for injection into the network, the specific energy, and the performance ratio. The maximum energy productions were noted at 10° and 15°, equaling 818.7 and 820.1 MWh/year, respectively, with the same performance ratios of 82.24%. The maximum specific production observed at these angles are 1,639 kWh/kWp/year and 1,642 kWh/kWp/year, respectively.

**Tableau 3:** Tilt angle fixed at 15° withvariable azimuth

| Azimuth (degre) | Produced Energy (MWh/year) | Specific Production (kWh/kWp/year) | PR (%) |
|---|---|---|---|
| 0 | 820.1 | 1,642 | 82.24 |
| 5 | 820.0 | 1,642 | 82.23 |
| 10 | 819.7 | 1,641 | 82.23 |
| 15 | 819.2 | 1,640 | 82.23 |
| 20 | 818.4 | 1,639 | 82.23 |
| 25 | 817.5 | 1,637 | 82.23 |
| 30 | 816.4 | 1,634 | 82.22 |
| 35 | 815.0 | 1,632 | 82.22 |
| 40 | 813.4 | 1,628 | 82.21 |
| 45 | 811.7 | 1,625 | 82.20 |
| 50 | 809.7 | 1,621 | 82.20 |

Here, we seek to examine the impact of azimuth on the production of electricity injected into the grid. In this study, we varied the azimuth from 0 to 50 in steps of 5 degrees when the value of the inclination angle is fixed at 15°. After simulation with PVsyst, we found a maximum produced energy of 820.1 MWh/year fed into the grid when the azimuth is set to 0° for a titl angle of 15°. At the latter, the specific energy and the performance ratio are 1,642 kWh/kWp/year and 82.24%,respectively. The study showed that the variation of the azimuth from 0 to 50 generated a drastic increase in the energy produced from 820.1 MWh/year to 809.7 MWh/year, a loss of 10.4 MWh/year and a performance ratio of 82.24% to 82.20%.For a fixed tilt angle of 15°, both the energy injected into the grid and the specific energy are functions of azimuth variation. High energy production is observed when the azimuth is at 0°, and these energies decrease as the azimuth moves away from 0° and increases. However, Y. Kassem et *al*. [15] assessed the feasibility of installing a 10 MW grid-connected photovoltaic power plant in Libya and selected 22 regions. Following a simulation using PVsyst software, they recorded the highest electricity production of 22,067.13 MWh in the city of Al Kufrah, meaning thattheir study was based on the optimal location of photovoltaic solar power plants. In our study, in Lambaye, we investigated the impact of varying the tilt angle and azimuth. We obtained a performance ratio of around 82.24% for the optimal combination (15°, 0°), while Eltawil et *al*. [16]

studied the performance of a 500 kWp grid-connected photovoltaic system in Mae Hong Son, Thailand, similar in size to our study system installed in Lambaye. Their good efficiency rate varying between 70% and 90% confirms the feasability of our solar photovoltaic system, which generated a performance ratio of 82.24%.

**PV field layout:**

The angle of inclination and orientation of solar panels, located in the village of Lambaye in Senegal, are shown in Figure 3.

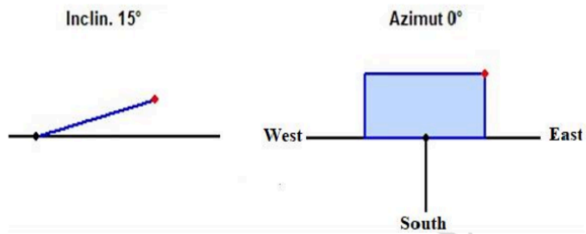


**Figure 3**: Tilt and orientation

In our study, the angle of inclination of the photovoltaic field (in relation to the horizontal) corresponds to the rounded-off latitude of Lambaye (14.8°0, rounded to 15°). As Senegal is in the northern hemisphere, the south-facing orientation is justified. We ran two scenarios in this study: one in which the angle of inclination varied in steps of 5 from 0° to 50°, with the azimuth fixed at 0°, and another in which the azimuth varied in steps of 5 from 0° to 50°, with the angle of inclination fixed at 15°. Consequently, we selected a tilt angle of 15° and an azimuth of 0° to maximize solar production. A study by B. Tashtoush et *al*. confirms our findings, showing that tilt angle affects solar system performance by maximizing energy production [17].

