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Poster Contributions

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Planning and optimization of a multipurpose farm using renewable energies (solar) in Yaoundé (Cameroon).

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Abstract. The instability of Cameroon's electricity network leads to recurrent power outages, which constitute a significant obstacle to socio-economic activity in the region [3]. This is also the case for the agricultural activities carried out by the GIC PROSER in the MEYO area of Yaoundé. The main objective of this work is to demonstrate a solution approach for an ecologically sustainable and relatively self-sufficient solar energy supply by GIC-PROSER, thus creating a prototypical model for other farms. For this purpose, a detailed calculation of the annual energy demand was performed. A first investigation was done in order to find out the potential of wind energy, but the wind speeds are not sufficient to provide enough electrical energy due to the location of the farm. Subsequently, a thorough and optimized planning of a solar generator was made, taking into account the solar radiation data of the area. Finally, an approximate of the economic efficiency calculation of this ecological generator was shown. This results in an annual demand of 25,647 kWh/a with a peak load of 12.8 kW. On the roofs of two farm buildings, 49 solar modules with 600 W each are to be installed, resulting in an output of about 29.4 kW. The solar generator (AC grid) provides an annual energy of almost 38,794 kWh. About 32% of this energy is consumed directly by the electrical equipment on the farm. About 55% can be used for battery charging. The annual surplus of produced energy, about 4,131.90 kWh, is fed directly into the grid. This leads to a degree of autonomy of 90%. This solar system costs about 16,000,000 FCFA (24,425 EUR) and it is amortized 11 years after its installation.

Keywords: Cameroon, multipurpose farm, planning, renewable energies.

Introduction

Today, the multipurpose space MEYO has several units such as: a nursery with 5,000 trees, two poultry production units with 2,000 chickens per 45-day wave, a banana plantation, one hectare of fruit trees, a feed production unit, a pigsty and a three-story residential building. All of these units are now operational. But the normal operation of the multipurpose farm depends on a sufficient and permanent supply of electrical energy. This is not the case in the multipurpose farm as well as in several small farms in the region. The direct consequences that can be identified are:

- Rapid aging of the multipurpose farm's electrical equipment.
- High electricity costs.
- Slowing down the economic dynamics of the multipurpose farm [4].

In addition, one of the current major difficulties is the planned relocation of the company from the current production site to a new and larger site, which is not yet covered by the electric utility. In order to overcome the various electrical problems of the multi-purpose enterprise of the GIC PROSER, different renewable energy systems have been implemented in this work. The drawing below shows an overview representation of the agro-complex of Meyo Farm. Here it is worth **mentioning** that the renewable energy sources drawn in Figure 1 are not yet present.

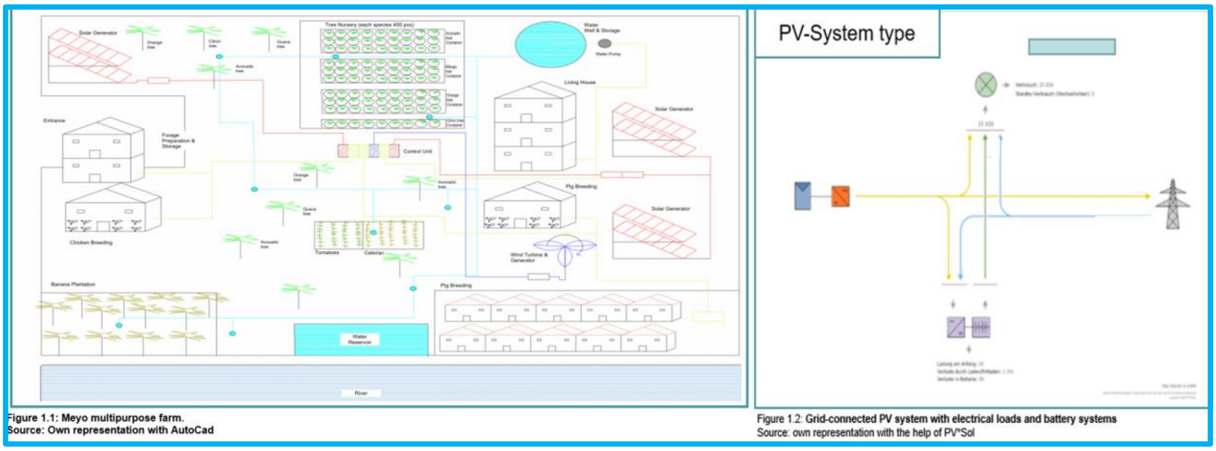

Figure 1.1: Meyo multipurpose farm.
Source: Own representation with AutoCad

Figure 1.2: Grid-connected PV system with electrical loads and battery systems
Source: own representation with the help of PV*Sol

Figure 1. Meyo multipurpose farm and system type of solar generator.

