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Technical and economic evaluation of a 30MWp PV solar power plant in Senegal, as part of the Senegal Emerging Project: analytical approach and software calculation with PVSyst

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Indicative summary

This study was carried out in Dakar as part of the Senegal Emerging Program. It consists of designing and sizing a solar PV power plant in order to reduce the cost of electricity in Senegal; to promote the availability and accessibility of electrical energy to a large part of the rural population. The study will also help to strengthen the existing electricity grid, to boost the country's industrialization and reduce greenhouse gas emissions into the environment. To achieve the main objective pursued in this article, two approaches are developed. First, the analytical method, then a software calculation in the PVSyst environment.

Simulation results are presented in two files, a technical file and a financial file. The results obtained from the calculations, optimization and analysis validate the methodology used in both approaches. This leads to the conclusion that the study carried out in this article is feasible; cost-effective; integrable; reasonable; and achievable. The next study will be carried out in Congo DRC, in order to share our knowledge, know-how and skills with a view to reinforcing existing generation plants and contributing to the availability, accessibility and development of Central African countries.

Keywords: renewable energy, software calculation, optimization, environment, energy saving;

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Introduction

Every day, the earth receives in the form of solar energy the equivalent of the entire world's electricity consumption for more than 20 years. Within the framework of a Customer-SENELEC cooperation, in order to take advantage of this enormous free green, non-polluting and silent source of energy, photovoltaic solar energy, we wish to set up a power plant in the THIES region of Senegal, based on photovoltaic technology, in order to produce electricity and sell it back to SENELEC at a price of 60 f CFA per kWh. According to the specifications, the plant will have a capacity of 30 MW peak, and an area of around 21 ha is available for the operation of this project.

In order to achieve this, an analytical sizing calculation of the plant's various components (equipment and materials) is carried out first, followed by a techno-economic analysis to demonstrate the acuity and interest of this research. This is followed by software calculations and simulations to compare the two solutions and draw conclusions, choosing the optimum one. These calculations and simulations are carried out in the PVSYST version 7.2.0 software environment. As mentioned above, the main objective of this project is to dimension the plant components and propose a financial balance sheet.

Finally, a technical file and a financial file are presented, summarizing the results of the study. The technical file will include the following elements: technology and number of photovoltaic modules; technology and number of inverters; technology and cross-section of electrical cables; junction boxes and protection devices, etc. The financial file will provide information on: the investment cost; the operating and maintenance cost; the payback time; and the annual gain over the life of the project.

This paper comprises 5 sections organized as follows. The second section consists of an analytical sizing calculation of the plant components; the third presents a techno-economic study followed by a financial evaluation of the project. The fourth section focuses on software calculations and simulations. The fifth section concludes the work with a few research prospects.

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Resultats :

The results of the simulations are shown in the following figures:

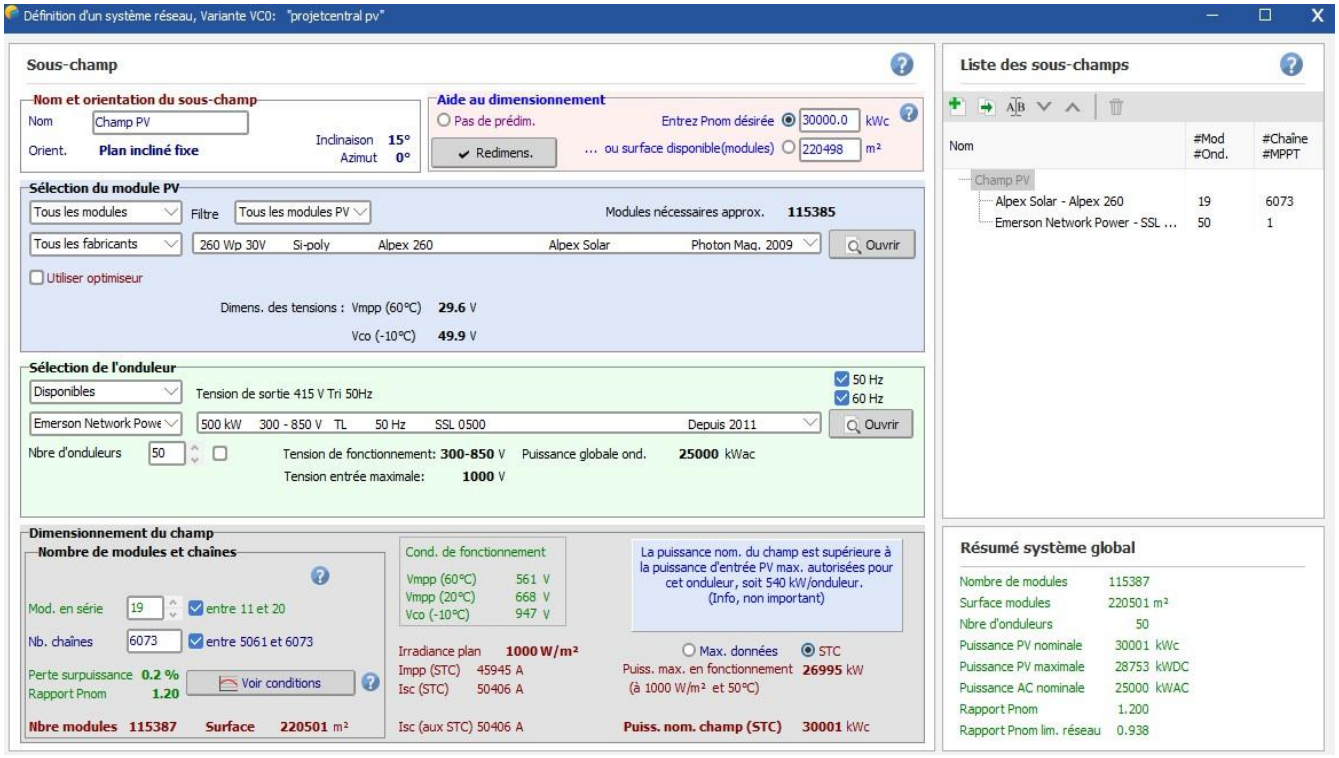

Figure 1 simulation results from the technical file

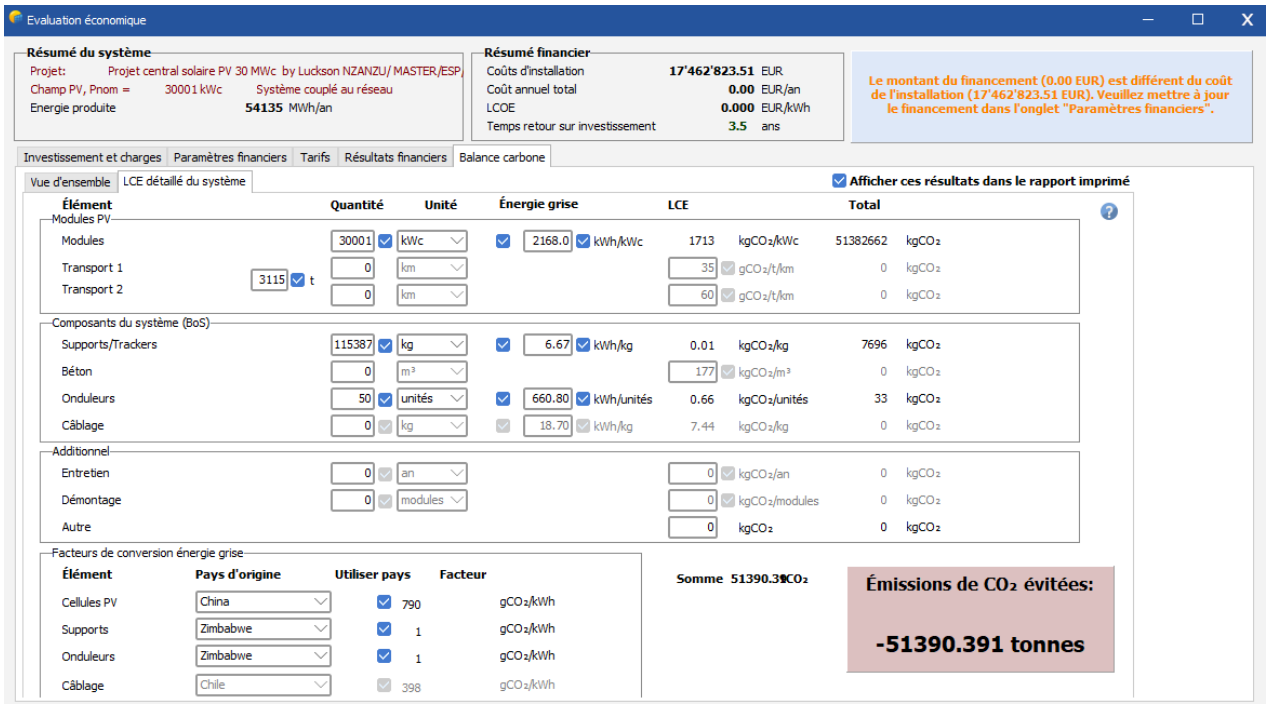

Figure 2 results of financial file simulations

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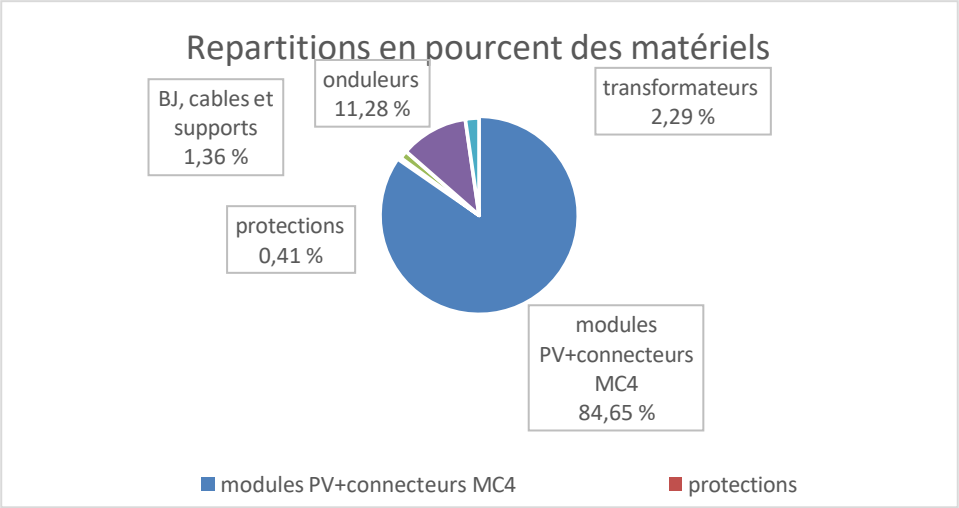

Figure 3 percentage breakdown of plant components by investment

Discussion & comments

The technical file includes:115385 PV modules with a peak capacity of 260 Watts each; 50 ABB inverters of 500 kW each;1500 PV fuses; 750 DC circuit breakers; 1500 surge arresters, cables with cross-sections of 150 $mm^2$for linking the PV tables to the inverters and those of 630 mm^2 for linking the inverters to the transformers. The number of MC4 connectors and the quantity of metal brackets have been estimated. The financial file provides information on the project's profitability. The return on investment (ROI) is 570.4%. The annual gain is €5,686,196.03 on a capital investment of €18,506,399.95. The payback time is approximately 3 years (3.5 years software value) over an estimated project life of 20 years. A depreciation allowance of €9,253.20 must be set aside each year, as well as €9,253.20 for plant maintenance and operation. We note that the bulk of the investment, around 80%, will be allocated to the purchase of PV modules, followed by 11% for inverters and almost 2% for transformers. It's encouraging and desirable to promote renewable energies, because by producing 71,725,000 kWh of energy per year, photovoltaics contribute to a reduction in CO2 emissions of around 51,096 tonnes per year, thus protecting mankind by limiting global warming.