## Photovoltaic system parameters for performance analysis

The parameters used to analyze the performance of a photovoltaic system are: the reference yield, the field yield, the final system yield, the field capture losses, the system losses, the performance ratios and the energy injected into the grid. Together, these parameters enable a comprehensive pre-feasibility analysis of a grid-connected PV system.

**Reference yield ($Y_R$)**

This is the ratio of the horizontal irradiance Ht (kWh/m²) in a plane to the reference irradiance under standard temperature conditions $H_R$ STC(1 kW/m²). $Y_R$ is expressed in kWh/m²/day and is calculated using the following formula [18, 14];

$$Y_R = \frac{H_t\ (kWh/m^2)}{H_R\ STC\ (1\ kW/m^2)} \quad (1)$$

**Array yield ($Y_A$)**

It is represented by the $Y_A$ and is defined as the ratio of the DC energy produced by the photovoltaic generator to its rated power. This parameter indicates the continuous energy output of the photovoltaic generator. It is estimated in hours per day, month or year [18, 14,16]. It is written as:

$$Y_A = \frac{E_{DC}\ (kWh)}{P_{pv,rated}\ (kWp)} \quad (2)$$

**Final system yield:**

The final system efficiency $Y_F$ is defined as the ratio of the AC energy output of the photovoltaic system (i.e. inverter power) to the peak power installed on the STC photovoltaic field. It is expressed as follows [18, 16]:

$$Y_F = \frac{E_{AC}\ (kWh)}{P_{pv,rated}\ (kWp)} \qquad (3)$$

**Array capture losses**:

Field capture losses ($L_C$) are defined as the difference between the reference yield ($Y_R$) and the field yield ($Y_A$). This parameter mainly represents losses occurring at the photovoltaic field level due to variations in photovoltaic cell temperature, partial shading, dust accumulation on photovoltaic panels, errors in the maximum power point and grid imbalance [16]. It is defined as:

$$L_C = \quad Y_R - Y_A \qquad (4)$$

**System Losses**

The system losses ($L_S$) is the difference between the continuous PV production yield ($Y_A$) and the final system yield($Y_F$). These losses are incurred by the inverters and other electrical components of a solar PV system [18, 16].

$$L_S = \quad Y_A - Y_F \qquad (5)$$

**Performance Ratio**

The performance ratio (PR) is the ratio of the actual energy fed into the grid to the rated power of the photovoltaic array, or of the reference yield to the final yield. It is essential for analysing the performance of solar photovoltaic systems and assessing the feasibility of installing them in certain areas in different regions. It is calculated using the expression below [14, 19, 20]:

$$PR = \frac{Y_F}{Y_R} * 100(\%) \qquad (6)$$

and

$$PR = \frac{Energy_{\ Measured}}{Energy_{\ Modeled}} * 100(\%) \qquad (7)$$

## Results and Discussion

This section analyses the simulation results of the proposed photovoltaic system. As a reminder, the parameters studied are primarily the energy produced, the energy injected, the performance ratio, and the sag loss diagram. These results were analyzed to evaluate the performance of the photovoltaic system. The 500 kWp solar photovoltaic system produces 820.1 MWh of energy per year, equating to a specific annual production of 1,642 kWh/kWp/year. The solar photovoltaic system to be installed in the village of Lambaye for grid injection has a performance ratio of 82.24%, which is high. While K. Saka et *al*. [21] evaluated the efficiency of grid-connected photovoltaic power plants using production data from a power plant in the province of Bursa in north-west Turkey during the first six years of its operation. Their analysis revealed that the plant had an average efficiency of 94.5% over this six-year period, with an annual electricity production surplus observed between April and September

**Balances and main results**

The balances and main results presented in Table 3 include the following variables: global irradiance on a horizontal area, average ambient temperature, global irradiance on a collector plane without optical corrections and effective global irradiance, which takes into account losses due to soiling and shading.

At the studiedsite, the annual global and diffuse irradiances on the horizontal areawere found to be 1953.2 kWh/m² and 1,053.1 kWh/m², respectively. We also found an annual global incident energy of 1996.4 kWh/m² on the collector without optical corrections, while the effective global irradiance after optical losses equaled 1954.7 kWh/m². Given this level of effective irradiance, our 500kWp photovoltaic solar array is estimated to produce 835.09 MWh of energy per year (DC), while the annual energy produced (AC) and fed into the grid is 820.07 MWh.