Requirements

Calculation of the energy demand of the multi-purpose farm.

In the initial planning phase, all the equipment that consumes electrical energy was listed and classified according to the production unit of the multipurpose farm and the power of this equipment. The maximum average daily energy consumption of the multipurpose farm was approximately 70 kWh, considering the operating time of these devices. Then, the load management including the simultaneity factor was performed with the PV*Sol program, which reduced the peak power by about 8 kW. The PV*Sol simulation program was used to determine the annual energy demand of about 25,650 kWh and the peak power of 12.8 kWp for the multipurpose operation. In Figure 2.2 below, in addition to the annual energy demand, the distribution of the consumptions according to the production unit of the multipurpose farm over the months can be seen. It can be seen that in January, for example, about 1,300 kWh are consumed by the feed production compared to the energy demand of the pig production, which is about 150 kWh in this month.

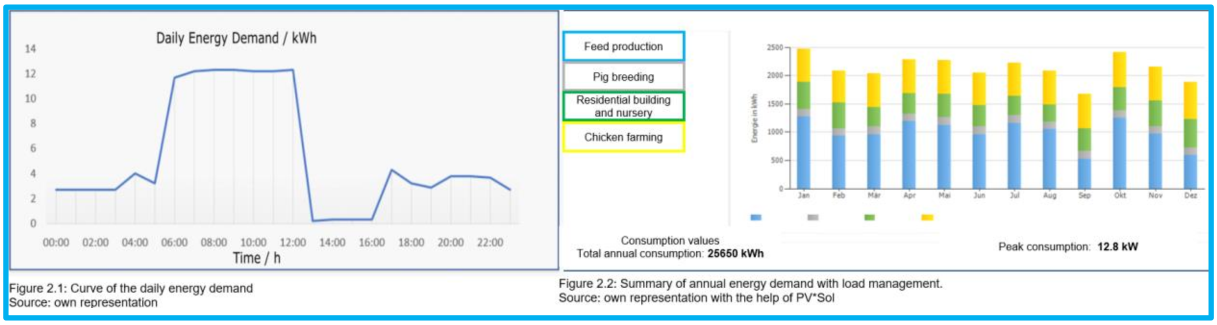

Figure 2.1: Curve of the daily energy demand
Source: own representation

Figure 2.2: Summary of annual energy demand with load management.
Source: own representation with the help of PV*Sol

Figure 2. Summary of daily and annual energy demand with load management.

Planning of the energy supply of the multipurpose farm with the help of solar energy (simulation with PVSOL).

Solar radiation spectrum and global radiation in Yaoundé.

The average global radiation in Cameroon is just over 3,000 hours of sunshine per year. In the more humid southern area (Yaoundé) of Cameroon, the average incident global radiation is about 1,600 kWh/m². For the planning of the solar power plant, data on solar radiation in Cameroon were imported into the simulation software PV*Sol.

The system type used in this was a grid-connected PV system with electrical loads with battery storage. The battery systems increase the degree of self-sufficiency of the whole system and in case of power failures an emergency power supply will continue to run for a certain time. The selected system is shown in Fig. 1.2.

Selection of the material, design of the modules and module interconnection.

On the roof of one of the company buildings, 28 solar panels with a nominal line 600 W rated power from Sun Day were installed, giving a solar generator power of about 16.8 kW. This power is much higher than the peak power required by the operation, which is 12.8 KW. An 18.7 kW- 3-phase inverter was used to interconnect the module (due to the existing three-phase machines for feed production). To support or increase the degree of self-sufficiency of the system was used three 48 V/200 Ah battery systems from the company Shenzhen UFO.

Dimensioning of the cables and circuit of the system

The program PV*Sol made it possible to enter the following information in the circuit during the simulation: (the length of the cable, the cable material, a variety of safety devices SS, LS, FI-S, TS, ÜSS, as well as the meters (one or two-sided). Then the cable cross-section (DC or AC side) and the cable losses are calculated automatically.