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Conclusion:

This article proposes the dimensioning of a solar power plant with a peak capacity of 30 MW over an area of around 21ha, in accordance with the specifications. At the end of the calculations and optimization followed by an analysis, we note that the results obtained by the software approach and simulations corroborate those obtained by the analytical method. This confirms the methodology and approach used.

Roughly speaking, these results allow us to conclude that this study is feasible (good sunshine in Senegal and availability of land); profitable (financial evaluation); integrable (positive impact on the environment); reasonable (initial investment, payback time and annual gain); and achievable (all the above conditions are met).

References:

[1] ANNE LABOURET - PASCAL CUMUNEL; JEAN-PAUL BRAUN - BENJAMIN FARAGGI; solar cells basics of photovoltaic energy; 5th edition ETSF; ISBN 978-2-10-055598-7;p134;

[2] Unicef; SOLAR PUMPING Applied to Drinking Water Supply in Rural Areas For technical managers in the public and private sectors;

[3] ZAROUR LAID; technical study of an off-grid photovoltaic-wind hybrid energy system; dissertation; July 2010;

[4] S. Yotto; Study and design of a mini photovoltaic power plant to supply part of the electrical installation of the presidency of the republic of benin, 2011; dissertation;

[5] GTZ; Technical and economic feasibility study of the grid-connected photovoltaic sector in Senegal; p115; report

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