Indeed, F. Cherfa et *al*. analyzed the performance of a grid-connected photovoltaic system over the course of a year, installed on the terrace of an administrative building at the Renewable Energy Development Center (REDC) in Algiers. Their system generated 10,981 kWh of energy, which was fed into the grid[22].

**Table 3:-** Balances and main results of a 500 kWp photovoltaic system.

| Months | G_Hor | G_Dif | T_amb | G_Inc | G_Eff | E_Array | E_Grid | PR |
|---|---|---|---|---|---|---|---|---|
| Jan | 134.5 | 71.9 | 24.41 | 151.6 | 148.6 | 64.80 | 63.63 | 0.840 |
| Feb | 140.1 | 80.5 | 25.65 | 151.5 | 148.4 | 63.76 | 62.63 | 0.828 |
| Mar | 182.1 | 93.4 | 28.58 | 189.2 | 185.7 | 77.92 | 76.51 | 0.810 |
| Apr | 186.9 | 94.00 | 29.21 | 184.9 | 181.3 | 76.07 | 74.70 | 0.809 |
| May | 188.7 | 102.5 | 30.39 | 179.5 | 175.5 | 74.40 | 73.07 | 0.815 |
| Jun | 178.2 | 100.9 | 30.46 | 166.9 | 163.0 | 69.66 | 68.42 | 0.821 |
| Jul | 189.3 | 97.7 | 29.97 | 178.00 | 173.90 | 74.41 | 73.05 | 0.822 |
| Aug | 177.0 | 101.2 | 28.98 | 172.3 | 168.5 | 72.40 | 71.11 | 0.826 |
| Sept | 157.2 | 83.8 | 28.02 | 159.5 | 155.9 | 66.64 | 65.43 | 0.821 |
| Oct | 156.5 | 87.00 | 29.66 | 167.00 | 163.80 | 69.78 | 68.52 | 0.821 |
| Nov | 136.2 | 73.40 | 27.83 | 151.9 | 148.9 | 63.91 | 62.76 | 0.827 |
| Dec | 126.26 | 66.80 | 25.41 | 144.2 | 141.2 | 61.34 | 60.24 | 0.837 |
| **Year** | **1953.2** | **1053.1** | **28.23** | **1996.4** | **1954.7** | **835.09** | **820.07** | **0.822** |

G_Hor(kWh/m²): Global horizontal irradiation T_amb(°C): Ambient temperature

G_Dif(kWh/m²): Horizontal diffuse irradiation G_Inc(kWh/m²): Global Incident in coll. Plane

G_Eff(kWh/m²): Effective Global cor. For IAM and shadings E_Grid(MWh): Energy injected into grid

E_Array(MWh): Effective energy at the output of the array PR: (Performance ratio)

**Normalized productions**

The normalized yields obtained from the PVsyst software simulation were used to analyse the results presented in Figure 4. They represent standardised variables for analysing the performance of installed solar photovoltaic systems. Photovoltaic field recovery losses equaled 0.89 kWh/kWp/day. System losses (i.e. inverter and electrical components) are estimated at 0.08 kWh/kWp/day, while useful energy production is estimated at 4.5 kWh/kWp/day.

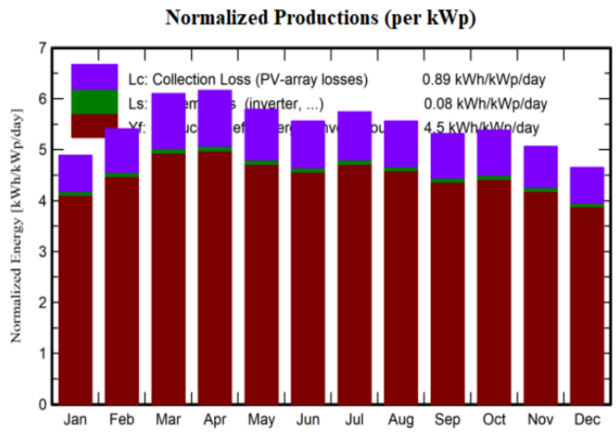


**Figure 4**: Normalized energy productions per installed kWp.

**Performance Ratio**

We simulated our 500 kWp solar photovoltaic system on PVsyst and found that it generated an average annual yield of 82.24%. Figure 5 shows the monthly variation in performance ratio obtained after simulation. As can be seen in the figure, there is a slight monthly variation, with a minimum value of 0.809 in April and a maximum value of 0.840 in January.