Economic efficiency calculation

For an efficient calculation of the profitability of a PV system, cost balance, investment costs, financing, taxes, operating and transport costs have been taken into account. The feed-in concept was not integrated in the economic efficiency calculation, since there is still no law in Cameroon for compensation for electricity fed into the public grid [1],

Result

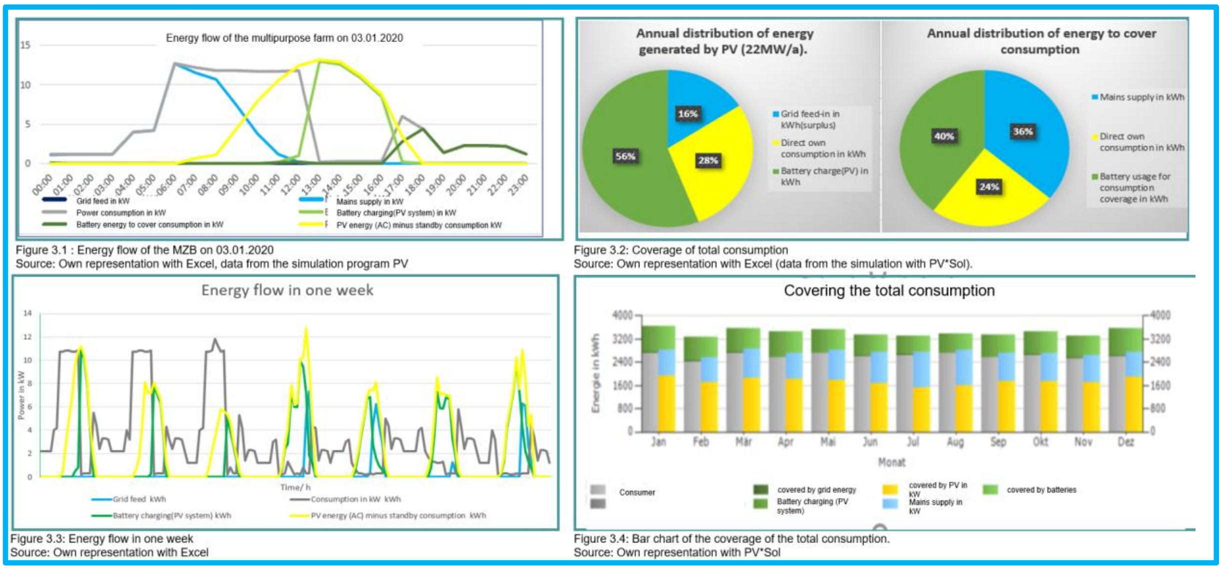

Figure 3.1 : Energy flow of the MZB on 03.01.2020
Source: Own representation with Excel, data from the simulation program PV
Figure 3.2: Coverage of total consumption
Source: Own representation with Excel (data from the simulation with PV*Sol).
Figure 3.3: Energy flow in one week
Source: Own representation with Excel
Figure 3.4: Bar chart of the coverage of the total consumption.
Source: Own representation with PV*Sol

Figure 3. Compilation of results.

This system generates 22,123 kWh per year, which is 86.6% of the farm's energy needs. 28.23% of this energy is used directly to meet demand. 55.9% is used to charge the batteries. Approximately 9,300 kWh of energy from the grid is used to power the photovoltaic system. The system costs about 10,000,000 FCFA (15,260 EUR) and will be paid back 8.5 years after its implementation.

Planning of the energy supply of the multipurpose farm with the help of wind power.

A small wind turbine with a power of 10 kW was chosen as the second energy source. To determine the height at which the wind turbine should be planned, the first step was to determine the wind data at 10 m and 50 m above ground using wind atlas online tools. The results of the simulation allowed to make a calculation of the annual mean wind speed at 30 m height using the logarithmic boundary profile and the roughness factor. Then it was possible to determine the wind distributions (frequency Weibull and Rayleigh distributions) at this height. These wind turbines installed at 30 m height produce 24,496 kWh of energy in this region. Due to the poor wind data in the Meyo area, the planning of the wind turbine in island mode was no longer carried out, as it is very difficult to show a payback.

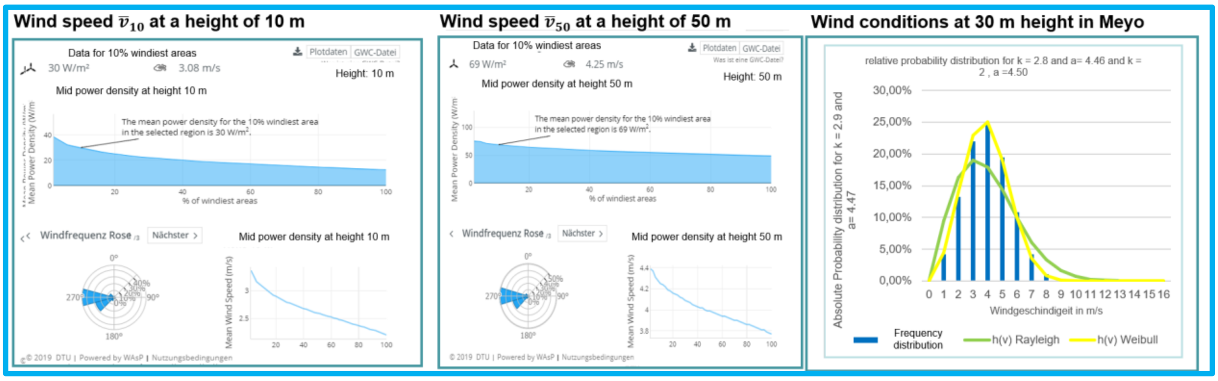

Figure 4. Wind conditions of the operating site

Optimization of the solar system

For the optimization, two three-phase inverters with 18.7 kW were used, a new south roof is equipped with 21 PV modules with a total power of 12.6 kWp. The total solar system has an output of 29.4 kWp with 21 modules each on the south roof and 28 modules on the north roof. For load optimization, the highest energy demand has a peak power of 12.8 kWp, which was between 07:00 and 13:00, was shifted by 3 hours, which seems feasible in terms of work organization. This can be seen from the red arrows in Figure 5.1 und 5.2.

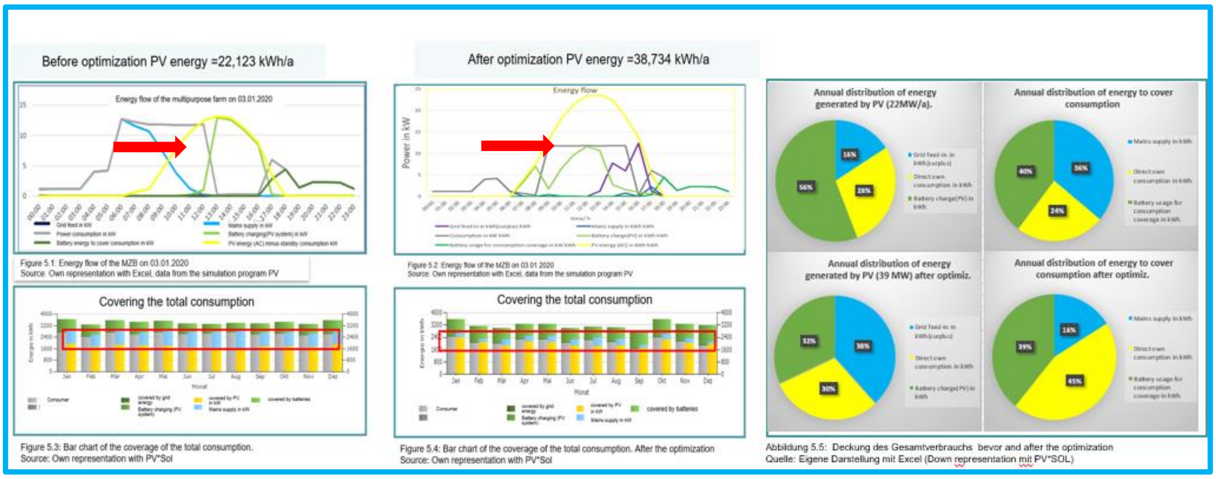

Figure 5. Compilation of results after the optimization

Simulation result after optimization

The simulation results show that the direct energy consumption of the technical equipment in multifunctional operation almost doubled. It increased from 6,246 kWh/a to 11,515 kWh/a. The system generates 38,734 kWh. 29.7% of this energy, i.e., 45% of the energy demand of the multifunctional operation, this energy is used directly to meet the demand. 32% of the generated energy is used to charge the batteries. The energy purchase from the grid decreased from 9,301.60 kWh to 4,131.90 kWh (from 36% to 16%). This leads to an increase in the degree of autonomy from 66.6% to 90%. This solar system costs about 16.000.000 FCFA (24.425 EUR) and will be paid back after about 11 years after its commissioning.

Conclusion

The solar planning approach optimized in this work would have positive impacts on the multipurpose farm. These impacts are as follows: annual savings of about 1,700,000 FCFA (2,594 EUR), increased productivity which will help in the fight against malnutrition in the region, in increased economic efficiency, in diversification of production units, in rapid growth of the business, in increasing the number of trainees and in improving competitiveness.

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