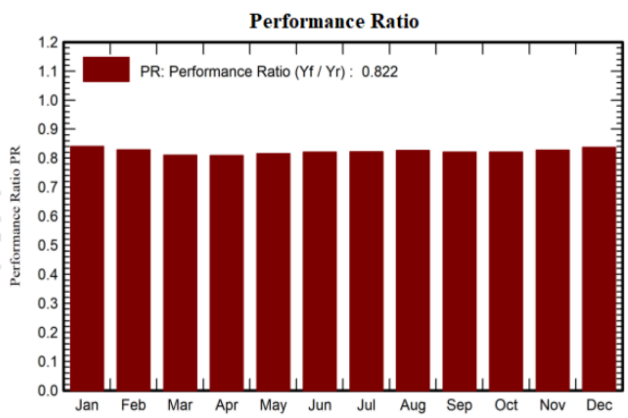


**Figure 5:** Performance ratio (%)

**Arrow loss diagram**

This is obtained by simulating the system under study. It provides an overview of the various losses encountered during the installation and operation of a planned solar PV system, as well as highlighting factors with a negative impact that should not be overlooked.

Figure 7 illustrates the various losses in the system. The overall irradiance on the horizontal area is 1,953 kWh/m², while the effective irradiance on the collector is 1,955 kWh/m² across a surface area of 2,522 m². Effective irradiance is a function of the electricity produced. Following photovoltaic conversion, the nominal energy under standard conditions (STC) is 978 MWh and the solar panel efficiency under STC is approximately 19.83%. The annual virtual energy of the PV solar array at maximum permissible power (MPP) is 839 MWh. There are numerous and varied losses such as the temperature losses which represent to 11.33%, and the irradiance losses areestimated at0.48%. Other losses include those due to ohmic losses, which are equated to 1.08%, and those due to panel and string inadequacy, which are estimated to 2.10%. There are two possible losses: the inverter losses during the operation (1.79%) and the inverter losses relative to the rated power (0.44%). The annual energy available at the inverter output to be fed into the grid is 820 MWh.

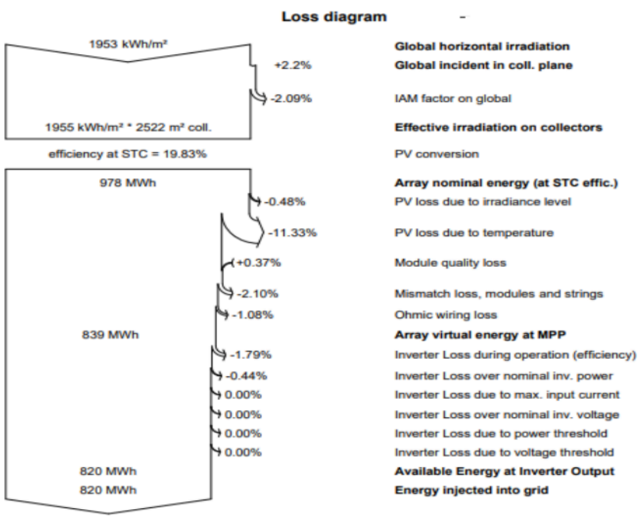


**Figure 6:** Arrow loss diagram for a 500 kWp solar photovoltaic system into grid

## Conclusion

This study discusses the simulated performance of a 500 kWp grid-connected solar photovoltaic system on the PVsyst software. Itis shown that the annual energy injected into the grid is 820.7 MWh/year andit is proportional to the estimated specific annual production of 1,642 kWh/kWp/year. The average annual performance ratio (PR) of the studied solar photovoltaic system is 82.24% in simulated operation at the Lambaye site. The energy fed into the grid varied from month to month, with a maximum output of 76.51 MWh in March and a minimum output of 60.24 MWh in December. The greatest losses were due to rising temperatures, accounting for 11.33%. Other losses are weak,ranging from 0.44% to 2.10%. These results enable us to assess the feasibility of the planned solar photovoltaic system and promote access to electricity for the people of Lambaye and the surrounding area.

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